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FINAL

NOLF CABANISS AND NOLF WALDRON

Air Installations Compatible Use Zones (AICUZ) Study

September 2020

NAS CORPUS CHRISTI, TEX.

Prepared by:
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EXECUTIVE SUMMARY

ES.1 INTRODUCTION

The United States Department of Defense (DOD) initiated the Air Installations Compatible Use Zones (AICUZ) Program to assist governments and communities in identifying and planning for compatible land use and development near military installations. The goal of the AICUZ Program is to protect the health, safety, and welfare of the public while also protection the operational capabilities of the military. Today, the AICUZ Program is a vital tool the Navy uses to communicate with neighboring communities, government entities, and individuals regarding compatible land uses and development concerns.

This AICUZ was prepared for Naval Air Station Corpus Christi (NASCC) in accordance with federal regulations, guidelines, and Office of the Chief of Naval Operations Instruction (OPNAVINST 11010.36C) (referred to as AICUZ Instruction), and is an update to the 2009 AICUZ Study. The scope of this AICUZ Study includes NOLF Cabaniss and NOLF Waldron, which both support operations from NASCC. Since the 2009 AICUZ Study, there have been changes that necessitate an AICUZ update. These include changes to number of aircraft, types of aircraft, and operations, as well as changes in local land uses. Pursuant to Navy AICUZ Instruction, this 2020 AICUZ Study evaluates noise contours and accident potential zones (APZs) from the 2009 AICUZ Study, as well as the planning noise contours and APZs as a part of this 2020 AICUZ effort. Noise contours and APZs, together, are commonly called the "AICUZ footprint." The 2020 AICUZ footprint is based on total operations projected out to year 2030. Utilizing the 2020 noise contours and APZs, this AICUZ Study identifies areas of incompatible land use, and recommends actions to encourage compatible land use.

The NASCC complex includes the main airfield (Truax Field) and three outlying landing fields to support training operations: NOLF Waldron, NOLF Cabaniss, and NOLF Goliad. Both Truax Field and NOLF Waldron are located in the Flour Bluff area of Corpus Christi on the Encinal Peninsula. The peninsula is surrounded by the Corpus Christi Bay to the north, Laguna Madre to the east, and the Oso Bay to the west. NOLF Waldron is accessed by Waldron Road which connects to the main highway through Corpus Christi, South Padre Island Drive (also referred to as State Highway 358).

NOLF Cabaniss is located in the southside area of Corpus Christi along the Oso Creek. NOLF Cabaniss is accessed by Saratoga Boulevard and located just east of the Crosstown Expressway (State Highway 286), a major highway in Corpus Christi. Oso Creek is the southern boundary of NOLF Cabaniss and is also the boundary for the city limits of Corpus Christi. South of Oso Creek is unincorporated Nueces County. Figure 1-1 in Chapter 1, Introduction, provides a regional map of the Corpus Christi area and identifies the locations of Truax Field, NOLF Waldron, and NOLF Cabaniss.

NASCC is an aviation training installation with a mission to maintain and operate facilities, as well as to provide services and material to support operations of aviation activities and units within the operating forces of the Navy (NAVFAC n.d.). The overall command assignment is to train pilots.

ES.2 AIRCRAFT OPERATIONS

AICUZ studies account for future missions and operations. As such, this 2020 AICUZ Study analyzes and presents two conditions for NOLF Cabaniss and NOLF Waldron. For NOLF Cabaniss, the two conditions are: (1) the 2009 noise contours and APZs, as presented in the 2009 AICUZ Study (Navy 2009); and (2) the 2020 operational data (including a 50 percent increase added to operational data for possible future operational increases [see Section 2.4.1, NOLF Cabaniss Annual Operations, for additional information]). For NOLF Waldron, two conditions were also analyzed: (1) the 2009 noise contours and APZs, as presented in the 2009 AICUZ Study (Navy 2009); and (2) data derived from the 2018 operational data from the Environmental Assessment (EA) for Providing Outlying Field Capabilities to Support T-6 Undergraduate Pilot Training (see Section 2.4.2, NOLF Waldron Annual Operations, for additional information) for 2020 AICUZ operations.

Compared to the 2009 AICUZ Study, the number of total operations at NOLF Cabaniss has decreased by 25,032 (Table ES-1). The primary factors attributed to the decrease in operations are the reduction in pattern operations flown at the airfield and the removal of the UC-12 aircraft at NOLF Cabaniss. Alternatively, at NOLF Waldron, total operations increased by 64,804 when comparing to the 2009 operation levels (Table ES-1).

TABLE ES-1 COMPARISON OF 2009 AND 2020 AICUZ STUDY ANNUAL OPERATIONS AT NOLF CABANISS AND NOLF WALDRON

NOLF Cabaniss	
2009 AICUZ	**2020 AICUZ**
109,050	**84,018**
NOLF Waldron	
2009 AICUZ	**2020 AICUZ**
185,196	**250,000**

Sources: Navy 2009; BRRC 2020
Note:
See Chapter 2, Aircraft Operations, for more information on operations.

ES.3 AIRCRAFT NOISE

This 2020 AICUZ Study discusses noise associated with aircraft operations, including average noise levels, noise abatement/flight procedures, noise complaints, sources of noise, airfield-specific noise contours, and analysis of changes from the previous (2009 AICUZ) and planning (2020) noise contours.

The operational data used in this 2020 AICUZ Study for NOLF Cabaniss was collected, compiled, and input into computer models that graphically depict noise exposures as noise contours. NOISEMAP is the DOD standard model for assessing noise exposure from military aircraft operations at air installations. Operational data used in this 2020 AICUZ Study for NOLF Waldron was collected from the 2018 EA for Providing Outlying Field Capabilities to Support T-6 Undergraduate Pilot Training. In support of the 2018 EA, a noise study was conducted where noise contours were generated based on the operational data.

Day-night average sound level (DNL) is depicted on a map as a noise contour that connects points of equal noise value. Contours are displayed in 5-decibel (dB) increments (i.e., 60, 65, 70, 75, 80, and 85 dB DNL). The 2020 noise contours for NOLF Cabaniss are contained within the airfield boundaries. The 2020 noise contours for NOLF Waldron overlay the area in the immediate vicinity of the airfield, with the vast majority of the higher noise contours concentrated within the airfield boundary. A comparison of the 2009 and 2020 AICUZ Study noise contours for NOLF Cabaniss shows some similarities in shape, general location, and DNL levels. The comparison also shows a decrease in overall size and coverage from the historical to the projected noise contours, as depicted in Figure 3-3 in Chapter 3, Aircraft Noise. At NOLF Waldron, a comparison of noise contours shows a decrease in overall size and coverage from the 2009 to the 2020 AICUZ Study noise contours, as depicted in Figure 3-6, also in Chapter 3, Aircraft Noise.

ES.4 AIRFIELD SAFETY

While the likelihood of an aircraft mishap is unlikely, accidents could occur. The Navy has designated areas with an accident potential based on historical data for aircraft mishaps near military airfields to assist in land use planning. APZs identify areas where an aircraft accident is most likely to occur if an accident were to take place. The APZs are not a prediction of accidents or accident frequency. When adopted by local planning authorities, APZs minimize potential harm to the public, pilots, and property if a mishap does occur by limiting incompatible uses in the designated APZ areas.

APZs follow departure, arrival, and pattern flight tracks. There are three types of APZs: the Clear Zone, APZ I, and APZ II. APZs extend from the end of the runway, but apply to the predominant arrival and/or departure flight tracks that the aircraft use. 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.

APZs in this 2020 AICUZ Study have been developed based on the projected aircraft operations (projected out to year 2030) for NOLF Cabaniss, and from the 2018 EA for Providing Outlying Field Capabilities to Support T-6 Undergraduate Pilot Training for NOLF Waldron.

The 2020 AICUZ Clear Zones and APZs for NOLF Cabaniss impact approximately 1,385.4 acres. Approximately 17 percent of the impacted areas are within the airfield boundary. The remaining 83 percent of impacted areas are off-station. The coverage of the Clear Zones and APZs for NOLF Cabaniss increased from the 2009 to the 2020 AICUZ Study. The acreage increases are attributed, in part, to the closed loops of the APZs associated with Runway 18/36 and Runway 13. While some similarities exist in the structure of the 2009 and 2020 APZs, there are some key differences, including the addition of an APZ I and APZ II to the approach end of Runway 36.

Likewise, the 2020 AICUZ Clear Zones and APZs for NOLF Waldron impact approximately 1,572.2 acres. Approximately 15 percent of the impacted areas are within the airfield boundary. The remaining 85 percent of the impacted areas are off-station. The APZ coverage for the 2020 AICUZ Study increased, compared to the 2009 AICUZ Study. The acreage increases are largely attributed to the addition of the closed loop APZs associated with Runway 13/31 and 18/36. The 2020 APZs expanded when compared to the 2009 AICUZ APZs, due to the projected increase in annual operations at NOLF Waldron. See Section 4.2.4, Comparison of Clear Zones and APZs For NOLF Waldron, for additional information.

ES.5 LAND USE COMPATIBILITY ANALYSIS

Successful AICUZ land use compatibility implementation is the collective responsibility of the Navy, state and local governments, and private sector and non-profit organizations. This AICUZ Study discusses federal, state, and local planning authorities, regulations, and programs that encourage compatible land use practices. Ultimate control over land use and development surrounding NOLF Cabaniss and NOLF Waldron is the responsibility of local governments and landowners, therefore, the Navy encourages local governments to plan for compatible development. In addition, the Navy focuses efforts on outreach and coordination with local jurisdictions to provide greater awareness and transparency of the operations in and around the airfields.

The AICUZ footprint (noise contours and APZs) of NOLF Cabaniss (Figure ES-1) is primarily located in Corpus Christi's city limits, as well as small areas of unincorporated Nueces County. The AICUZ footprint of NOLF Waldron (Figure ES-2) is located entirely within the Corpus Christi city limits. Corpus Christi land use planning programs, comprehensive plans, zoning codes, ordinances, and other authorities that have the potential to influence land use near the airfields are discussed as part of this AICUZ Study.

The AICUZ Study presents the land use compatibility analysis that identifies any existing or planned land use, zoning, and development compatibility issues, as well as to provide recommendations to manage existing and future development within and around the AICUZ footprint to ensure long-term land use compatibility between local land development and the Navy's operational mission. The 2020 AICUZ footprint is discussed further in Section 5, Land Use Compatibility Analysis.

The Navy has developed land use compatibility recommendations for noise zones and APZs to foster land use compatibility. For land use planning purposes in AICUZ studies, noise exposure areas are divided into three noise zones, based on DNL measurements. Noise Zone 1 (<65 dB DNL) is an area of low or no impact. Noise Zone 2 (65 to <75 dB DNL) is an area of moderate impact where some land use controls are recommended. Noise Zone 3 (≥75 dB DNL) is the most impacted area where the greatest degree of compatible land use controls are recommended. Likewise, recommended land use compatibility guidelines are established for Clear Zones, APZ I, and APZ II. AICUZ guidelines recommend that land uses that concentrate large numbers of people (e.g., apartments, churches, and schools) be avoided within the APZs.

This AICUZ Study addresses land use compatibility within aircraft noise zones and APZs at NOLF Cabaniss and NOLF Waldron by examining existing and future land uses near the airfields. To analyze whether existing and planned land uses are compatible with aircraft operations, the 2020 AICUZ noise contours and APZs were overlaid on parcel data and land use classification information. The land use analysis was performed using the Navy's land use compatibility guidance and land use data from the City of Corpus Christi. Noise contours and/or APZs impact areas off the airfield in all directions. While the majority of the areas impacted are contained within the boundaries of the airfield, there are areas of residential development either currently located or planned for within certain APZs and noise zones.

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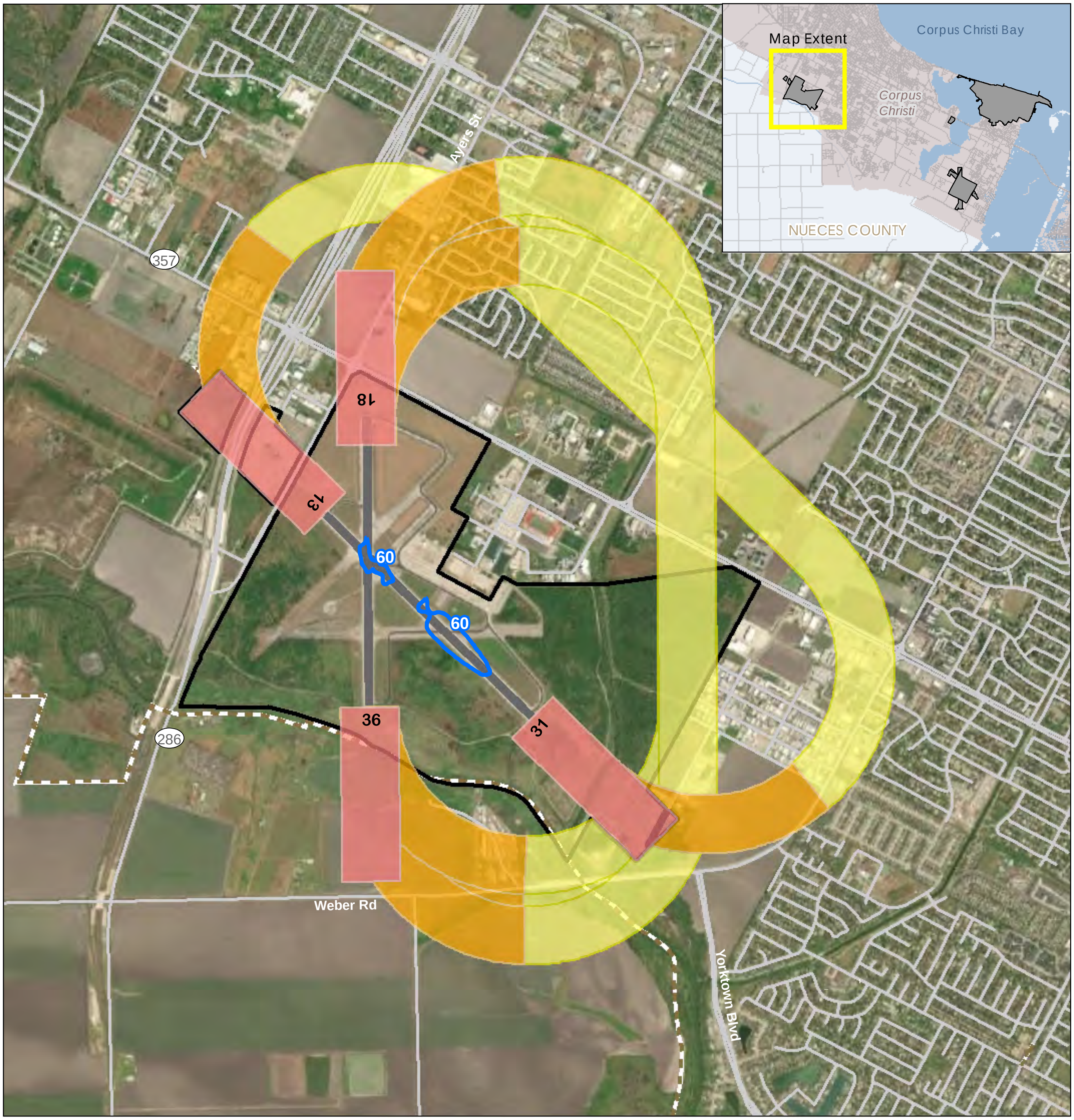

Figure ES-1
2020 AICUZ Footprint, NOLF Cabaniss

Naval Air Station
Corpus Christi, Texas

Source: ESRI 2018, Navy 2020, BRRC 2020
Ecology and Environment, Inc. 2020

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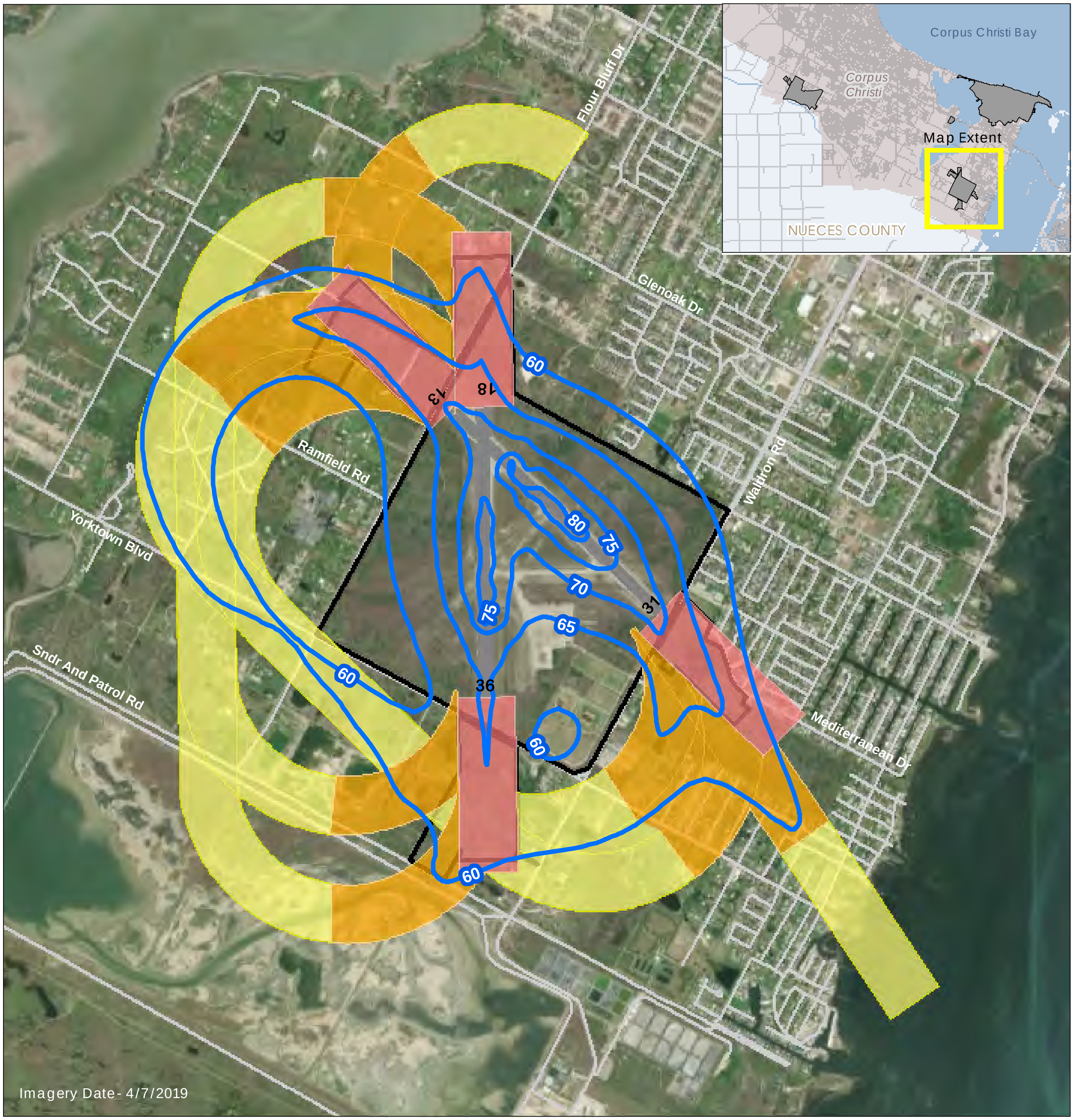

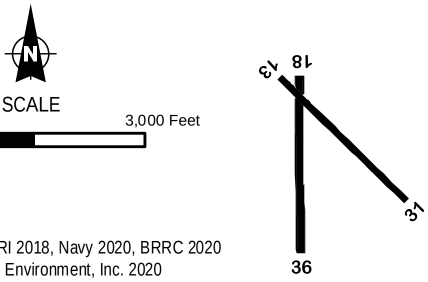

Legend

▭ NOLF Waldron

▬ Runway

〰 Road

〰 2020 AICUZ Noise Contours (dB)

2020 AICUZ APZs

🟥 Clear Zone

🟧 APZ I

🟨 APZ II

Source: ESRI 2018, Navy 2020, BRRC 2020
Ecology and Environment, Inc. 2020

Figure ES-2
2020 AICUZ Footprint,
NOLF Waldron

Naval Air Station
Corpus Christi, Texas

ES.6 LAND USE TOOLS AND RECOMMENDATIONS

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

The Navy has the responsibility to communicate and collaborate with local governments on land use planning, zoning, and compatibility concerns that can have an impact on its mission. State and local governments have the authority to implement regulations and programs to control development and direct growth to ensure land use activity is compatible within the AICUZ footprint. Local governments are encouraged to recognize their responsibility in providing land use controls in those areas encumbered by the AICUZ footprint by incorporating AICUZ information into their planning policies and regulations. Cooperation between NASCC and neighboring communities to the airfields is key to the AICUZ Program's success. The AICUZ Study recommendations, when implemented, will continue to advance the goal, "to protect the health, safety, and welfare of those living near military airfields, while preserving the defense flying mission." More information on specific tools and recommendations for areas of compatibility concern can be found in Chapter 6, Land Use Tools and Recommendations.

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ACRONYMS AND ABBREVIATIONS

AICUZ	Air Installations Compatible Use Zones
Air Ops	Air Operations
APHIS WS	U.S. Department of Agriculture, Animal and Plant Health Inspection Service, Wildlife Services
APZ	accident potential zone
ATC	Air Traffic Control
BASH	bird/animal aircraft strike hazard
BPAS	Building Permit Allocation System
CFR	Code of Federal Regulations
CNATRA	Chief of Naval Air Training
CO	Commanding Officer
CBCOG	Coastal Bend Council of Governments
CPLO	Community Planning and Liaison Officer
dB	decibel
dBA	A-weighted decibel
DNL	day-night average sound level
DOD	U.S. Department of Defense
EA	environmental assessment
EMI	electromagnetic interference
ETJ	extraterritorial jurisdiction
FAA	Federal Aviation Administration
FCF	Functional Check Flights
FCLP	field carrier landing practice
GIS	geographic information system
HUD	U.S. Department of Housing and Urban Development
JLUS	Joint Land Use Study
Marine Corps	U.S. Marine Corps
NALF	Naval Auxiliary Landing Field
NAS	Naval Air Station
NASCC	Naval Air Station Corpus Christi
NAVFAC	Naval Facilities Engineering Command

Navy	U.S. Department of the Navy
NEPA	National Environmental Policy Act
NLR	Noise Level Reduction
NOLF	Naval Outlying Landing Field
OPNAVINST	Office of the Chief of Naval Operations Instruction
PAO	Public Affairs Officer
REPI	Readiness and Environmental Protection Integration
SB	Senate Bill
SLEP	Service Life Expectancy Program
SLUCM	Standard Land Use Coding Manual
SUA	Special Use Airspace
TCC	Texas Commanders Council
TMPC	Texas Military Preparedness Commission
U.S.C.	United States Code
UFC	Unified Facilities Criteria
VFR	visual flight rules

1

INTRODUCTION

Recognizing the need to foster compatible land and air uses, the U.S. Department of Defense (DOD) initiated the Air Installations Compatible Use Zones (AICUZ) Program in 1973 to help governments and communities identify and plan for coordinated compatible land use and development around installations. The goal of the AICUZ Program is to protect the health, safety, and welfare of the public while also protecting the operational capabilities of the military. This goal is accomplished by achieving compatible land use around an air installation. Mutual cooperation between installations and their neighboring communities is key to the AICUZ Program's success.

The AICUZ Program recommends that noise contours, accident potential zones (APZs), height obstruction criteria, and land use recommendations be incorporated into local community planning policies and activities to minimize impacts to the military mission and the residents in the surrounding communities.

As the communities that surround an airfield grow and develop, the U.S. Department of the Navy (Navy) has the responsibility to communicate and collaborate with local governments on land use planning and mission impacts. As stakeholders in the community, installations provide the local community with an understanding of the military mission and operations in order to ensure the community's health, safety, and welfare. Installations also protect the mission of the Navy.

This 2020 AICUZ Study for Naval Outlying Landing Field (NOLF) Cabaniss and NOLF Waldron was prepared for Naval Air Station (NAS) Corpus Christi (NASCC) in accordance with federal regulations, guidelines, and Office of the Chief of Naval Operations Instruction (OPNAVINST 11010.36C), and is an update to the 2009 AICUZ Study.

1.1 PURPOSE, SCOPE, AND AUTHORITY

The DOD established the AICUZ Program to balance the need for aircraft operations with community concerns regarding aircraft noise and accident potential. The AICUZ Program provides a format to document the effects of aircraft operations in a community, while encouraging compatible development to minimize future conflicts.

These are the objectives of the AICUZ Program, according to the OPNAVINST 11010.36C:

- To protect the health, safety, and welfare of civilians and military personnel by encouraging land use that is compatible with aircraft operations;
- To reduce noise impacts caused by aircraft operations, while meeting operational, training, and flight safety requirements, both on and in the vicinity of air installations;
- To inform the public and seek cooperative efforts to minimize noise and aircraft accident potential impacts by promoting compatible development; and
- To protect Navy and U.S. Marine Corps (Marine Corps) installation investments by safeguarding the installation's operational capabilities.

To help meet AICUZ Program objectives, the Federal Aviation Administration (FAA) and DOD have developed specific instructions and guidance to encourage local communities to restrict development or land uses that could endanger pilots operating aircraft near an airfield. Examples of such development or land uses include lighting (direct or reflected) that would impair pilot vision; towers, tall structures, and vegetation that penetrate navigable airspace or are constructed near an airfield; uses that generate smoke, steam, or dust; uses and/or vegetation that attract birds (especially waterfowl), as well as deer or other wildlife; and electromagnetic interference (EMI) sources that may adversely affect aircraft communication, navigation, or other electrical systems.

To meet the objectives of the AICUZ Program, the Navy recommends that local community planning authorities incorporate development criteria in areas surrounding an installation and incorporate noise exposure contours and APZs into local plans and development ordinances. Noise exposure contours and APZs, which are described in detail in Chapter 3, Aircraft Noise, and Chapter 4, Airfield Safety, are areas of concern for air installations and neighboring communities. Noise contours and APZs, together, are commonly called the "AICUZ footprint." Because the AICUZ footprint often extends beyond the "fence line" of an installation, presenting the AICUZ Study to local governments is essential to fostering mutually beneficial land uses and development.

An AICUZ Study presents analysis of community development trends, land use tools, and mission requirements to recommend strategies for communities to prevent incompatible development. Implementation of these strategies requires cooperation between the Installation Commanding Officer (CO), Community Planning and Liaison Officer (CPLO), and local governments. Key documents that outline the authority for the establishment and implementation of the AICUZ Program, as well as guidance on facility requirements, are derived from:

- DOD Instruction 4165.57, "Air Installations Compatible Use Zones," dated May 2, 2011 (incorporating Change 2, Effective August 31, 2018);
- OPNAVINST 11010.36C, "Air Installations Compatible Use Zones Program," dated October 9, 2008 (referred to as the AICUZ Instruction);
- Unified Facilities Criteria 3-260-01, "Airfield and Heliport Planning and Design," dated February 4, 2019 (incorporating Change 1, Effective May 5, 2020);

The Navy's AICUZ Program Instruction (OPNAVINST 11010.36C) currently governs the AICUZ Program.

- Naval Facilities Engineering Command (NAVFAC) P-80.3, "Facility Planning Factor Criteria for Navy and Marine Corps Shore Installations: Airfield Safety Clearances," dated January 1982; and
- United States Department of Transportation, FAA Regulations, Title 14 Code of Federal Regulations (CFR) Part 77, "Objects Affecting Navigable Airspace."

The scope of this AICUZ Study analyzes the following for NOLF Cabaniss and NOLF Waldron:

- 2009 and 2020 aircraft operations, including arrivals, departures, and pattern work (e.g., touch-and-go);
- Noise contours;
- Clear Zones and APZs;
- Land use compatibility; and
- Compatible land use recommendations.

1.2 PREVIOUS AICUZ EFFORTS, RELATED STUDIES, AND AICUZ STUDIES OVERVIEW

1.2.1 PREVIOUS AICUZ EFFORTS AND RELATED STUDIES

There have been various AICUZ studies completed for NASCC and associated outlying fields since the inception of the AICUZ Program. The following list includes previous studies completed for NASCC and NOLFs:

- Original AICUZ Study for NASCC, including Naval Auxiliary Landing Field[1] (NALF) Waldron and NALF Cabaniss, 1978;
- AICUZ Study update for NASCC, including NALF Waldron and NALF Cabaniss, 1986;
- AICUZ Study for NASCC, including NALF Waldron and NALF Cabaniss, 2009; and
- Final Environmental Assessment (EA) for Providing Outlying Field Capabilities to Support T-6 Undergraduate Pilot Training, Training Wing Four, NASCC, Texas, 2018 (hereafter referred to as the 2018 EA [environmental assessment] for T-6 Undergraduate Pilot Training, NASCC).

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[1] Previously identified as Naval Auxiliary Landing Fields, airfields are now referred to as Naval Outlying Landing Fields (NOLFs).

1.2.2 CHANGES THAT NECESSITATE AN AICUZ UPDATE

AICUZ updates follow DOD and Navy Instruction. Updates are determined necessary based on a variety of factors, but primarily are conducted if an air installation has a significant change or projected change in aircraft operations, a significant increase in nighttime flying activities, a change in the aircraft based and operating at the installation, or changes in flight paths or runway utilization. Other factors include updates to the DOD or Navy Instruction, updates to noise modeling methods, and/or local community land use changes and developments.

This 2020 AICUZ Study was developed in accordance with the AICUZ Instruction and is an update to the 2009 AICUZ Study. The justifications for this 2020 AICUZ Study include:

- The current AICUZ Study was conducted in 2009.
- The mix of aircraft types operating at NOLF Cabaniss and NOLF Waldron have changed.
- The number and type of aircraft operations have changed at NOLF Cabaniss and NOLF Waldron.
- The mix of aircraft operations along designated flight tracks resulted in changes to APZs at NOLF Cabaniss and NOLF Waldron.
- Local land use and development patterns have changed around NOLF Cabaniss and NOLF Waldron. Documenting these changes will assist the installation to encourage continued compatible development.

These factors have differing effects on the AICUZ footprint. These effects, as well as the extent of changes from the 2009 AICUZ Study, are discussed further in Chapter 2, Aircraft Operations; Chapter 3, Aircraft Noise; and Chapter 4, Airfield Safety.

1.3 LOCATION

NASCC is located along the southeast coast of Texas within the City of Corpus Christi in Nueces County. Corpus Christi is located on the Corpus Christi Bay, west of Mustang Island. The city and regional areas are characterized by generally flat terrain with predominantly scrub brush and ranch and farmlands. Corpus Christi is located approximately 130 miles southeast of the City of San Antonio and 125 miles north of the United States-Mexico border (Figure 1-1).

The NASCC complex includes the main airfield, Truax Field, and three outlying landing fields to support training operations: NOLF Waldron, NOLF Cabaniss, and NOLF Goliad. Both Truax Field and NOLF Waldron are located in the Flour Bluff area of Corpus Christi on the Encinal Peninsula. The peninsula is surrounded by the Corpus Christi Bay to the north, Laguna Madre to the east, and the Oso Bay to the west. NOLF Waldron is accessed by Waldron Road which connects to the main highway through Corpus Christi, South Padre Island Drive (also referred to as State Highway 358).

NOLF Cabaniss is located in the southside area of Corpus Christi along the Oso Creek. NOLF Cabaniss is accessed by Saratoga Boulevard and located just east of the Crosstown Expressway (State Highway 286), a major highway in Corpus Christi. Oso Creek is the southern boundary of NOLF Cabaniss and is also the boundary for the city limits of Corpus Christi. South of Oso Creek is unincorporated Nueces County. Figure 1-1 provides a regional map of the Corpus Christi area and identifies the locations of Truax Field, NOLF Waldron, and NOLF Cabaniss.

NOLF Goliad is located approximately 65 miles northwest of NASCC within unincorporated Goliad County, Texas, but is not included in this AICUZ Study (a standalone AICUZ Study for NOLF Goliad was completed in 2015). Operational changes described in Section 1.2, Previous AICUZ Efforts, Related Studies, and AICUZ Studies Overview, do not apply to NOLF Goliad.

1.4 HISTORY

The 75th Congress commissioned NASCC in 1938 to provide facilities to train pilots for emergency situations. The first flight training began May 5, 1941. Most notably, George H.W. Bush graduated flight school from NASCC in June 1943 at the age of 18.

NOLF Cabaniss was dedicated July 9, 1941, to honor Commander Robert W. Cabaniss who was killed in a plane crash in 1927. During its first years of service, the auxiliary airfield was primarily utilized for basic and intermediate training. During the Vietnam War, NOLF Cabaniss became a major facility for helicopter repair and maintenance (Global Security n.d.[a]).

NOLF Waldron was dedicated March 5, 1943, in honor of Lieutenant Commander John C. Waldron who was killed in action at the Battle of Midway on June 4, 1942. Presently, NOLF Waldron is used as a touch-and-go air training field (Global Security n.d.[b]).

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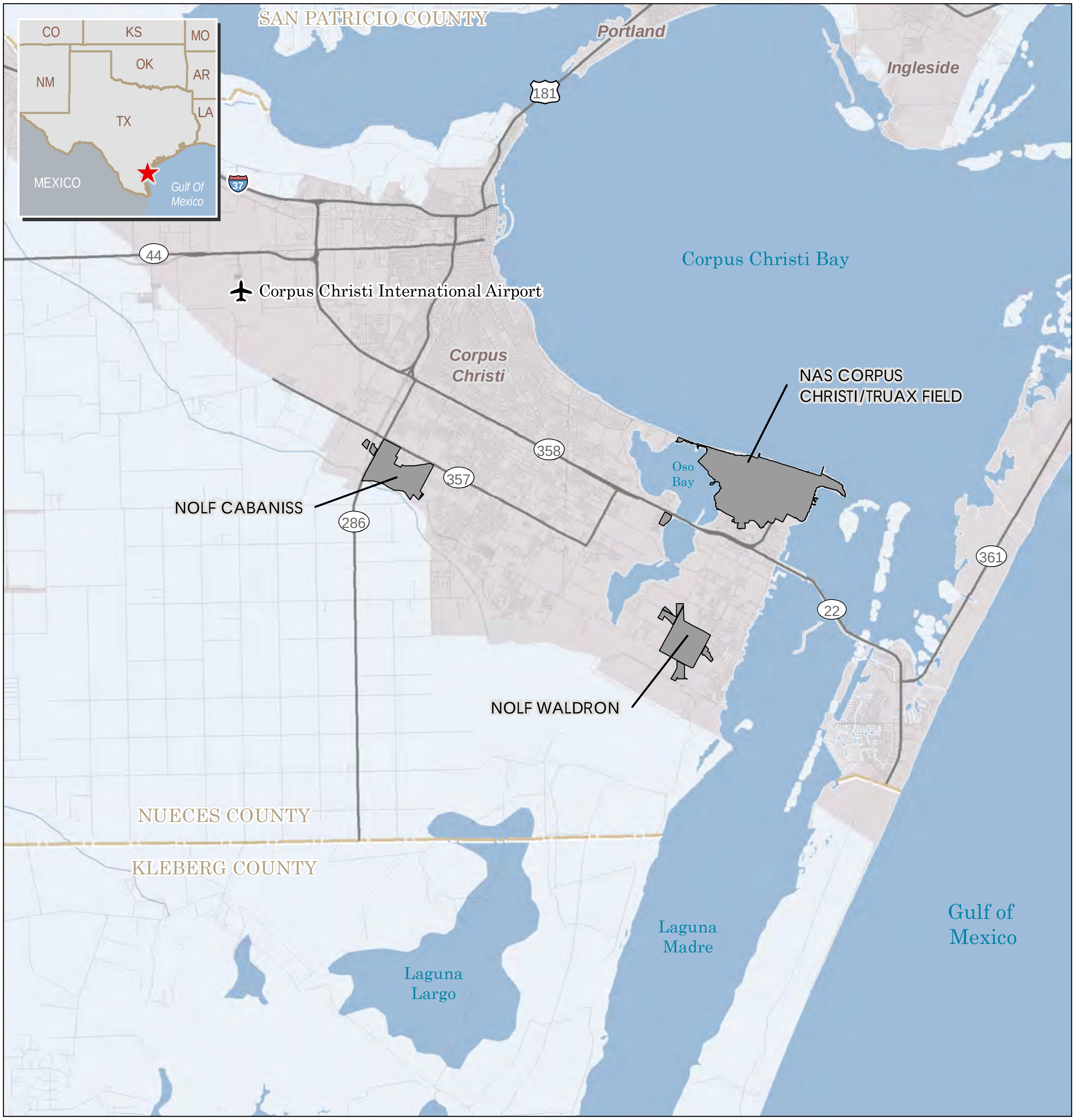

N

SCALE

0 4 Miles

Legend

▨ Military Area

▨ Urban Area

▨ Waterbody

✈ Airport

County Boundary

Road

Figure 1-1
Regional Location

Naval Air Station
Corpus Christi, Texas

Source: ESRI 2018; Navy, 2020
Ecology and Environment, Inc. 2020

1.5 INSTALLATION MISSION

NASCC is an aviation training installation with a mission to maintain and operate facilities, as well as to provide services and material to support operations of aviation activities and units within the operating forces of the Navy. (NAVFAC n.d.). The overall command assignment is to train pilots.

The Chief of Naval Air Training (CNATRA) is headquartered at NASCC and oversees the training operation throughout the Southeast Region. CNATRA's command includes five training air wings, 16 training squadrons, and more than 14,000 Navy and civilian personnel.

1.6 TENANTS

NASCC hosts more than 40 tenant commands and activities. Of these, the following is the major command performing aviation activities at NOLF Cabaniss and NOLF Waldron. The aircraft associated with these units and their operations are described in greater detail in Section 2.2.

Training Air Wing 4. According to the Chief Naval Air Training Command History, TW-4 is comprised of four individual units: Training Squadrons TWENTY-SEVEN (VT-27), TWENTY-EIGHT (VT-28), THIRTY-ONE (VT-31), and THIRTY-FIVE (VT-35). VT-27 and VT-28 are two of five primary training squadrons within CNATRA (the other three are located at NAS Whiting Field in Milton, Florida). They fly the T-6B Texan II training aircraft. VT-31 and VT-35 provide advanced multi-engine training in the T-44C Pegasus (CNATRA n.d.[a]). VT-31 is also responsible for intermediate phase flight training for future E-2C Hawkeye and C-2A Greyhound pilots. VT-35 was established as a Joint Advanced Multi-Engine Training Squadron in October 1999. Presently, TW-4 trains 600 new qualified aviators each year (CNATRA n.d.[a]).

1.7 LOCAL ECONOMIC IMPACTS AND POPULATION GROWTH

The military provides direct, indirect, and induced economic benefits to the regional and local communities where they are located through jobs and wages, regional sales and production, and contracts (expenditures). Benefits include employment opportunities and increases in local business revenue, property sales, and tax revenue. The military creates a stable and consistent source of revenue for surrounding communities. Working to achieve compatibility with local development and activities, NASCC continues to ensure the viability of their installation and their positive impact on local communities and the surrounding region.

NASCC is the largest employer in Corpus Christi and Nueces County, employing approximately 9,800 military, civilian, and contract personnel and creating $3.62 billion in economic impact to Texas. This results in a gross domestic product of $2.24 billion and $1.47 billion in personal disposable income for the state.

Corpus Christi is the eighth largest city in Texas with a population of 326,554 (a 7 percent increase from 2010). Corpus Christi comprises 90 percent of the total population of Nueces County. Nueces County has a population of 362,295 and experienced a 6.5 percent growth rate between 2010 and 2018. The median income of Corpus Christi and Nueces County are $55,709 and $55,048, per year, respectively, with a poverty rate of approximately 16 percent (U.S. Census Bureau 2019).

Texas is the second most populous state in the United States with a population of 28.7 million in 2018, an increase of 15.3 percent from 25 million in 2010 (U.S. Census Bureau 2019). The population is projected to grow significantly over the following decades. According to the Texas Demographic Center, by 2030, the population of Texas is projected to grow to 35 million and, by 2050, the population will grow to over 47 million (Office of the Texas Governor 2017).

2

AIRCRAFT OPERATIONS

This chapter of the AICUZ Study discusses aircraft types and aircraft operations at NOLF Cabaniss and NOLF Waldron, including based aircraft, flight operations, airspace, and flight track use and procedures.

2.1 AIRFIELDS

The following sections present the general airfield features of NOLF Cabaniss and NOLF Waldron, including runways, operating hours, and other features.

2.1.1 NOLF CABANISS

NOLF Cabaniss is a 971-acre training airfield for visual flight rules (VFR) touch-and-go practice for the T-44C aircraft in support of TW-4 pilot training operations at NASCC. No aircraft are permanently staged at the airfield. As previously stated, the airfield is located in the southside area of Corpus Christi, approximately 8.6 miles west of the main airfield, Truax Field (Figure 1-1).

NOLF Cabaniss has two runways, 13/31 and 18/36. Runway 13/31 is 5,000 feet long and 150 feet wide. Runway 18/36 is also 5,000 feet long and 150 feet wide, however a displaced threshold on Runway 18 results in a landing length of approximately 4,500 feet (NASCC 2019). The primary runway is Runway 13 and supports a majority of aircraft operations. The airfield's elevation is approximately 31 feet above mean sea level. The runways at NOLF Cabaniss are Class A runways. Figure 2-1 illustrates the airfield layout and surrounding area.

The airfield's normal hours of operation are Monday through Thursday from 0800 to 2300 and Friday from 0800 to 1900 (all times Central). NOLF Cabaniss is closed Saturday, Sunday, and all federal holidays (NASCC 2019).

2.1.2 NOLF WALDRON

NOLF Waldron is an 851-acre training airfield for VFR touch-and-go practice for the T-6B aircraft in support of TW-4 pilot training operations at NASCC. No aircraft are permanently staged at the airfield. As previously stated, the airfield is located in the Flour Bluff area of Corpus Christi on the Encinal Peninsula, approximately 4 miles southwest of the main airfield, Truax Field (Figure 1-1).

NOLF Waldron has two runways, 13/31 and 18/36. Runway 13/31 is 5,000 feet long and 200 feet wide, and runway 18/36 is also 5,000 feet long and 200 feet wide (NASCC 2019). The primary runway is Runway 13 and supports a majority of aircraft operations. The airfield's elevation is approximately 25 feet above mean sea level. The runways at NOLF Waldron are Class A runways. NOLF Waldron utilizes the Basic Training Outlying fields (T-34) criteria based on a permanent waiver from the Naval Air Systems Command. Figure 2-2 illustrates the airfield layout and surrounding area.

Monday through Thursday, the airfield's normal hours of operation are based on the hours of Truax Field (0700 to 2300), opening 30 minutes after Truax Field is open and closing at sunset. On Friday, the airfield opens 30 minutes after Truax Field opens, and closes at 1900 or sunset, whichever occurs first. NOLF Waldron is closed Saturday, Sunday, and all federal holidays (NASCC 2019).

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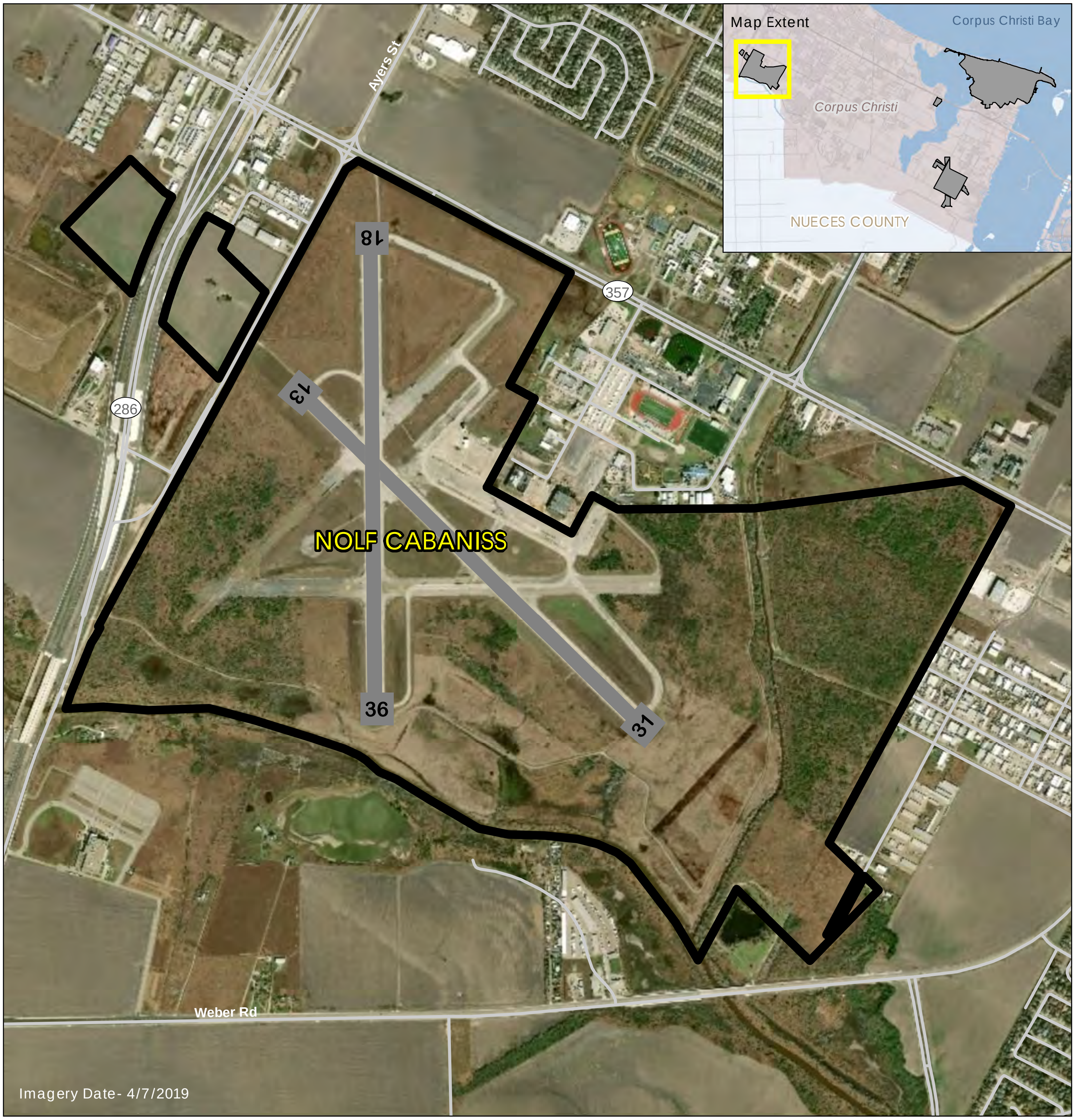

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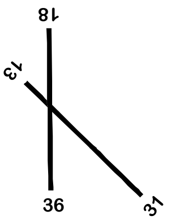
SCALE

0 2,000 Feet



Legend

▭ NOLF Cabaniss

▬ Runway

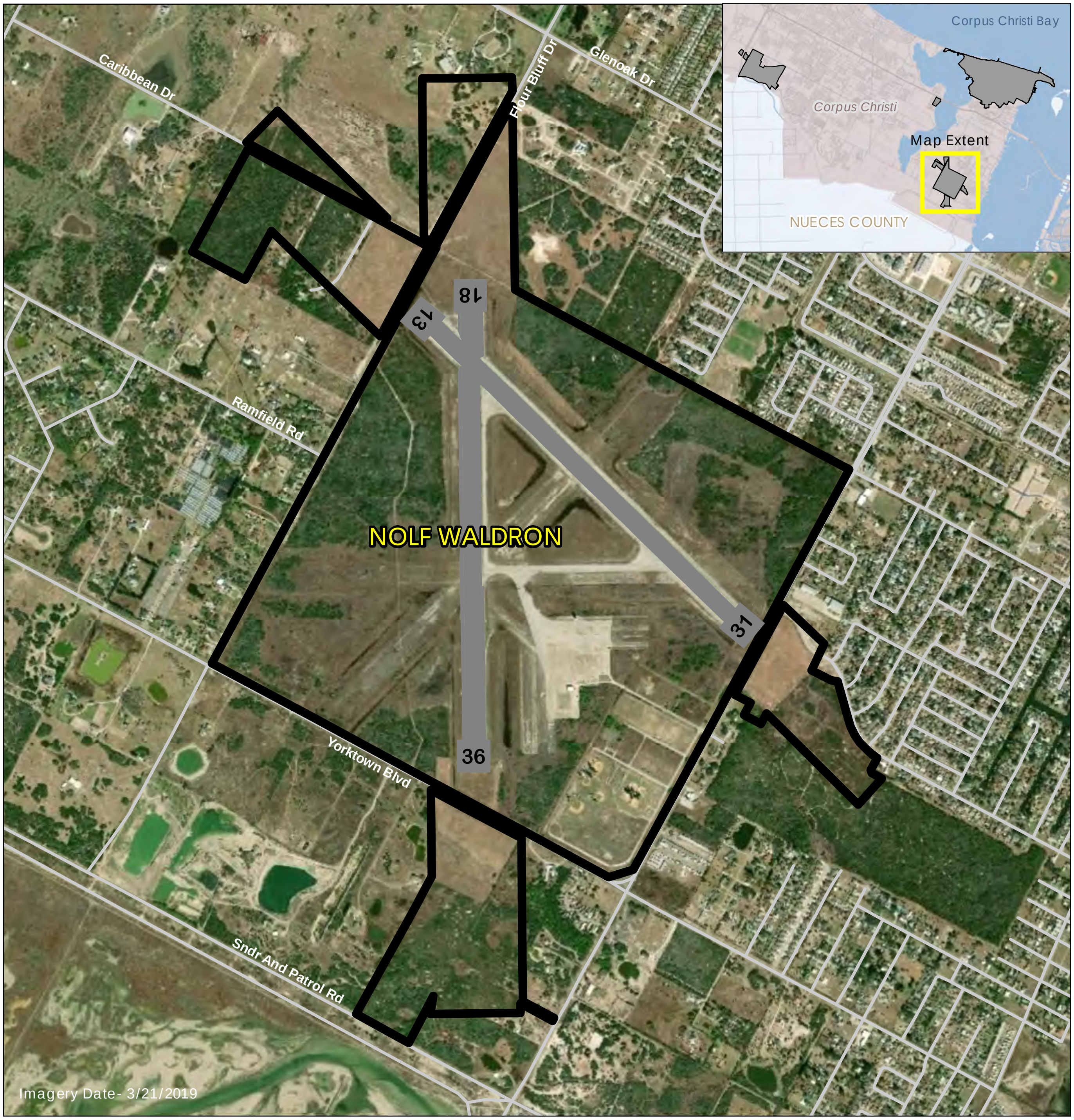
⁄\ Road

Figure 2-1
NOLF Cabaniss

Naval Air Station
Corpus Christi, Texas

Source: ESRI 2018; Navy, 2020
Ecology and Environment, Inc. 2020

Path: L:\Buffalo\CorpusChristi_AICUZ\MAPS\MXDs\Report_AICUZ\Spring_2020\Figure 2-2.mxd 5/8/2020



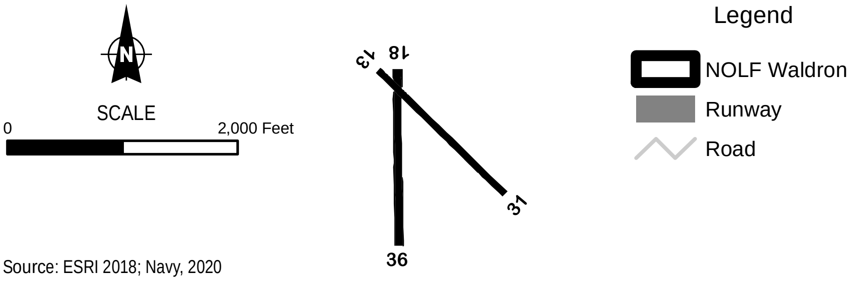


Figure 2-2
NOLF Waldron

Naval Air Station
Corpus Christi, Texas

Source: ESRI 2018; Navy, 2020
Ecology and Environment, Inc. 2020

2.2 AIRCRAFT TYPES

NOLF Cabaniss and NOLF Waldron both support only fixed-wing operations. No rotary-wing operations are conducted at either of these airfields. Additionally, no aircraft are stationed permanently at NOLF Cabaniss nor NOLF Waldron. Transient aircraft rarely conduct operations at NASCC and no transient aircraft visit NOLF Cabaniss or NOLF Waldron.

2.2.1 T-6 "TEXAN II"

The T-6 is a single-engine, tandem seat training aircraft utilized for both day or night VFR or instrument flight rules flight operations. A Pratt & Whitney PT6A-68 free-turbine turboprop engine powers the aircraft. The T-6 has a length of 33.4 feet, a height of 10.8 feet, and a wingspan of 33.5 feet (CNATRA n.d.[b]). Pilots from NASCC fly the T-6B variant of the "Texan II," which has upgraded avionics. The T-6B aircraft is utilized at NOLF Waldron.

2.2.2 T-44 "PEGASUS"

The T-44 is a twin-engine, pressurized aircraft utilized for advanced multi-engine training and intermediate carrier-based turboprop aircraft training at NASCC. Two 550 shaft horsepower PT6A-34B turboprop engines, manufactured by Pratt & Whitney, power the aircraft. The T-44 has a length of 35.6 feet, a height of 14.3 feet, and a wingspan of 50.3 feet. The aircraft has a maximum range of 1,625 nautical miles and can reach a maximum airspeed of 250 knots (CNATRA n.d.[c]). The T-44C aircraft is utilized at NOLF Cabaniss.

2.2.3 T-45 "GOSHAWK"

The T-45 aircraft is used for intermediate and advanced portions of the Navy pilot and navigator training program for jet carrier aviation and tactical strike missions. There are two versions of the T-45 aircraft currently in operational use at this time, the T-45A and T-45C derivatives. The T-45A replaced the T-2 Buckeye trainer and the TA-4 trainer with an integrated training system that includes the T-45A Goshawk aircraft, operations and instrument fighter simulators, academics, and a training integration system. The T-45 Service Life Expectancy Program (SLEP) will be conducted at NASCC for a period of 8 to 10 years. It will consist of complete maintenance overhaul of aircraft and Functional Check Flights (FCF) in and out of NASCC.

2.3 ENGINE MAINTENANCE RUN-UP OPERATIONS

No pre-flight or engine maintenance run-up operations are performed at NOLF Cabaniss or NOLF Waldron; therefore, these airfields do not have designated run-up locations. Run-up locations are designated areas at an airfield where pilots or mechanics can conduct last minute engine checks without obstructing ground traffic.

2.4 FLIGHT OPERATIONS

As a planning document, the AICUZ Study forecasts aircraft operations out 10 to 15 years into the future on a similar planning horizon that local governments use in their planning documents. Therefore, projected operations are incorporated into this 2020 AICUZ Study.

A flight operation refers to any occurrence of an aircraft taking off or landing on the runway at an airfield. A common example of a takeoff operation is a departure of an aircraft to another location; a landing operation is an aircraft arrival from another location to the airfield. Additionally, a takeoff and landing may be part of a training maneuver or pattern (e.g., touch-and-go), which includes a takeoff and landing back to the same runway. These patterns are considered two separate operations because the departure and arrival each count as a single operation. Typical flight operations at NASCC include:

- **Departure:** An aircraft takes off to leave the installation/airfield or as part of a training maneuver.
- **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.
- **Overhead Break Arrival:** An expeditious arrival wherein an aircraft approaches the runway 200 feet above the altitude of the landing pattern, and 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.
- **Pattern Work:** Refers to traffic pattern training where the pilot performs takeoffs and landings in quick succession by taking off, flying the pattern, and then landing. Traffic pattern training is demanding and utilizes all the basic flying maneuvers a pilot learns: takeoffs, climbs, turns, climbing turns, descents, descending turns, and straight and level landings. Specific types of pattern work include:
    - Touch-and-Go: An aircraft lands and takes off on a runway without coming to a full stop. After touching down, the pilot immediately accelerates to takeoff power and takes off again. A touch-and-go pattern is counted as two operations—the landing counts as one operation, and the takeoff as another.
    - Low Approach: An approach to a runway during which the pilot does not make contact with the runway.

Each airfield has designated runways with designated flight procedures that provide for safety, consistency, and control of an airfield. A flight track is the route an aircraft follows while conducting an operation at the airfield, between airfields, or to/from a military operations area, and demonstrates how the aircraft will fly in relation to the airfield.

Flight tracks are graphically represented as single lines, but how closely an aircraft flies to the specified track can vary due to aircraft performance, pilot technique, and weather conditions, such that the actual flight track could be considered a band or corridor varying from a few hundred feet to several miles wide. Flight tracks are typical or average representations based on pilot and Air Traffic Control (ATC) input. Specific flight tracks for both NOLF Cabaniss and NOLF Waldron are further discussed in Sections 2.4.1, NOLF Cabaniss Annual Operations, and 2.4.2, NOLF Waldron Annual Operations, respectively.

2.4.1 NOLF CABANISS ANNUAL OPERATIONS

"Annual operations" describe all aircraft operations that occur at NOLF Cabaniss during a calendar year, including based and transient aircraft (no transient aircraft currently operate at NOLF Cabaniss). As described previously, total annual operations account for each arrival and departure, including those conducted as part of a pattern operation. Aircraft operations are tracked using systems maintained by ATC personnel. For this 2020 AICUZ Study, the operational data were gathered and validated. For planning purposes, a 50 percent increase in the operation counts was factored in to account for possible increases in pilot training requirements or potential additional aircraft. The operational data are projected into the future in a similar planning horizon to that of local governments and their planning documents. This AICUZ Study describes how operational information was gathered and provides a concise interpretation of operations data for the 2009 and the 2020 AICUZ.

2009 AICUZ STUDY

The operational tempo has fluctuated over time because of changes in mission and utilized aircraft. As missions change, so do training requirements, which change the amount and type of operations flown and flight tracks utilized. The 109,050 annual operations, as presented in the 2009 AICUZ (see Table 2-1), are attributed to the variety of mission operations and aircraft that were at the airfield during calendar year 2009. The T-44C operations were derived from a 5-year average of operations at NOLF Cabaniss between 2004 and 2008. Additionally, the 2009 AICUZ included the VT-35 squadron utilizing the UC-12 aircraft at NOLF Cabaniss. The VT-35 squadron is no longer flying the UC-12 aircraft and has no operations at NOLF Cabaniss.

2020 AICUZ STUDY

AICUZ studies account for future missions and operations. The 84,018 total annual operations presented in this AICUZ Study (see Table 2-1) reflect current operations and projected future operational increases through the year 2030. A 50 percent increase in the operation counts was factored in to account for possible increases in pilot training requirements associated with new or additional aircraft. It is reasonably foreseeable that the T-44C aircraft could be replaced during the 10-year planning horizon. As shown in Table 2-1, total projected annual operations have decreased by 25,032 when compared with the 2009 operations. Table 2-2 details the differences in projected operations by aircraft type between 2009 and 2020.

The primary factors attributed to the decrease in operations are the reduction in pattern operations flown at the airfield and the removal of the UC-12 aircraft at NOLF Cabaniss. Since the 2009 AICUZ Study, pattern operations decreased by approximately 22,610 operations annually.

TABLE 2-1 COMPARISON OF ANNUAL OPERATIONS BY OPERATION TYPE AT NOLF CABANISS

Operation Type[1]	2009 AICUZ[2]	2020 AICUZ[3]
Arrivals	3,422	2,211
Departures	3,422	2,211
Pattern Operations	102,206	79,596
GRAND TOTAL	**109,050**	**84,018**

Sources: Navy 2009; BRRC 2020

Notes:

[1] No operations are currently conducted between 2200–0700 hours (acoustic nighttime), nor were they in 2009.

[2] Includes 564 total operations from the UC-12 aircraft.

[3] Totals reflect the 50 percent increase in 2020 operations to reflect possible increases in future operations.

TABLE 2-2 COMPARISON OF ANNUAL OPERATIONS BY AIRCRAFT TYPE AT NOLF CABANISS

Aircraft Type	2009 AICUZ	2020 AICUZ[1]
T-44C	108,486	84,018
UC-12	564	0
GRAND TOTAL	**109,050**	**84,018**

Sources: Navy 2009; BRRC 2020

Notes:

[1] Totals reflect the 50 percent increase in 2020 operations to reflect possible increases in future operations.

2.4.2 NOLF WALDRON ANNUAL OPERATIONS

"Annual operations" describe all aircraft operations that occur at NOLF Waldron during a calendar year, including based and transient aircraft (no transient aircraft currently operate at NOLF Waldron). Section 2.4.1, NOLF Cabaniss Annual Operations, details the various factors included in developing the noise contours and APZs. For NOLF Waldron, in this 2020 AICUZ Study, the operational data were gathered and validated from the 2018 Final EA for Providing Outlying Field Capabilities to Support T-6 Undergraduate Pilot Training. The operational data are projected into the future through 2030, in a similar planning horizon to that of local governments and their planning documents.

2009 AICUZ STUDY

Similar to NOLF Cabaniss, the 2009 AICUZ had 185,196 annual operations (see Table 2-3), which were attributed to the variety of mission operations and aircraft that were at the airfield during calendar year 2009. The 2009 AICUZ Study used modeled operations for NOLF Waldron to account for projected conditions and the replacement of the T-34C aircraft operations with T-6B aircraft operations. Under the conditions presented in the 2009 AICUZ Study, an estimated 80 percent of T-6B OLF operations would be conducted at NOLF Waldron.

2020 AICUZ

Modeled flight operations for this AICUZ are derived from the 2018 EA for Providing Outlying Field Capabilities to Support T-6 Undergraduate Pilot Training. For the noise study produced for this EA, the Navy determined that the maximum capacity of T-6B flight training operations at NOLF Waldron is 250,000 annual airfield operations. The EA was produced to meet the future needs of TRAWING FOUR and their NOLF capacity and support infrastructure. As shown in Table 2-3, operations will increase by 64,804 total operations from the previous counts. Table 2-4 details the differences in operations by aircraft type between 2009 and 2020.

TABLE 2-3 COMPARISON OF ANNUAL OPERATIONS BY OPERATION TYPE AT NOLF WALDRON

Operation Type[1]	2009 AICUZ[2]	2020 AICUZ[3]
Arrivals	12,198	10,417
Departures	12,198	10,417
Pattern Operations	160,800	229,166
GRAND TOTAL	**185,196**	**250,000**

Sources: Navy 2009; BRRC 2017
Notes:
[1] No operations are currently conducted between 2200–0700 hours (acoustic nighttime), nor were they in 2009.
[2] Includes 564 total operations from the UC-12 aircraft.
[3] Based off of the 2018 EA.

TABLE 2-4 COMPARISON OF ANNUAL OPERATIONS BY AIRCRAFT TYPE AT NOLF WALDRON

Aircraft Type	2009 AICUZ	2020 AICUZ[1]
T-6B	185,196	250,000
GRAND TOTAL	**185,196**	**250,000**

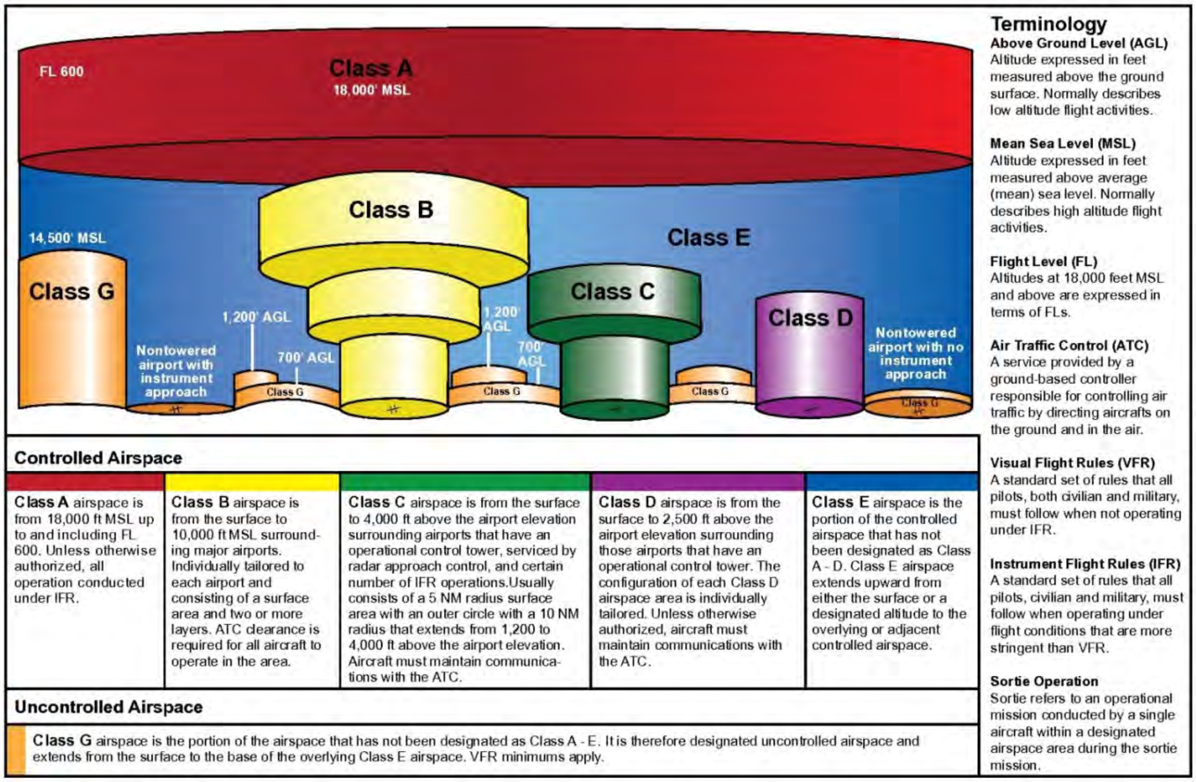
Sources: Navy 2009; BRRC 2020
Notes:
[1] Based off of the 2018 EA.

2.5 AIRSPACE

The FAA, which manages the National Airspace System, approves the use of airspace over NOLF Cabaniss and NOLF Waldron. The National Airspace System seeks to ensure the safe, orderly, and efficient flow of commercial, private, and military aircraft.

There are two categories of airspace: regulatory and non-regulatory. Within these two categories, there are four types of airspace: controlled, uncontrolled, special use, and other airspace. Controlled airspace—designated Class A through Class E—includes the airspace within which ATC clearance is required or must maintain two-way radio communication with the ATC facility within the airspace. Uncontrolled airspace is the portion of the airspace not designated as Class A through Class E within which ATC has no authority or responsibility to control air traffic. (FAA 2020) (Figure 2-3).

FIGURE 2-3 GENERAL AIRSPACE CLASSIFICATIONS



Controlled Airspace

Class A airspace is from 18,000 ft MSL up to and including FL 600. Unless otherwise authorized, all operation conducted under IFR.	**Class B** airspace is from the surface to 10,000 ft MSL surrounding major airports. Individually tailored to each airport and consisting of a surface area and two or more layers. ATC clearance is required for all aircraft to operate in the area.	**Class C** airspace is from the surface to 4,000 ft above the airport elevation surrounding airports that have an operational control tower, serviced by radar approach control, and certain number of IFR operations.Usually consists of a 5 NM radius surface area with an outer circle with a 10 NM radius that extends from 1,200 to 4,000 ft above the airport elevation. Aircraft must maintain communications with the ATC.	**Class D** airspace is from the surface to 2,500 ft above the airport elevation surrounding those airports that have an operational control tower. The configuration of each Class D airspace area is individually tailored. Unless otherwise authorized, aircraft must maintain communications with the ATC.	**Class E** airspace is the portion of the controlled airspace that has not been designated as Class A - D. Class E airspace extends upward from either the surface or a designated altitude to the overlying or adjacent controlled airspace.

Uncontrolled Airspace

Class G airspace is the portion of the airspace that has not been designated as Class A - E. It is therefore designated uncontrolled airspace and extends from the surface to the base of the overlying Class E airspace. VFR minimums apply.

Terminology

Above Ground Level (AGL)
Altitude expressed in feet measured above the ground surface. Normally describes low altitude flight activities.

Mean Sea Level (MSL)
Altitude expressed in feet measured above average (mean) sea level. Normally describes high altitude flight activities.

Flight Level (FL)
Altitudes at 18,000 feet MSL and above are expressed in terms of FLs.

Air Traffic Control (ATC)
A service provided by a ground-based controller responsible for controlling air traffic by directing aircrafts on the ground and in the air.

Visual Flight Rules (VFR)
A standard set of rules that all pilots, both civilian and military, must follow when not operating under IFR.

Instrument Flight Rules (IFR)
A standard set of rules that all pilots, civilian and military, must follow when operating under flight conditions that are more stringent than VFR.

Sortie Operation
Sortie refers to an operational mission conducted by a single aircraft within a designated airspace area during the sortie mission.

NOLF Cabaniss and NOLF Waldron airspaces are classified as Class D airspace (Figure 2-4). Class D airspace generally extends from the surface to 2,500 feet above ground level surrounding those airports that have an operational control tower. Each aircraft must establish two-way radio communication with the air traffic controller prior to entering the airspace and maintain communication while flying within the airspace. VFR arrivals must contact Corpus Christi Approach prior to entering the Class D airspace for radar services and sequencing over the appropriate VFR entry points.

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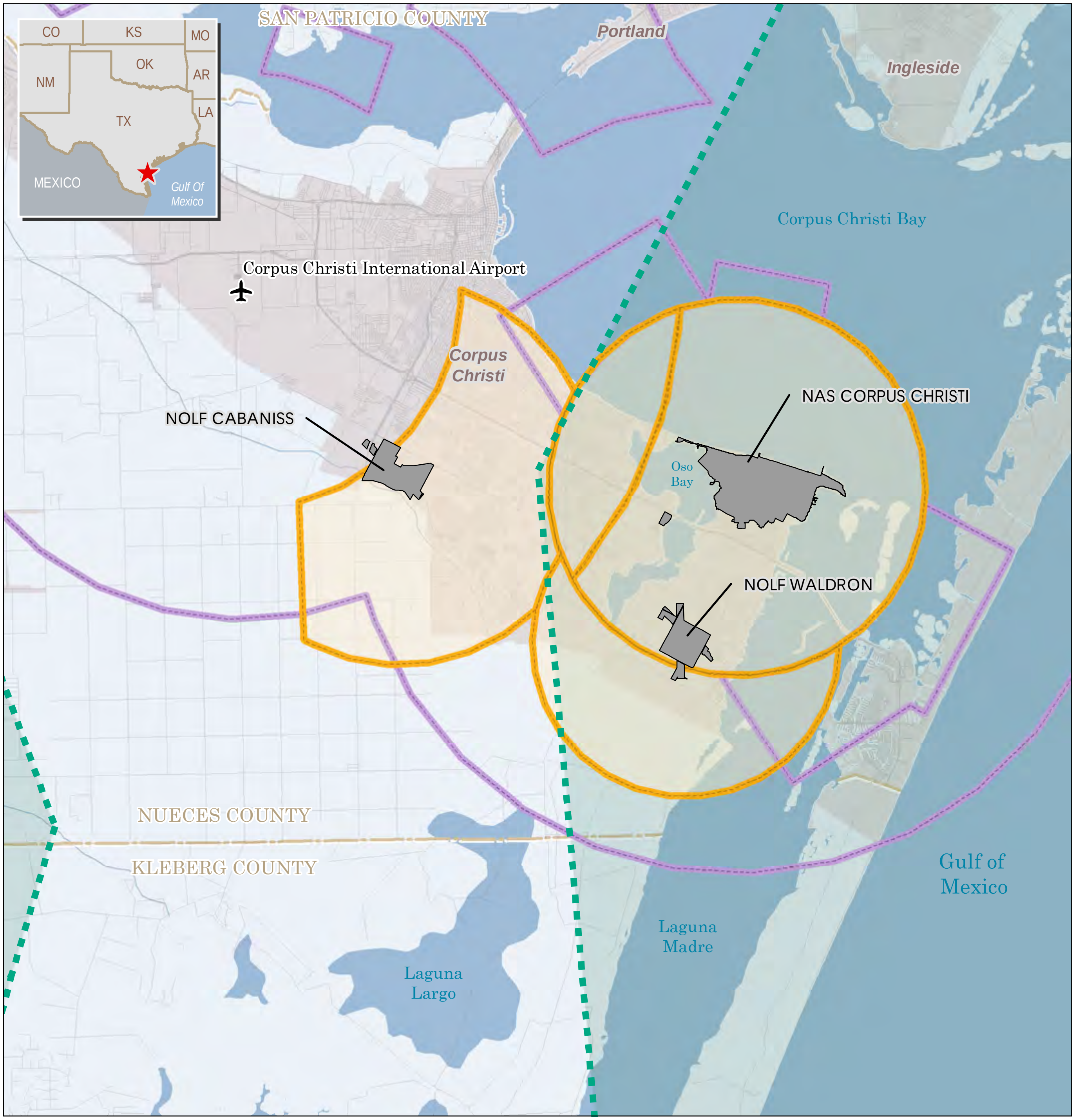

Figure 2-4
Regional Airspace

Naval Air Station
Corpus Christi, Texas

Source: ESRI 2018; Navy, 2020 Ecology and Environment, Inc. 2020, FAA 2016

2.6 RUNWAY AND FLIGHT TRACK UTILIZATION

All aircraft operating at NOLF Cabaniss and NOLF Waldron follow the course rules in the NASCC Air Operations Manual, which sets runway use, sets the course rules for the airfield, and establishes the patterns and procedures for aircraft movement. As discussed in Section 2.4, Flight Operations, flight tracks are the general paths aircraft fly while conducting missions or operations. The following factors determine flight track utilization: operations performed, runway utilized for the operation, and flight track followed to conduct the operation. Flight tracks are nominal representations (often a few hundred feet to several miles wide) depicting an aircraft's typical route. Flight tracks demonstrate how and where aircraft fly in relation to an airfield and provide safety, consistency, and control of an airfield. The 2009 AICUZ Study noise modeling files served as a baseline for the flight tracks and utilization data for NOLF Cabaniss, and were then verified and updated. The flight tracks and utilization data for NOLF Waldron were gathered and validated from the 2018 EA for Providing Outlying Field Capabilities to Support T-6 Undergraduate Pilot Training. These sources were utilized in this AICUZ Study to inform the flight operation counts of aircraft flights for the 2009 study and planning operations. The effect of flight track utilization on noise contours is presented in Chapter 3, Aircraft Noise; the association between flight tracks and APZs is included in Chapter 4, Airfield Safety.

The NOLF Cabaniss airfield is comprised of two asphalt runways: Runways 13/31 and 18/36. The changes in runway utilization from the 2009 AICUZ to 2020 levels are shown in Table 2-5. Historically, Runway 13 has been and continues to be the most active runway and was used 70 percent of the time at the time of the 2009 AICUZ and 62 percent of the time during this AICUZ Study. Figure 2-5 illustrates the representative flight tracks for NOLF Cabaniss, including arrivals, closed patterns, and interfacility departures.

TABLE 2-5 CHANGES IN RUNWAY UTILIZATION AT NOLF CABANISS

Runway	Percent Utilization	
	2009 AICUZ	2020 AICUZ
13	70	62
31	15	4
18	10	17
36	5	17

Sources: Navy 2009; BRRC 2020

The NOLF Waldron airfield is comprised of two asphalt runways: Runways 13/31 and 18/36. The changes in runway utilization from the 2009 AICUZ to 2020 levels are shown in Table 2-6. Historically, Runway 13 has been and continues to be the most active runway and was used 83 percent of the time at the time of the 2009 AICUZ and 70 percent of the time during this AICUZ Study. Figure 2-6 illustrates the representative flight tracks for NOLF Waldron, including arrivals, closed patterns, and interfacility departures.

TABLE 2-6 CHANGES IN RUNWAY UTILIZATION AT NOLF WALDRON

Runway	Percent Utilization	
	2009 AICUZ	2020 AICUZ
13	83	70
31	12	5
18	3	5
36	2	20

Sources: Navy 2009; Navy 2018

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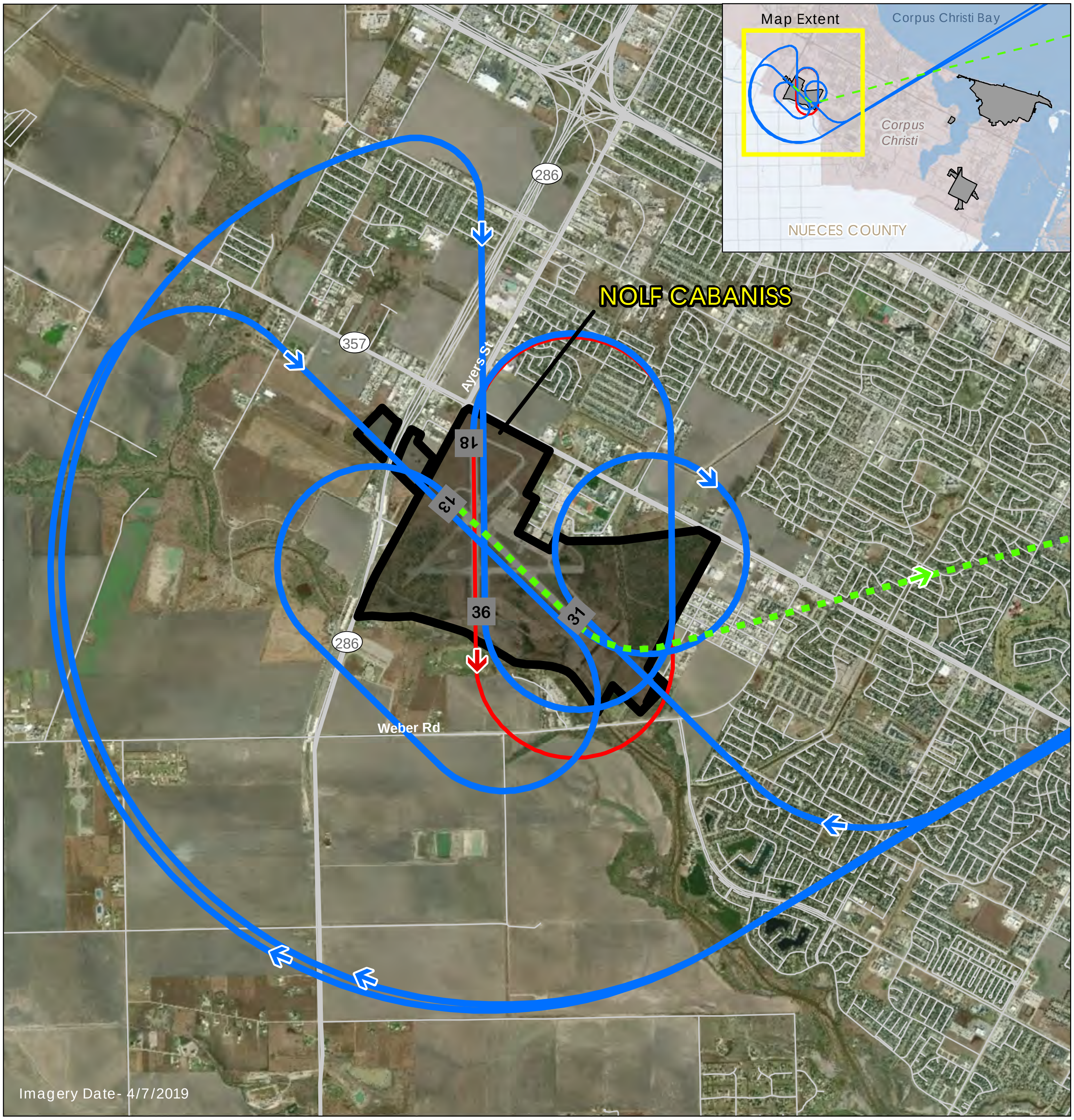

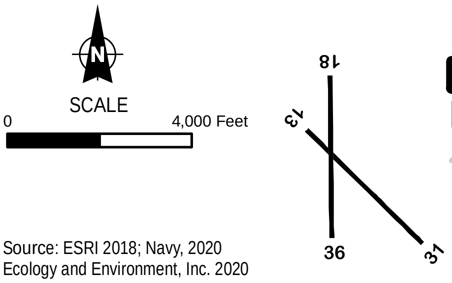

Legend

▭	NOLF Cabaniss	🟦	Arrival
▩	Runway	🟥	Closed Pattern
⁄	Road	◆◆	Interfacility Departure

Source: ESRI 2018; Navy, 2020
Ecology and Environment, Inc. 2020

Figure 2-5
Representative Flight Tracks, NOLF Cabaniss

Naval Air Station
Corpus Christi, Texas

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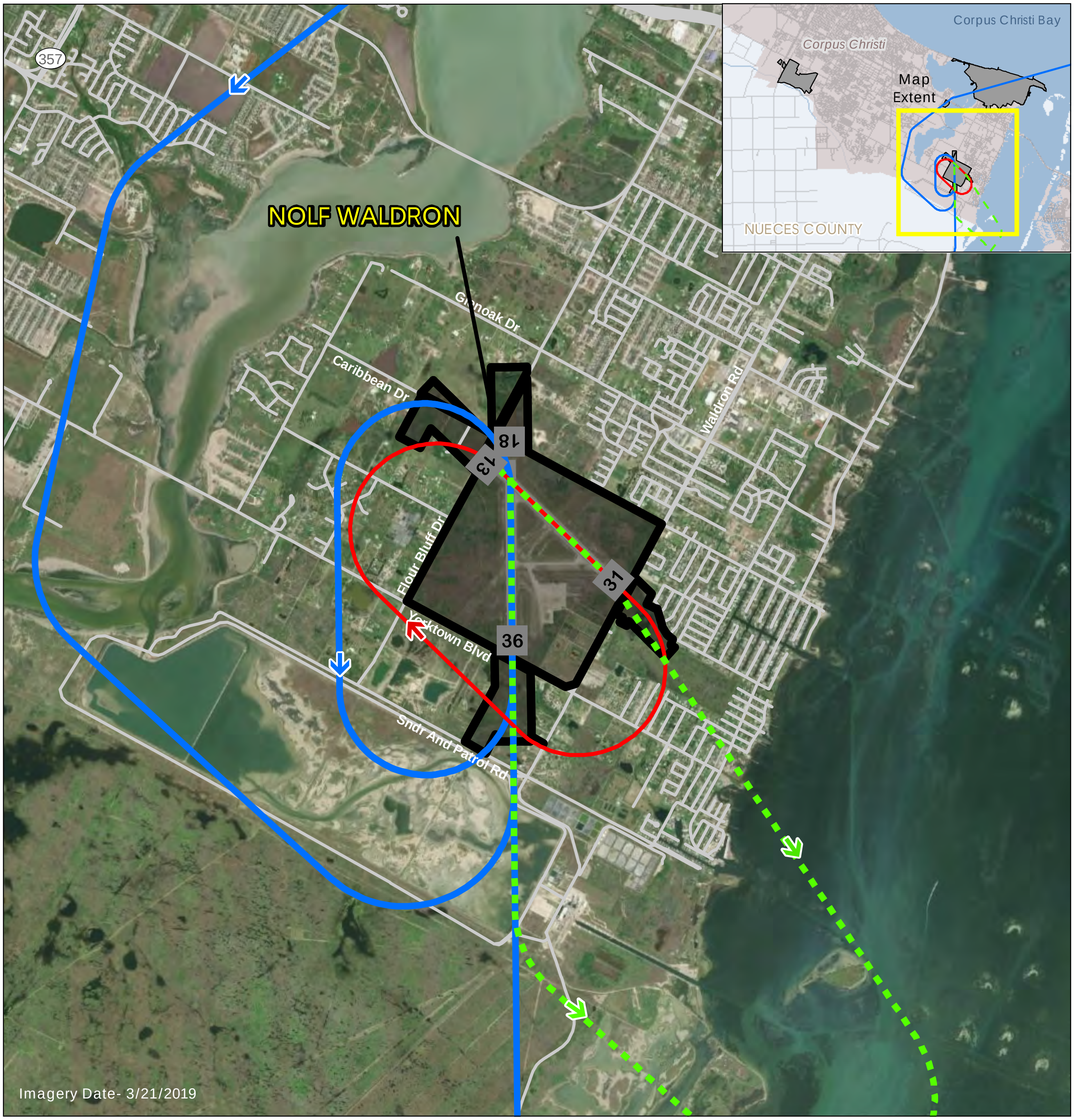
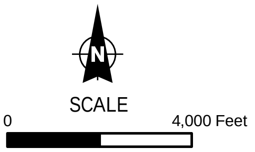
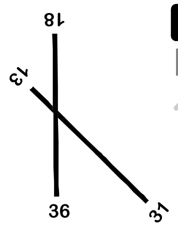






Legend

- ▭ NOLF Waldron
- ▆ Runway
- ∧ Road
- ∧ Arrival
- ∧ Closed Pattern
- ◆ Interfacility Departure

Figure 2-6
Representative Flight Tracks, NOLF Waldron

Naval Air Station
Corpus Christi, Texas

Source: ESRI 2018; Navy, 2020
Ecology and Environment, Inc. 2020

3

AIRCRAFT NOISE

Aircraft noise can play a key role in shaping an installation's relationship with an adjacent community. Aircraft noise is also a factor in local land use planning. Because noise from aircraft operations could have an impact on areas near NASCC's NOLFs, the Navy has analyzed the noise resulting from aircraft and has established noise contours around the installation using the guidance provided in the AICUZ Instruction. Noise contours provide communities and planning organizations with information to better plan for development near airfields. The noise contours developed for this AICUZ Study represent the noise generated by aircraft, based on aircraft type, aircraft operations, and the time of day aircraft are flown. This chapter discusses noise associated with aircraft operations, including average noise levels, noise abatement/flight procedures, noise complaints, sources of noise, airfield-specific noise contours, and analysis of changes from the 2009 AICUZ and the 2020 AICUZ (projected)noise contours. The 2020 AICUZ noise contours for NOLF Cabaniss and NOLF Waldron are presented in the following sections along with detailed descriptions of the noise environments for the NOLFs. Also provided are comparisons and figure overlays of the 2009 AICUZ Study and the 2020 AICUZ Study noise contours.

3.1 NOISE METRICS

Sound is vibrations in the air that multiple sources can generate. When sound is invasive or unwanted, it is often considered noise. Generally, sound becomes noise to a listener when it interferes with normal activities. Common sources of noise include roadway traffic, recreational activities, railway activities, and aircraft operations. For further discussion of noise and its effect on people and the environment, see Appendix A. In this AICUZ Study, all sound or noise levels are measured in A-weighted decibels (dBA), which represent sound pressure adjusted to better represent human hearing response. Humans are most sensitive to sound frequencies within the range of human speech and less sensitive to lower and higher frequencies. The A-weighted scale emphasizes those mid-range frequencies while de-emphasizing the remaining frequencies.

On an A-weighted scale, barely audible sound is just above 0 dB, and normal speech has a sound level of approximately 60 to 65 dB. Generally, a sound level above 120 dB will cause discomfort to a listener, and the threshold of pain is 140 dB (Berglund and Lindvall 1995).

The noise exposure from aircraft at NOLFs Cabaniss and Waldron is measured using the day-night average sound level (DNL) noise metric. The DNL noise metric, established in 1980 by the Federal Interagency Committee on Urban Noise, presents a reliable measure of community sensitivity to aircraft noise and has become the standard metric used in the United States. DNL averages the sound energy from aircraft operations at a location over a 24-hour period. DNL also adds an additional 10 dB to events occurring during acoustic nighttime hours (between 10:00 p.m. and 7:00 a.m.). These decibel (dB) adjustments represent the added intrusiveness of sounds due to increased sensitivity to noise when ambient sound levels are low.

Typical A-Weighted Sound Levels and Common Sounds

0 dB – Threshold of Hearing
20 dB – Ticking Watch
45 dB – Bird Calls (distant)
60 dB – Normal Conversation
70 dB – Vacuum Cleaner (3 ft)
80 dB – Alarm Clock (2 ft)
90 dB – Motorcycle (25 ft)
100 dB – Ambulance Siren (100 ft)
110 dB – Chain Saw
120 dB – Rock Concert
130 dB – Jackhammer
140 dB – Threshold of Pain

DNL provides a single measure of overall noise impact by combining disparate noise events (e.g., brief events with high noise levels, longer duration events at lower noise levels, and events occurring during different times of day which are more likely to disturb people in the community). Scientific studies and social surveys conducted to evaluate community annoyance with all types of environmental noise have found DNL to be the best measures available for predicting community annoyance (FICUN 1980; 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 DNL of 65 dB could result from only a few noisy events or from a large number of quieter events.

DNL is depicted on a map as a noise contour that connects points of equal noise value. Contours are displayed in 5-dB increments (e.g., 60, 65, 70, 75, 80, and 85 dB DNL). Noise levels inside a contour may be similar to those outside a contour line. Where the contour lines are close together, the change in noise level is greater. Where the lines are far apart, the change in noise level is more gradual. Calculated noise contours do not represent exact measurements and are discussed further in Section 3.4, Noise Complaints and Abatement.

For land use planning purposes, the AICUZ Program divides noise exposure into three categories, known as "noise zones," based on DNL measurements:

- Noise Zone 1: <65 dB DNL;
- Noise Zone 2: 65 to <75 dB DNL; and
- Noise Zone 3: Greater than or equal to 75 dB DNL (≥75 dB DNL).

Land use recommendations within these zones are discussed and provided in Section 5.4, Land Use Compatibility Analysis. Noise Zone 1 for this study specifically examines noise that is within 60 to 64 dB DNL. However, per the AICUZ Instruction, Noise Zone 1 is essentially an area of low or no impact and, therefore, there are no recommended land use controls for land use within this area (Appendix B).

3.2 NOISE MODELING AND AIRFIELD NOISE SOURCES

This AICUZ Study presents the 2009 AICUZ and 2020 AICUZ noise contours at NOLF Cabaniss and NOLF Waldron. As part of this AICUZ Study, a noise study was conducted to measure the noise exposure changes at NOLF Cabaniss since the 2009 AICUZ Study. For the noise study, noise contours for aircraft operations occurring at NOLF Cabaniss were developed using NOISEMAP noise modeling software. In support of the 2018 Final EA For Providing Outlying Field Capabilities to Support T-6 Undergraduate Pilot Training, NASCC conducted a noise analysis. The noise environment for this EA was also modeled using NOISEMAP, and is utilized to measure the noise exposure changes at NOLF Waldron.

NOISEMAP is the DOD standard model for assessing noise exposure from military aircraft operations at air installations. NOISEMAP calculates DNL contours resulting from aircraft operations using variables such as aircraft types and aircraft profiles comprised of changing power settings, speeds, and altitudes as aircraft traverse the airspace. The model analyzes all the operational data (types of aircraft, number of operations, flight tracks, altitude, speed of aircraft, engine power settings, and engine maintenance run-ups), environmental data (average humidity and temperature), and surface hardness and terrain. The result of the modeling is noise contours; lines connecting points of equal value. Noise contours generated from this information represent the noise environment and planning contours for NOLFs Cabaniss and Waldron.

3.3 AICUZ NOISE CONTOURS

Noise contours can be mapped to show noise exposure resulting from modeled aircraft operations. Noise contours, when overlaid with local land uses, can assist NASCC, local community planning organizations, and citizens in locating and addressing incompatible land uses and in planning for future development.

The noise contours provided in this AICUZ Study are identified as either 2009 AICUZ or as 2020. The 2020 AICUZ noise contours and operational data used in this AICUZ Study are projected into the future. The operational tempo over time and the projected operations for NOLFs Cabaniss and Waldron are presented in Chapter 2, Aircraft Operations, and detailed in Tables 2-1 through 2-4.

The 2020 AICUZ noise contours for each NOLF are presented in the following sections, along with detailed descriptions of the noise environment. Also provided are comparisons and figure overlays of the 2009 and 2020 noise contours. The comparison identifies changes to noise exposure (based on changes and projected changes in aircraft operations) and allows the identification of incompatible land use and potential recommendations to reduce noise exposure. Land use and recommendations for addressing incompatibility issues within noise contours are provided and discussed in Chapter 5, Land Use Compatibility Analysis, and Chapter 6, Land Use Tools and Recommendations.

3.3.1 NOLF CABANISS 2020 NOISE CONTOURS

As shown on Figure 3-1, the projected noise contours for NOLF Cabaniss do not extend off the base boundary. Noise contours align with the runways and follow the dominate flight tracks for arrivals, departures, and closed patterns at the airfield; noise propagates outward from those paths. The 2020 AICUZ noise contours only include a 60 dB DNL noise contour.

The acreage within the projected noise contours was calculated using geographic information system (GIS) overlay analysis. The total area within the projected noise contours all fall within Noise Zone 1 (<65 dB DNL, specifically 60-64 dB DNL) and totals approximately 15 acres. Noise Zone 1 does not extend outside the boundaries of the airfield.

NOISE GRADIENT AND PROPAGATION

The sound associated with aircraft operations extends beyond the plotted DNL contours. Figure 3-2 provides a DNL color gradient that illustrates how the noise originating at NOLF Cabaniss dissipates into the surrounding communities. The sequence of sound waves propagates through the air. During the propagation, sound waves are reflected, refracted, and attenuated (i.e., weakened) by the density of the air. Therefore, the highest noise levels are concentrated at the source on NOLF Cabaniss and decrease to lower levels farther out off-station and minimally into the City of Corpus Christi. The noise falls within Noise Zone 1 and is primarily concentrated on base.

3.3.2 COMPARISON OF NOISE CONTOURS FOR NOLF CABANISS

A comparison of the 2009 and 2020 noise contours shows some similarities in shape, general location, and DNL levels. The comparison also shows a decrease in overall size and coverage from the 2009 to the 2020 noise contours, as depicted on Figure 3-3. The 2009 AICUZ noise contours at NOLF Cabaniss included 60 dB DNL and 65 dB DNL and did not extend beyond the boundaries of the airfield. There are no longer 65 dB DNL noise contours present at NOLF Cabaniss.

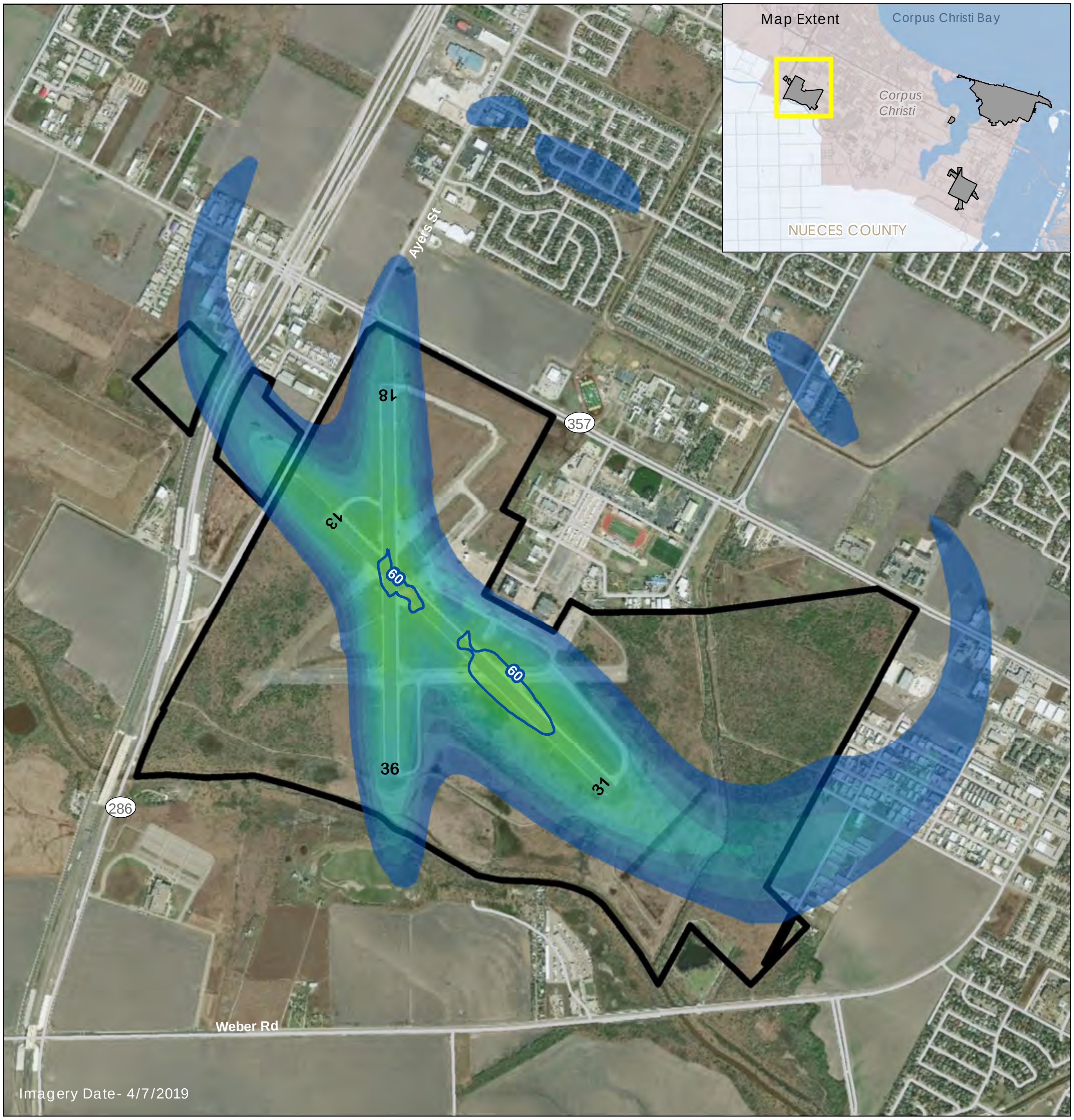
The changes between the 2009 and 2020 noise contours are attributed to the decrease in operations flown at the airfield and the removal of the UC-12 aircraft, which were included in the 2009 AICUZ Study, but are no longer utilized at NOLF Cabaniss.

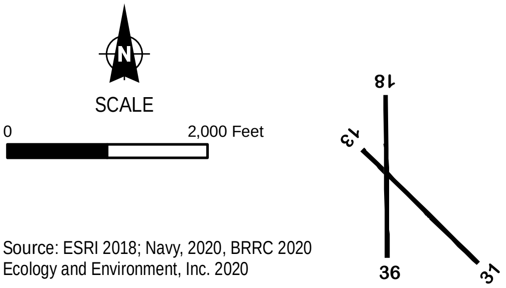
Path: L:\Buffalo\CorpusChristi_AICUZ\MAPS\MXDs\Report_AICUZ\Spring_2020\Figure 3-1.mxd   5/8/2020

Figure 3-1
2020 AICUZ Noise Contours, NOLF Cabaniss

Naval Air Station
Corpus Christi, Texas

Source: ESRI 2018; Navy, 2020, BRRC 2020
Ecology and Environment, Inc. 2020





Legend

- ▭ NOLF Cabaniss
- ▬ Runway
- Road
- 2020 AICUZ Noise Contours (dB)

Noise Gradient (dB)
50
81

Source: ESRI 2018; Navy, 2020, BRRC 2020
Ecology and Environment, Inc. 2020

Figure 3-2
2020 AICUZ Noise Gradient,
NOLF Cabaniss

Naval Air Station
Corpus Christi, Texas

Path: L:\Buffalo\CorpusChristi_AICUZ\MAPS\MXDs\Report_AICUZ\Spring_2020\Figure 3-3.mxd 5/8/2020

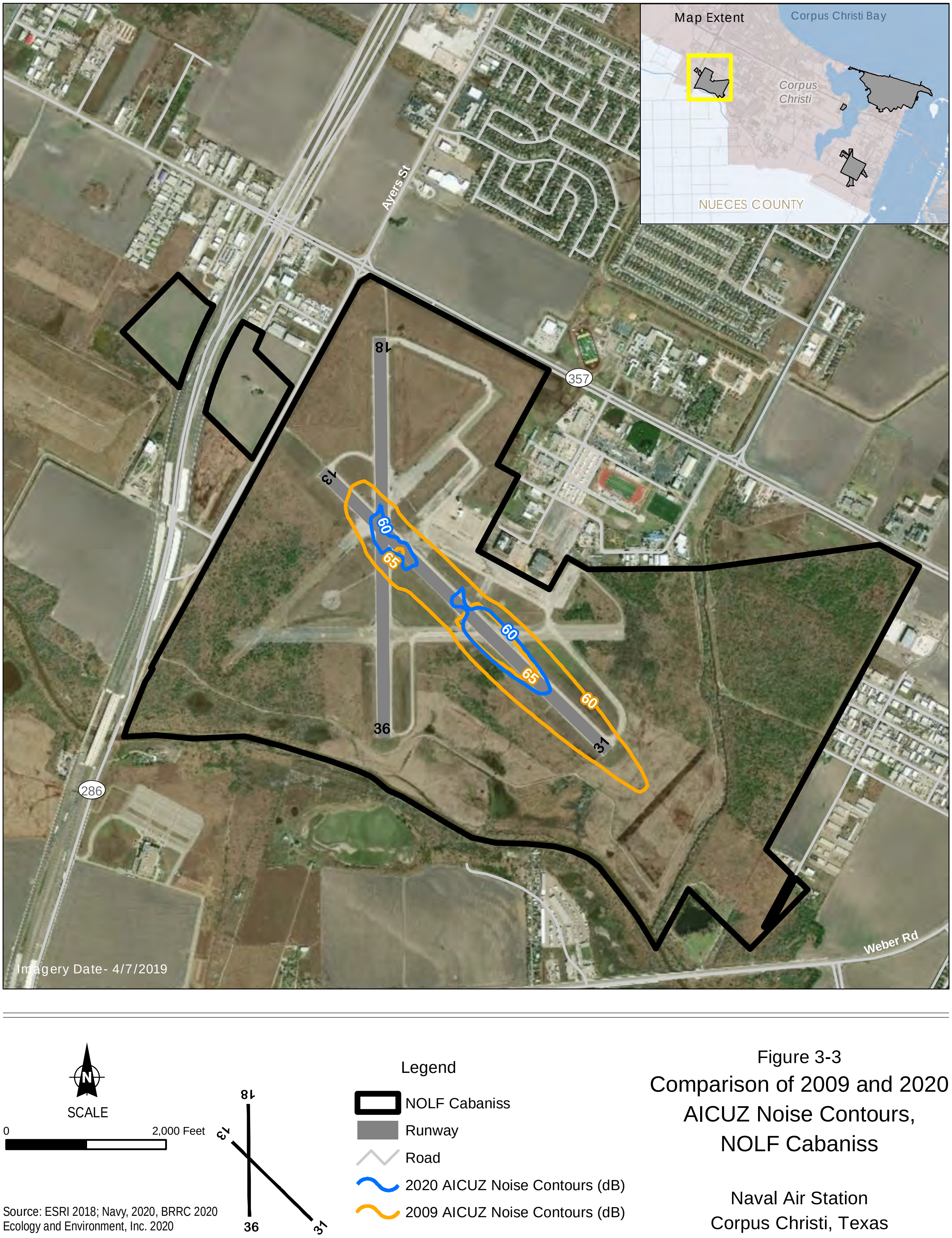


Figure 3-3
Comparison of 2009 and 2020 AICUZ Noise Contours, NOLF Cabaniss

Naval Air Station
Corpus Christi, Texas

Source: ESRI 2018; Navy, 2020, BRRC 2020
Ecology and Environment, Inc. 2020

3.3.3 NOLF WALDRON 2020 NOISE CONTOURS

The 2020 noise contours for NOLF Waldron extend outside of the airfield boundary, mostly to the northwest and southeast (Figure 3-4). The acreage within the projected noise contours was calculated using a GIS overlay analysis and is presented in Table 3-1. To further describe the noise contours, they are divided into two general areas: inside NOLF Waldron's boundary (on-station) and outside the boundary (off-station). The total area within the projected noise contours is approximately 1,352 acres. There are 580 acres of land outside of the airfield boundary that have a DNL between 60 and 64 dB. Within Noise Zone 2 (65-74 dB DNL) there are approximately 27 acres located off-station. No land within Noise Zone 3 (≥75 dB DNL) is outside of NOLF Waldron's boundary.

TABLE 3-1 AREAS WITHIN THE NOISE ZONES AT NOLF WALDRON

	Noise (DNL)	On-station	Off-station	Total Area (Acres)
2020 AICUZ				
Noise Zone 1	60-64	348.45	579.74	928.19
Noise Zone 2	65-69	230.8	27.34	258.14
	70-74	126.24	0.02	126.26
Noise Zone 3	75-80	32.27	0	32.27
	80-84	6.95	0	6.95
	80+	0	0	0
	TOTAL AREA	**744.7**	**607.1**	**1,351.80**

Sources: Navy 2018; BRRC 2020
Note:
Noise contours shown within Noise Zone 1 include only the 60-64 dB DNL for this analysis. Noise Zone 1 is an area of low or no impact. There are no recommended land use controls for Noise Zone 1 and, as a result, it is not included in the Land Use Compatibility Analysis in Section 5.4.1.

NOISE GRADIENT AND PROPAGATION

Similar to NOLF Cabaniss, the sound associated with aircraft operations at NOLF Waldron extends beyond the plotted DNL contours. Figure 3-5 provides a DNL color gradient that illustrates how the noise originating at NOLF Waldron dissipates over the base and the surrounding communities. The highest noise levels are concentrated at the source on NOLF Waldron and decrease to lower levels farther out off-station and into the City of Corpus Christi.

3.3.4 COMPARISON OF NOISE CONTOURS FOR NOLF WALDRON

A comparison of the 2009 and 2020 noise contours shows the shape, general location, and DNL levels of each noise footprint. The comparison also shows a decrease in overall size and coverage from the 2009 to the 2020 noise contours, as depicted on Figure 3-6. The 2009 noise footprint covered 2,403 acres, as compared to 1,352 acres for the 2020 footprint (on- and off-station). There was a decrease of approximately 1,101 acres when comparing off-station impacts for the 2009 footprint (1,707.75 acres) to the 2020 footprint (607.1 acres).

The changes between the 2009 and 2020 noise contours are attributed to the number and types of operations projected to occur. Operational changes due to pattern work are projected to increase in comparison to the 2009 AICUZ Study; however, these operations are flown closer to and more centralized within the base, resulting in flight tracks that are closer to the base boundary and extend less into the community.

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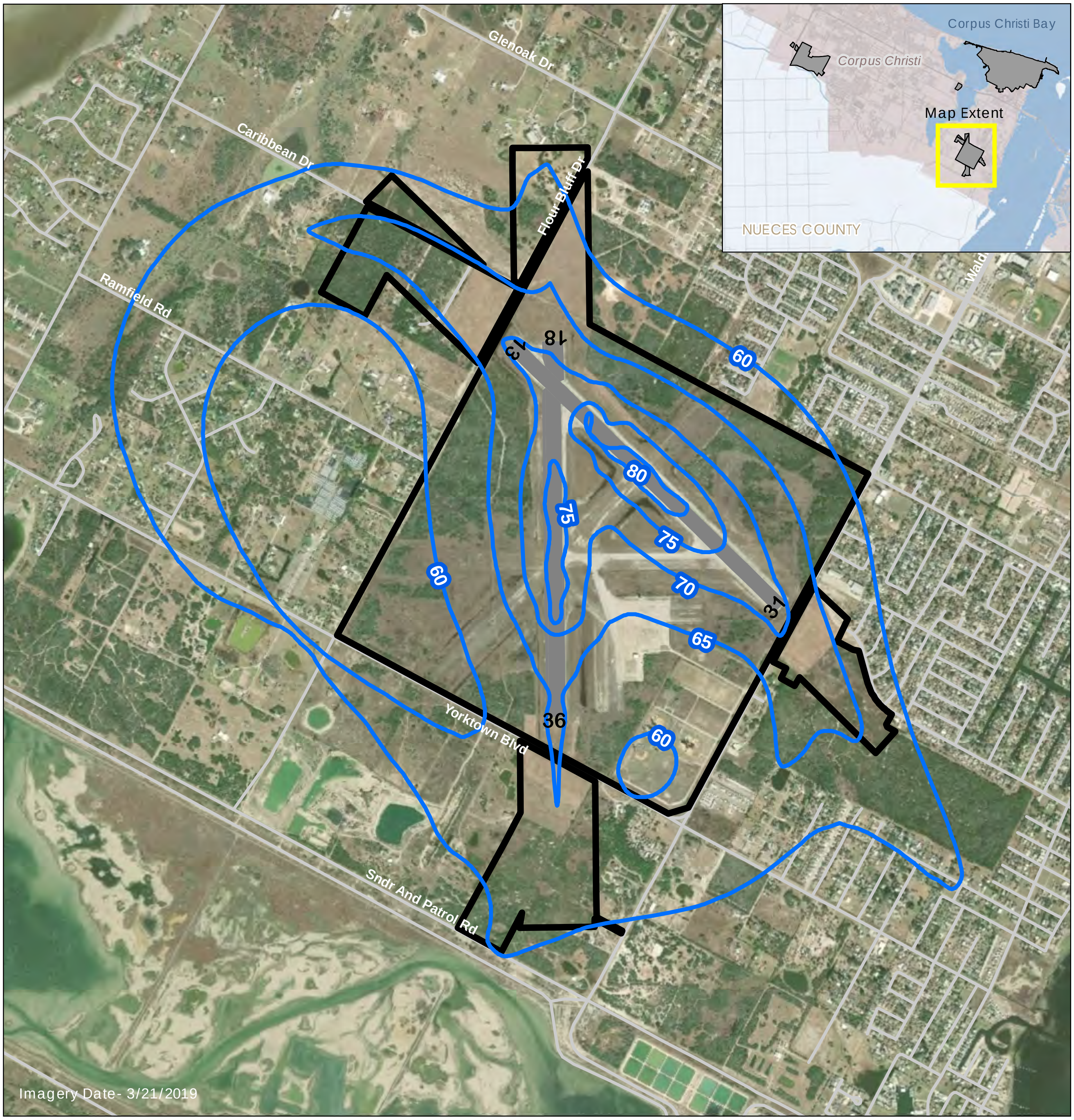
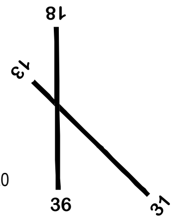


SCALE

0 2,000 Feet



Legend

▭ NOLF Waldron

▬ Runway

⋀ Road

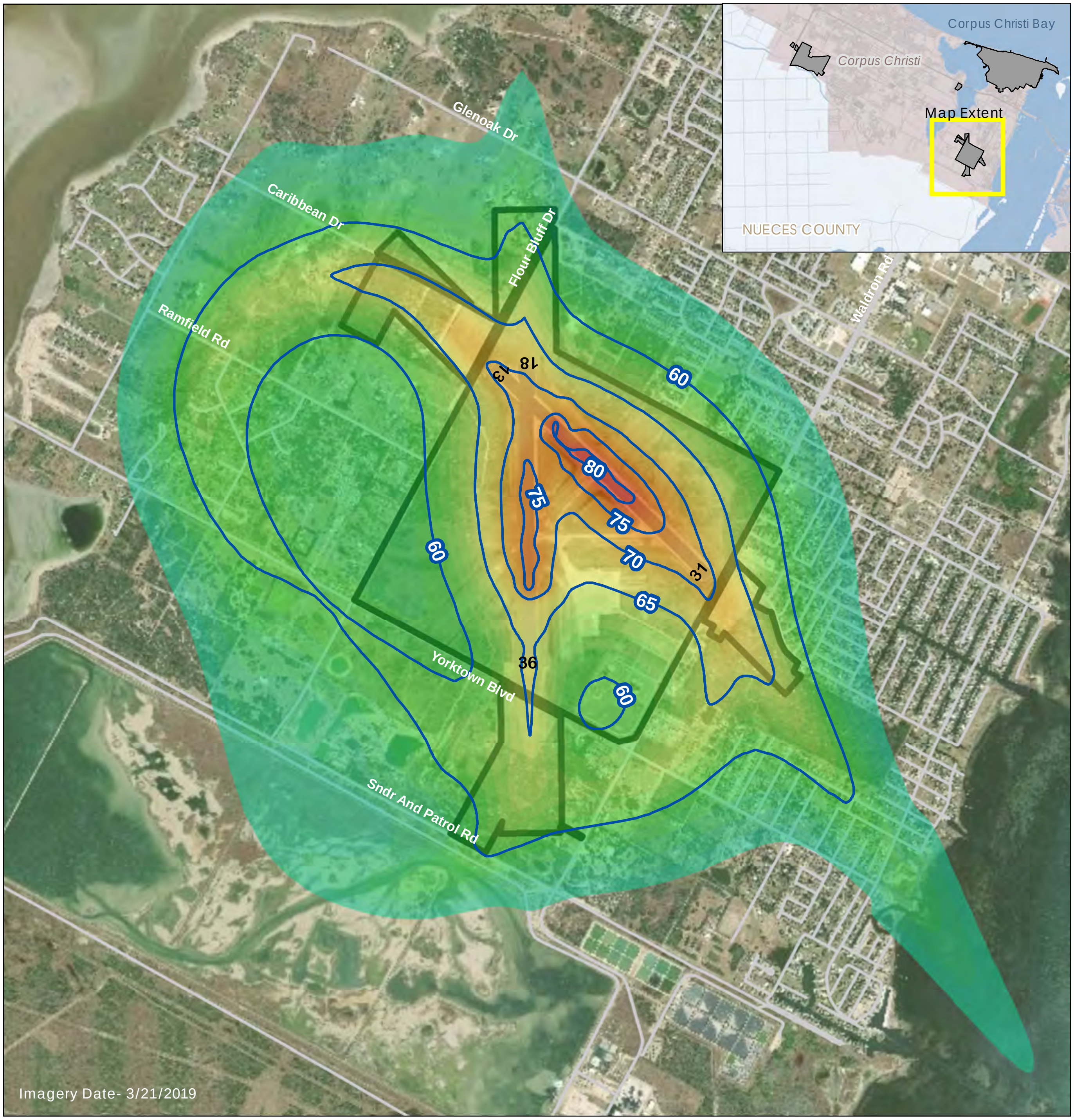
～ 2020 AICUZ Noise Contours (dB)

Figure 3-4
2020 AICUZ Noise Contours, NOLF Waldron

Naval Air Station
Corpus Christi, Texas

Source: ESRI 2018; Navy, 2020, BRRC 2020
Ecology and Environment, Inc. 2020

Path: L:\Buffalo\CorpusChristi_AICUZ\MAPS\MXDs\Report_AICUZ\Spring_2020\Figure 3-5.mxd 5/12/2020



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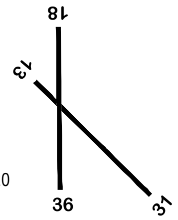


Source: ESRI 2018; Navy, 2020, BRRC 2020
Ecology and Environment, Inc. 2020

Legend

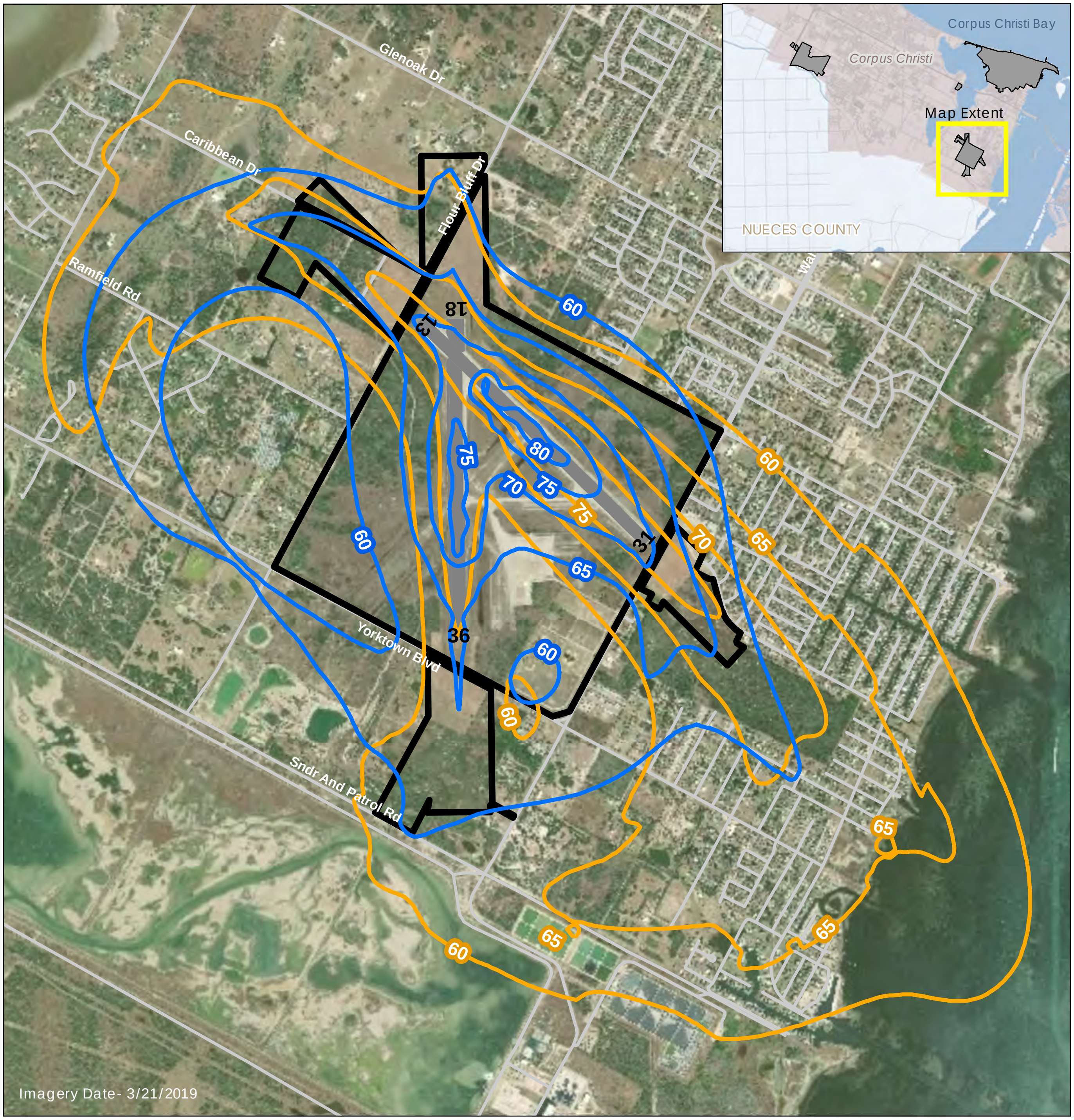
▭ NOLF Waldron
▬ Runway
╱╲ Road
〰 2020 AICUZ Noise Contours (dB)

Noise Gradient (dB)
50
81

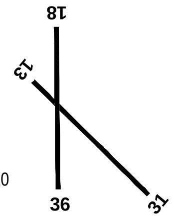
Figure 3-5
2020 AICUZ Noise Gradient, NOLF Waldron

Naval Air Station
Corpus Christi, Texas

Path: L:\Buffalo\CorpusChristi_AICUZ\MAPS\MXDs\Report_AICUZ\Spring_2020\Figure 3-6.mxd 5/8/2020



SCALE
0 2,000 Feet



Legend

- NOLF Waldron
- Runway
- Road
- 2020 AICUZ Noise Contours (dB)
- 2009 AICUZ Noise Contours (dB)

Figure 3-6

Comparison of 2009 and 2020 AICUZ Noise Contours, NOLF Waldron

Naval Air Station
Corpus Christi, Texas

Source: ESRI 2018; Navy, 2020, BRRC 2020
Ecology and Environment, Inc. 2020

3.4 NOISE COMPLAINTS AND ABATEMENT

NASCC employs noise abatement and avoidance procedures for the NOLFs to the best of their ability, commensurate with safety and operational training requirements. Noise abatement procedures are implemented under the Air Ops Manual and are summarized below. The purpose of these procedures is to minimize impacts from aircraft noise. Noise impacts cannot be completely minimized or avoided; therefore, on few occasions, NASCC receives calls from concerned citizens regarding noise and manages those noise concerns and complaints according to the protocol discussed below.

3.4.1 NOISE COMPLAINTS

There are little to no noise complaints associated with aircraft operations at NOLF Cabaniss and NOLF Waldron. NASCC does not have a designated noise complaint hotline. If a noise complaint is called in, it is typically captured by the receiver and sent to the airfield management office. There, the duty officer processes the complaint and sends it via email to the associated squadron and to the CPLO. The CPLO then processes and responds to it accordingly.

3.4.2 NOISE ABATEMENT

There are measures in place to reduce noise impacts for NASCC and the associated outlying fields, including NOLF Cabaniss and Waldron. Noise abatement procedures for NASCC include the following:

- Employ prudent airmanship techniques to reduce aircraft noise impacts on the surrounding community;
- Avoid overflight of schools, including Texas A&M University–Corpus Christi, and nearby local schools; and
- Avoid overflight of the Barney M. Davis Energy Center (NASCC 2019).

4

AIRFIELD SAFETY

Community and airfield safety are paramount to the Navy. The Navy has established a flight safety program and areas of accident potential around NASCC and the two NOLFs to assist in planning for health, safety, and welfare in communities near the airfields. Cooperation between the Navy and local communities can improve land use planning and development surrounding naval airfields. APZs in this 2020 AICUZ Study were developed based on NASCC's unique training environment based on the projected annual aircraft operation as described in Chapter 3, Aircraft Noise. The following sections present the 2020 AICUZ APZs for NOLF Cabaniss and NOLF Waldron, including a detailed analysis of the areas within them. Also provided are comparisons and figure overlays for the 2020 AICUZ Study and the 2009 AICUZ APZs. These comparisons help identify changes to the APZs based on projected aircraft operations and help target land use recommendations to mitigate incompatible development. Identifying safety issues assists the community in developing land uses compatible with airfield operations. These issues include areas of accident potential and hazards around the airfield that obstruct or interfere with aircraft arrivals and departures, pilot vision, communications, or aircraft electronics. While aircraft mishaps are rare, they do occur. Flight safety programs are designed to reduce hazards that cause aircraft mishaps; APZs are designed to minimize harm if a mishap occurs. Flight safety not only includes measures for pilot safety during aircraft operations, but also for the safety of those in the community. APZs are not a prediction of the number of accidents that have occurred or the odds of an accident occurring. APZs only reflect the most likely location of an accident. Airfield safety at NOLF Cabaniss and NOLF Waldron is discussed in detail in this chapter.

4.1 ACCIDENT POTENTIAL ZONES

Recognizing the need to identify areas of accident potential, in the 1960s, 1970s, and 1980s the military conducted studies of historical accidents and operations data throughout the military. The studies showed that most aircraft mishaps occur on or near the runway, diminishing in likelihood with distance from the runway. Based on the studies, the DOD identified APZs as areas where an aircraft accident would most likely occur, if one were to occur.

APZs align with departure, arrival, and pattern flight tracks. While APZs are not a prediction of the number of accidents or the odds of an accident occurring, APZs reflect the most likely location of an accident and are designed to minimize potential harm if a mishap were to occur by limiting activities in these locations. The Navy and local planning authorities use APZs to ensure compatible development in proximity to runway ends and slightly beyond. Although the likelihood of an accident is remote, the Navy recommends that land uses that concentrate large numbers of people, such as apartments, churches, and schools, are not located within APZs.

4.1.1 CLEAR ZONE AND APZ REQUIREMENTS AND DIMENSIONS

APZ configurations and dimensions are derived from the AICUZ Instruction and are established for all runway classifications. There are three APZs: Clear Zone, APZ I, and APZ II. APZs are, in part, based on the number of operations conducted at the airfield—more specifically, the number of operations conducted for specific flight tracks.

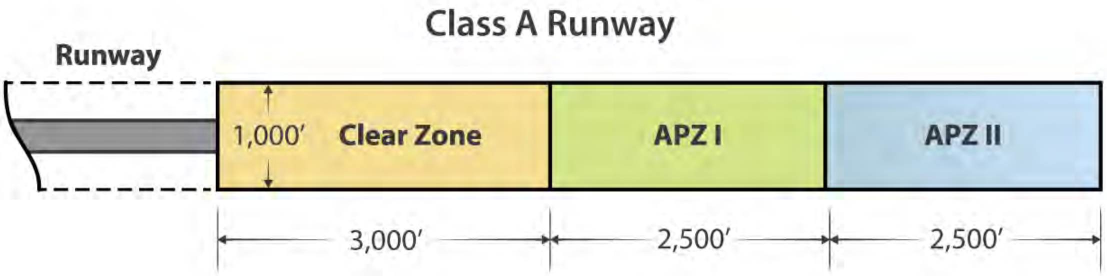
DOD fixed-wing runways are separated into two classes, Class A and Class B. Class A runways are primarily used by light aircraft and do not have the potential for intensive use by heavy or high-performance aircraft. Class B runways are all other fixed-wing runways. The runways at NOLF Cabaniss and NOLF Waldron are designated as Class A. The AICUZ Instruction defines the components of standard APZs for Class A runways as shown on Figure 4-1 and described below:

- **Clear Zone.** The Clear Zone extends 3,000 feet immediately beyond the end of the runway. The Clear Zone measures 1,000 feet in width at the runway threshold and to its outer edges. A Clear Zone is required for all active runways and should remain undeveloped.
- **APZ I.** APZ I is the rectangular area beyond the Clear Zone that still has a measurable potential for aircraft accidents relative to the Clear Zone. APZ I is provided under flight tracks that experience 5,000 or more annual operations (departures or approaches). APZ I is 1,000 feet in width and 2,500 feet in length and may be rectangular or curved to conform to the shape of the predominant flight track.
- **APZ II.** APZ II is the rectangular area beyond APZ I (or the Clear Zone, if APZ I is not used) that has a measurable potential for aircraft accidents relative to APZ I or the Clear Zone. APZ II is always provided where APZ I is required. The dimensions of APZ II are 1,000 feet in width by 2,500 feet in length and, as with APZ I, may be curved to correspond with the predominant flight track.

APZ I is provided under flight tracks that experience 5,000 or more annual operations (departures or approaches). An APZ II area is designated whenever APZ I is required.

Based on analysis of historic mishaps around military airfields, an accident is more likely to occur in APZ I than in APZ II, and is more likely to occur in the Clear Zone than in APZ I or APZ II.

FIGURE 4-1 STANDARD CLASS A RUNWAY, FIXED-WING APZS



APZs extend from the end of the runway, but apply to the predominant arrival and/or departure flight tracks used by the aircraft. The AICUZ Instruction permits modification of APZ dimensions for safety purposes and specific operations. Per the AICUZ Instruction, if the APZ annual operations threshold is fulfilled due to Field Carrier Landing Practice (FCLP) or similar pattern operations, then APZ II can extend the entire length of the FCLP track, resulting in a closed loop for the entire pattern. Modification can result in varying lengths of APZ II based on the specific flight track and the point at which it exits the Clear Zone.

Due to safety concerns, most land uses within the Clear Zone are incompatible with military aircraft operations. Within APZ I and APZ II, some land uses are compatible; however, people-intensive uses (e.g., schools, apartments, churches) should be restricted because of the greater risk. Chapter 5, Land Use Compatibility Analysis, further explains land use compatibility within Clear Zones and APZs.

4.2 AICUZ CLEAR ZONES AND APZS

The following sections present the 2020 APZs for NOLF Cabaniss and NOLF Waldron, including a detailed analysis of their development and the areas exposed to them. Also provided are comparisons and figure overlays with the historic 2009 APZs. The comparisons identify changes to APZs based on projected aircraft operations. An analysis of land use and compatibility within the APZs for the airfields are provided and discussed in Section 5.4, Land Use Compatibility Analysis.

4.2.1 NOLF CABANISS 2020 CLEAR ZONES AND APZS

Clear Zones and APZs that were developed according to projected annual aircraft operations for NOLF Cabaniss are presented in Figure 4-2. The projected APZs graphically represent the detailed aircraft operations counts, flight tracks, and runway utilization data presented in Section 2.4.1, NOLF Cabaniss Annual Operations, and according to AICUZ Instruction APZ development guidance. All runways at NOLF Cabaniss are active; therefore, Clear Zones are applied. The APZ closed loops associated with Runway 18/36 are located closely together; as such, small gaps of areas between the two sets of APZs were closed in to create a larger area for simplicity in the land use compatibility analysis. This way, there are not small areas of land between the two APZ closed loops where there would not be any compatibility recommendations. Acreages associated with the projected APZs are provided in Table 4-1 and are discussed in this section and in Chapter 5, Land Use Compatibility Analysis.

TABLE 4-1 AREAS WITHIN THE CLEAR ZONES AND APZS AT NOLF CABANISS

	On-station	Off-station	Total Area (Acres)
2020 AICUZ			
Clear Zone	162.5	112.9	275.4
APZ I	3.5	364.1	367.6
APZ II	64.5	677.9	742.4
TOTAL AREA	**230.5**	**1,154.90**	**1,385.40**

4.2.2 COMPARISON OF CLEAR ZONES AND APZS FOR NOLF CABANISS

Figure 4-3 compares NOLF Cabaniss' Clear Zones and APZs in the 2009 AICUZ and 2020 AICUZ. The Clear Zones and APZs are organized by on-station and off-station. When comparing acreage under the 2009 AICUZ and the 2020 AICUZ Clear Zones and APZs , the following should be noted:

- The 2009 AICUZ Clear Zone and APZ footprints covered 1,276.50 acres, as compared to 1,385.4 acres for the 2020 AICUZ (on- and off-station);
- There was an increase of 62.8 acres when comparing off-station impacts for the 2009 AICUZ (1,092.10 acres) to the 2020 AICUZ (1,154.90 acres); and
- There are 112.9 acres within the Clear Zones at NOLF Cabaniss that are located outside the base boundary.

The acreage increases are attributed, in part, to the closed loops of the APZs associated with Runway 18/36 and Runway 13. While some similarities exist in the structure of the 2009 and 2020 APZs, there are some key differences, including the addition of an APZ I and APZ II to the approach end of Runway 36. The pattern operations meet the APZ criteria, resulting in closed loop APZ I and APZ II for the entire flight pattern. Pattern operations at NOLF Cabaniss include touch-and-go flight patterns which are similar to FCLP patterns.[2] In the 2009 AICUZ, only a Clear Zone was applied to the approach end of Runway 36. Additionally, changes in operations dictate the alterations in the projected APZs compared to the historic.

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[2] FCLPs are training procedures that simulate landing an aircraft on the flight deck of an aircraft carrier. Similar to a touch-and-go, FCLPs have specific altitudes, turning radii, and power settings in order to replicate, as closely as possible, the procedures of landing on an aircraft carrier. The pattern operations at NOLF Cabaniss were considered FCLPs for APZ development purposes in accordance with OPNAVINST 11010.36C, Air Installations Compatible Use Zones (AICUZ) Program.

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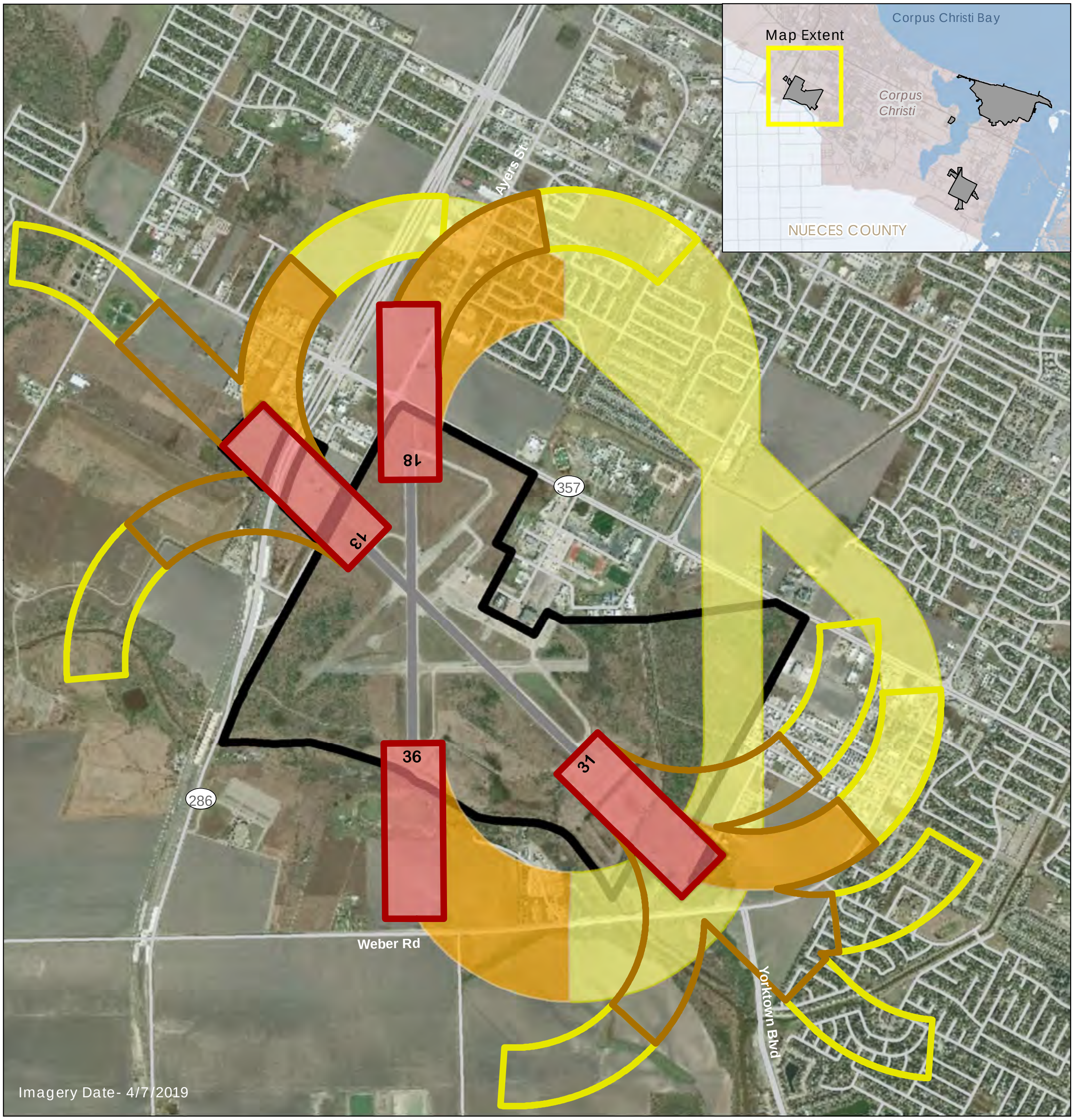
Source: ESRI 2018; Navy, 2020, BRRC 2020
Ecology and Environment, Inc. 2020

Figure 4-2
2020 AICUZ Clear Zones and Accident Potential Zones, NOLF Cabaniss

Naval Air Station
Corpus Christi, Texas

Path: L:\Buffalo\CorpusChristi_AICUZ\MAPS\MXDs\Report_AICUZ\Spring_2020\Figure 4-3.mxd 5/8/2020



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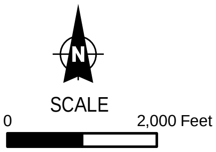

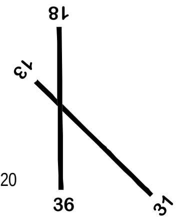

Legend

2009 AICUZ APZs		2020 AICUZ APZs	
🟥	Clear Zone	🟥	Clear Zone
🟫	APZ I	🟧	APZ I
🟨	APZ II	🟨	APZ II

- ⬛ NOLF Cabaniss
- ▬ Runway
- ⋀ Road

Figure 4-3

Comparison of 2009 and 2020 AICUZ Clear Zones and Accident Potential Zones, NOLF Cabaniss

Naval Air Station
Corpus Christi, Texas

Source: ESRI 2018, Navy 2020, BRRC 2020
Ecology and Environment, Inc. 2020

4.2.3 NOLF WALDRON 2020 CLEAR ZONES AND APZS

Clear Zones and APZs that were developed according to projected annual aircraft operations for NOLF Waldron are presented in Figure 4-4. The APZs graphically represent the detailed aircraft operations counts, flight tracks, and runway utilization data presented in Section 2.4.2, NOLF Waldron Annual Operations, and according to AICUZ Instruction APZ development guidance. All runways at NOLF Waldron are active; therefore, Clear Zones are applied. Acreages associated with the planning APZs are provided in Table 4-2 and are discussed in this section and in Chapter 5, Land Use Compatibility Analysis.

TABLE 4-2 AREAS WITHIN THE CLEAR ZONES AND APZS AT NOLF WALDRON

	On-station	Off-station	Total Area (Acres)
2020 AICUZ			
Clear Zone[1]	207.8	65.3	273.1
APZ I	27.2	497.4	524.6
APZ II	3.4	771.1	774.5
TOTAL AREA	**238.4**	**1,333.80**	**1,572.20**

Notes:

[1] The Clear Zones for Runway 13 and Runway 18 overlap with each other. The total amount of overlap between the two Clear Zones is 1.96 acres.

4.2.4 COMPARISON OF CLEAR ZONES AND APZS FOR NOLF WALDRON

Figure 4-5 compares NOLF Waldron's Clear Zones and APZs in the 2009 AICUZ and 2020 AICUZ. The Clear Zones and APZs are organized by on-station and off-station. When comparing acreage under the 2009 AICUZ and 2020 AICUZ Clear Zones and APZs, the following should be noted:

- The 2009 AICUZ Clear Zone and APZ footprints covered 1,020.30 acres, as compared to 1,572.2 acres for the 2020 AICUZ (on- and off-station);
- There was an increase of 533.30 acres when comparing off-station impacts for the 2009 AICUZ (800.50 acres) to the 2020 AICUZ (1,333.80 acres); and
- There are 65.3 acres within the Clear Zones at NOLF Waldron that are located outside the base boundary.

The acreage increases are largely attributed to the addition of the closed loop APZs associated with Runway 13/31 and 18/36. The 2020 APZs expanded compared to the 2009 AICUZ APZs due to the projected increase in annual operations at NOLF Waldron. Section 2.4.2, NOLF Waldron Annual Operations, details the projected increase in operations based on the 2018 Final EA for Providing Outlying Field Capabilities to Support T-6 Undergraduate Pilot Training. The operational increase at NOLF Waldron is mostly due to pattern work. The pattern operations meet the APZ criteria, resulting in closed loop APZ I and APZ II for the entire flight pattern. Pattern operations at NOLF Waldron include touch-and-go flight patterns which are similar to FCLP patterns.[3] This change in operations lead to changes in flight tracks, and therefore, APZs, resulting in APZs that are primarily the result of closed loop APZs.

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[3] FCLPs are training procedures that simulate landing an aircraft on the flight deck of an aircraft carrier. Similar to a touch-and-go, FCLPs have specific altitudes, turning radii, and power settings in order to replicate, as closely as possible, the procedures of landing on an aircraft carrier. The pattern operations at NOLF Waldron were considered FCLPs for APZ development purposes in accordance with OPNAVINST 11010.36C, Air Installations Compatible Use Zones (AICUZ) Program.

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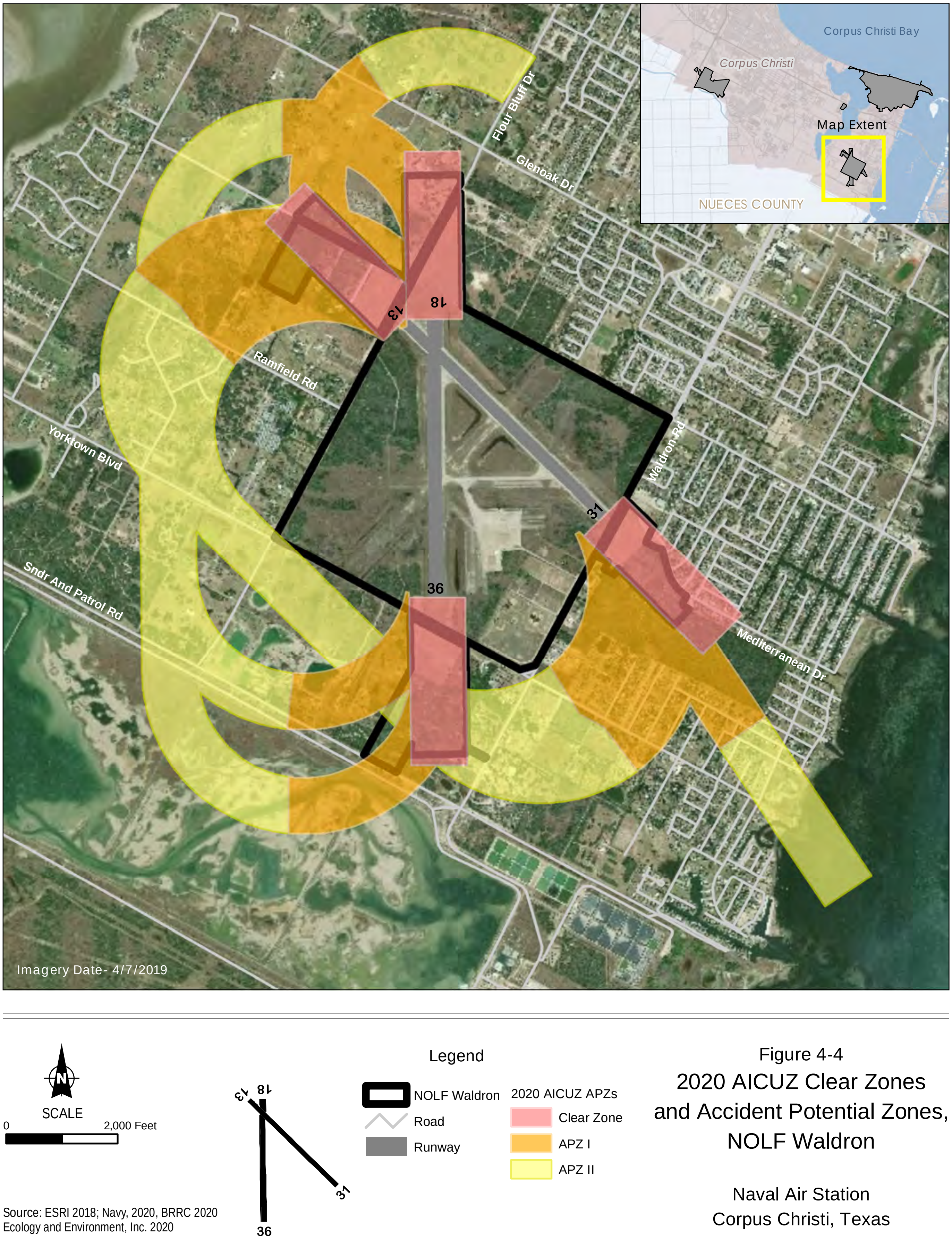
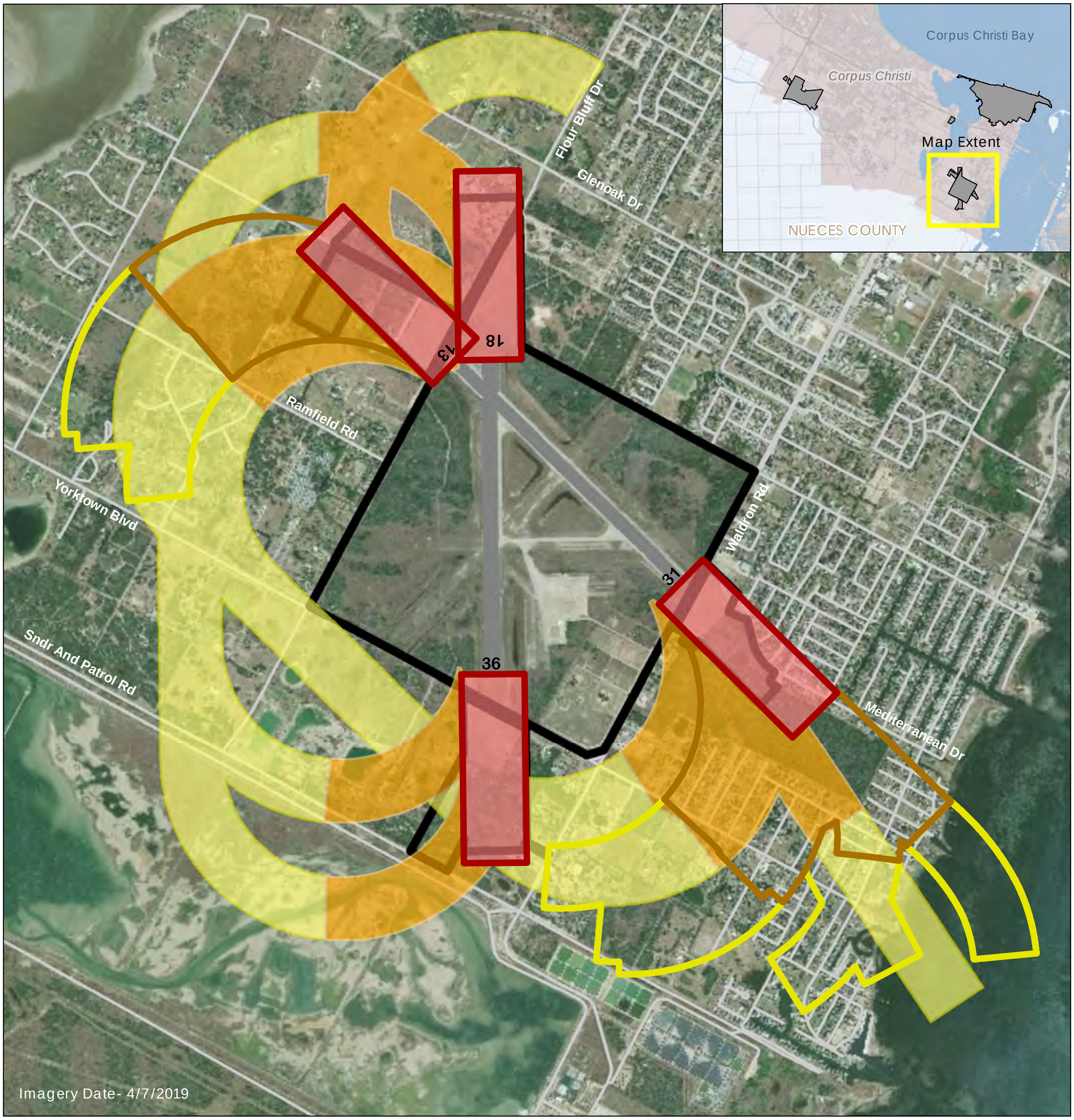


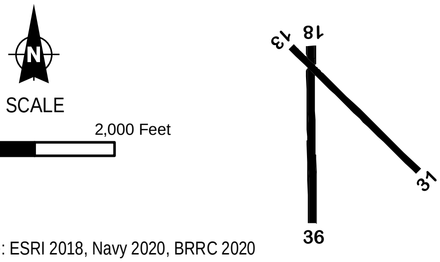
Source: ESRI 2018; Navy, 2020, BRRC 2020
Ecology and Environment, Inc. 2020

Figure 4-4
2020 AICUZ Clear Zones and Accident Potential Zones, NOLF Waldron

Naval Air Station
Corpus Christi, Texas

Path: L:\Buffalo\CorpusChristi_AICUZ\MAPS\MXDs\Report_AICUZ\Spring_2020\Figure 4-5.mxd 5/8/2020





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2009 AICUZ APZs		2020 AICUZ APZs	
🟥	Clear Zone	🟥	Clear Zone
🟫	APZ I	🟧	APZ I
🟨	APZ II	🟨	APZ II

- ⬛ NOLF Waldron
- ▬ Runway
- ⁄ Road

Source: ESRI 2018, Navy 2020, BRRC 2020
Ecology and Environment, Inc. 2020

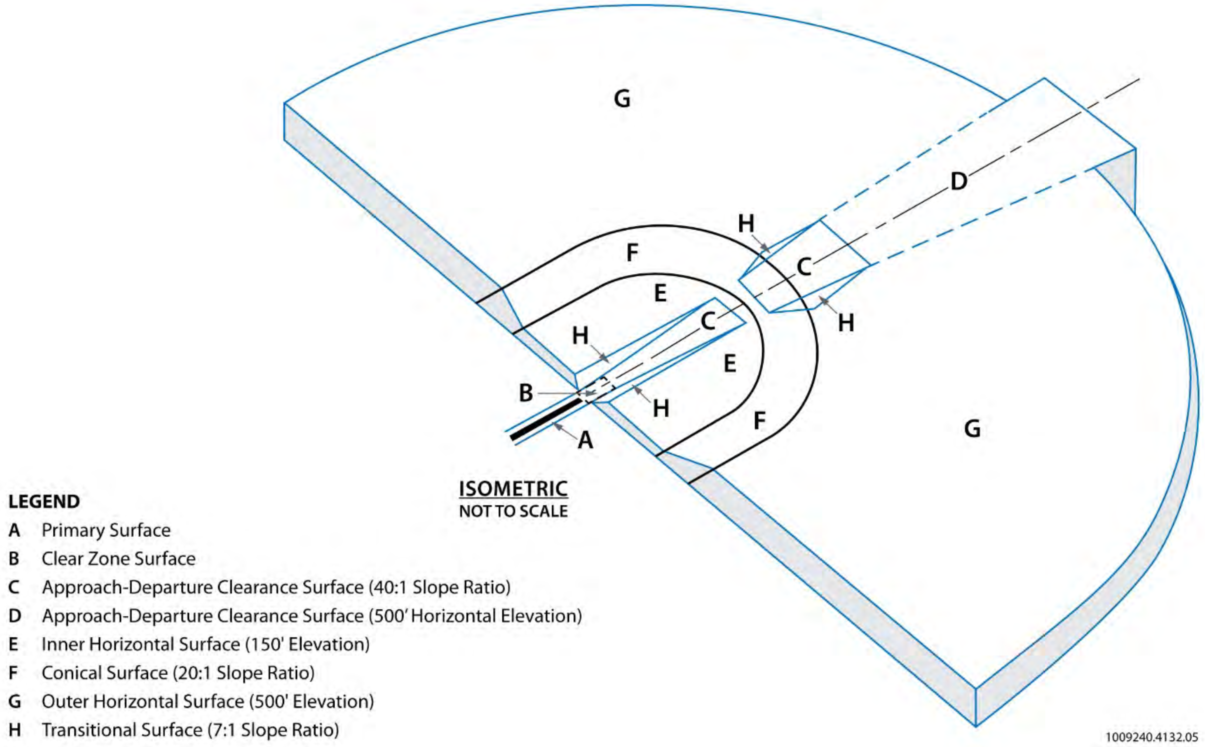
Figure 4-5
Comparison of 2009 and 2020 AICUZ Clear Zones and Accident Potential Zones, NOLF Waldron

Naval Air Station
Corpus Christi, Texas

4.3 IMAGINARY SURFACES

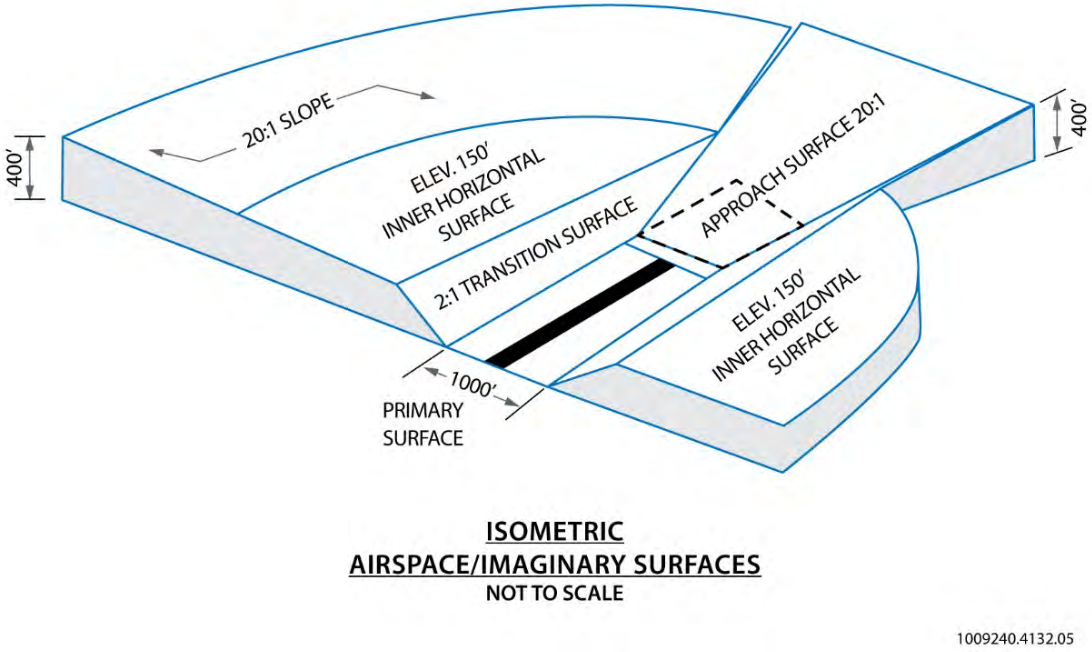
The Navy and the FAA identify a complex series of imaginary planes and transition surfaces that define the airspace that needs to remain free of obstructions around an airfield. Obstruction-free imaginary surfaces help ensure safe flight approaches, departures, and pattern operations. Obstructions include natural terrain and man-made features, such as buildings, towers, poles, wind turbines, cell towers, and other vertical obstructions to airspace navigation. In general, no aboveground structures are permitted in the primary surface of Clear Zones, and height restrictions apply to transitional surfaces as well as approach and departure surfaces. Height restrictions are more stringent nearing the runway and flight path. As discussed previously, all runways at NOLF Cabaniss and NOLF Waldron are Class A runways, with NOLF Waldron utilizing the Basic Training Outlying Fields (T-34) criteria based on a permanent waiver from the Naval Air Systems Command. An illustration of the imaginary surfaces for fixed-wing Class A runways is provided as Figure 4-6, and an illustration of the isometric airspace/imaginary surfaces for Basic Training Outlying Fields (T-34) is provided as Figure 4-7. Figures 4-8 and 4-9 illustrate the imaginary surfaces specific to NOLF Cabaniss and NOLF Waldron, respectively.

FIGURE 4-6 IMAGINARY SURFACES AND TRANSITION PLANES FOR CLASS A RUNWAY



Source: UFC 2-200-05N, Figure II-1, Appendix E

FIGURE 4-7 ISOMETRIC AIRSPACE/IMAGINARY SURFACES FOR BASIC TRAINING OUTLYING FIELD (T-34 AIRCRAFT)



Source: UFC 2-200-05N, Figure II-12, Appendix E

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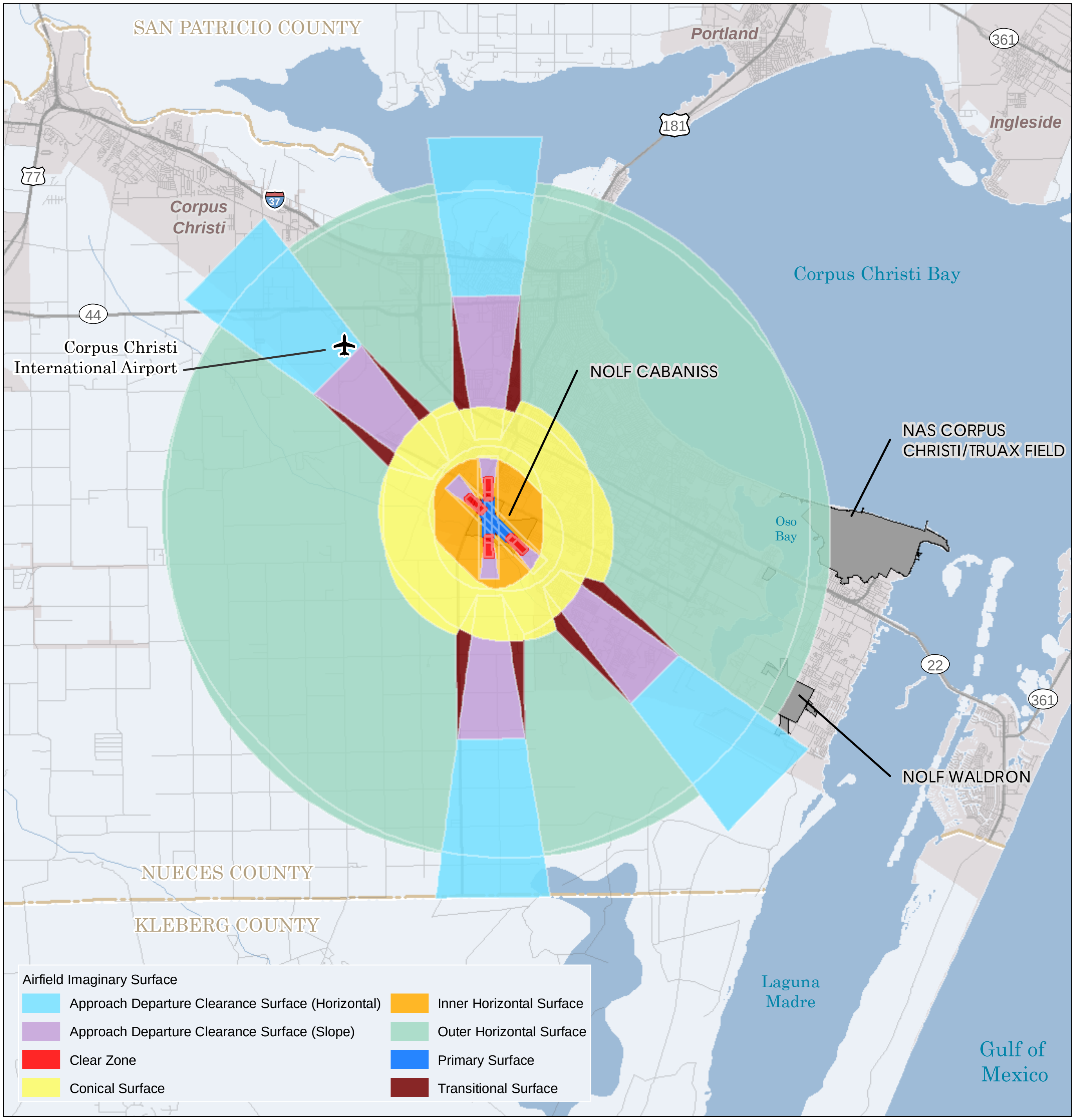

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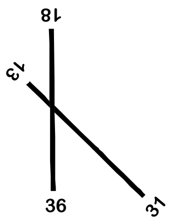
SCALE

0 4 Miles



Legend

- ▨ Military Area
- ▨ Urban Area
- ▨ Waterbody
- ✈ Airport
- County Boundary
- Road

Figure 4-8
Imaginary Surfaces for NOLF Cabaniss

Naval Air Station
Corpus Christi, Texas

Source: ESRI 2018; Navy, 2020
Ecology and Environment, Inc. 2020

Path: L:\Buffalo\CorpusChristi_AICUZ\MAPS\MXDs\Report_AICUZ\07_2020_90_percent\FINAL\Figure 4-9.mxd 9/8/2020

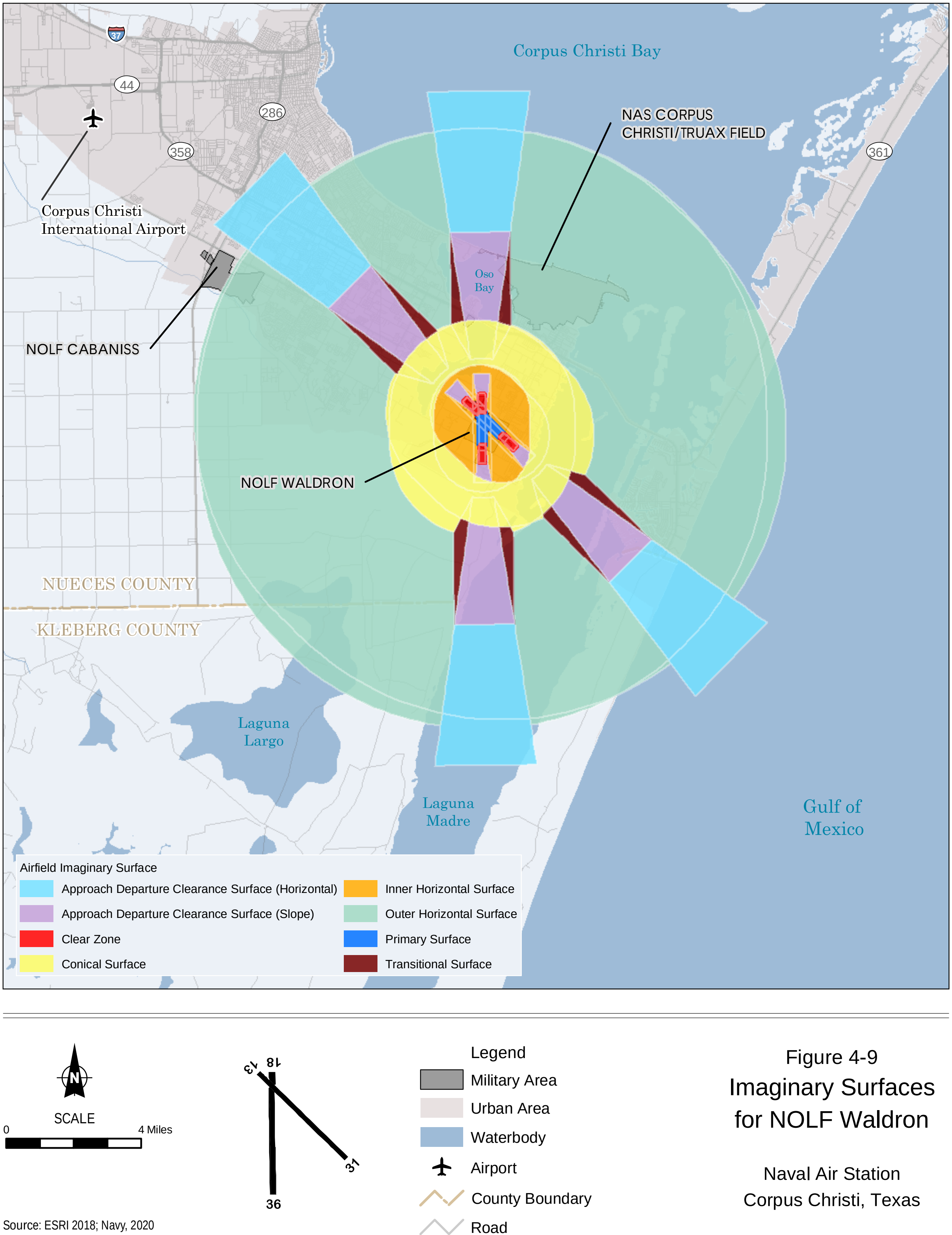


Figure 4-9
Imaginary Surfaces for NOLF Waldron

Naval Air Station
Corpus Christi, Texas

Source: ESRI 2018; Navy, 2020
Ecology and Environment, Inc. 2020

4.4 HEIGHT AND OBSTRUCTION CONCERNS

4.4.1 BIRD/ANIMAL AIRCRAFT STRIKE HAZARDS

Bird/animal aircraft strike hazards (BASH) are another safety concern to aircraft operations. Birds and wildlife are drawn to different habitat types found in the airfield environment (e.g., edges, grass, brush, forest, water, and warm pavement). Because of the speed of the aircraft, collisions with wildlife can have considerable force and can cause substantial damage. Although most bird and animal strikes do not result in crashes, they can cause structural and mechanical damage to aircraft, as well as loss of flight time.

Most bird collisions occur when the aircraft is at an elevation of less than 1,000 feet. To reduce BASH, the FAA and the military recommend locating land uses that attract birds at least 10,000 feet from active movement areas of the airfields. Land uses that attract birds and other wildlife include transfer stations, landfills, golf courses, wetlands, stormwater ponds, and dredge disposal sites. Design modifications can reduce the appeal of these land uses for birds and other wildlife.

The Navy BASH program aims to minimize the risk of collisions involving birds/wildlife and aircraft and the subsequent loss of life and property. The BASH abatement program accomplishes this through awareness, avoidance, monitoring, and actively controlling bird and animal population movements. Some of the procedures outlined include monitoring the airfield for bird and other wildlife activity, issuing bird hazard warnings, installing and maintaining bird/wildlife avoidance measures, initiating bird/wildlife avoidance procedures when potentially hazardous bird/wildlife activities are reported, and submitting BASH reports for all incidents. NASCC has an effective BASH program that involves the distribution of information and active and passive measures to control how birds use the critical areas around the airfield. Methods outlined in the plan to reduce BASH risk at the airfield include habitat management, bird dispersal, depredation, and bird avoidance.

The United States Navy, Commander Navy Installations Command has entered into an agreement with the U.S. Department of Agriculture, Animal and Plant Health Inspection Service, Wildlife Services (APHIS WS) to provide assistance to mitigate potential and realized wildlife hazards at Navy air stations. APHIS WS is recognized as the appropriate agency to conduct wildlife hazard management at military installations, as well as civilian airports, to reduce wildlife hazards. APHIS WS has assigned two full-time wildlife biologists at NASCC to conduct Wildlife Hazard Assessments and mitigate wildlife hazards on the airfield. NASCC also has a natural resources manager who works with the two BASH staff at the installation to mitigate potential wildlife hazards. Aircrews flying in and around NASCC will continue to adhere to the BASH program and flight operations standard operating procedures, using all available resources to minimize exposure during higher risk times of day and migration periods.

4.4.2 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 activities that create electromagnetic interference (EMI). The American National Standards Institute defines EMI as any electromagnetic disturbance that interrupts, obstructs, or otherwise degrades or limits the effective performance of electronics/electrical equipment. EMI can be intentional, as in electronic warfare, or unintentionally, such as high-tension line leakage. Megawatt wind turbines cause EMI and pose a hazard to air navigation. 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. EMI also affects consumer devices, such as cell phones, FM radios, television reception, and garage door openers. For air operations, EMI is a concern because it can disrupt navigation and communications equipment. There also have been reports of EMI affecting aircraft fuel systems, warning lights, and propulsion. Any of these disruptions could lead to loss of aircraft and life. Questions about EMI with existing and/or proposed development can be directed to NASCC's CPLO.

4.4.3 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 can cause a spot, or "halo," to remain at the center of the visual field for a few seconds or more, rendering a pilot virtually blind. This is particularly dangerous at night when the flash can diminish the eye's adaptation to darkness. Partial recovery takes only a few minutes, but full recovery can take 40 to 45 minutes. Visible lasers, including low-powered legal laser pointers, are emerging as a safety concern for pilots. Visual interference with pilot performance due to lasers can result in temporary flash blindness, glare, disruptions, and distractions. These are most hazardous during critical phases of flight—landings, takeoffs, and emergency maneuvers. There is also concern about urban lighting that is not downward-directed, as well as the potential impacts of light-emitting diode, or "LED," lights on pilots who are training with night vision goggles.

4.4.4 SMOKE, STEAM, AND DUST

Land uses that generate 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. Examples include dust from agricultural activities and thermal plumes from geothermal industries.

4.5 OTHER POTENTIAL COMPATIBILITY CONCERNS

In addition to the typical height obstruction concerns that most Navy installations plan and mitigate for, NASCC also has local issues that they monitor and work toward alleviating. Construction activities around Corpus Christi occasionally require cranes. Near NOLF Cabaniss in particular, the installation has experienced issues with cranes going up in Class D airspace. The FAA states that anything taller than 200 feet and located within 50,000 feet of a military airfield must file a notification prior to construction. On several instances, NASCC has experienced cranes erected near NOLF Cabaniss and has had difficulty coordinating with the FAA. As the cranes are off base, the installation has no authority to remove them, however they can file an objection with the FAA. The issue is then at the FAA's discretion on whether to allow the crane to remain. If the FAA denies the installation's objection, the Navy files a Notice to Airmen, so aviators are aware of the obstruction.

NASCC also closely monitors wind energy development in the area. Texas ranks first nationally for both installed and under construction wind capacity in the United States, with over 29 gigawatts of wind production (AWEA 2020). In the past, wind development in the state has been largely unregulated and allowed to be located relatively close to military installations. In 2017, the Texas State Legislature passed a bill which exempted all wind farms within 25 nautical miles of a military base from receiving tax incentives. As wind development continues in Texas, the military is working closely with state officials to better guide where wind development would be appropriate, so as not to interfere with military operations. In south Texas, including in the vicinity of NASCC, wind development has and continues to surge. In 2017, the 81-turbine Chapman Ranch Wind Farm began operating. This wind farm is located just south of Corpus Christi, near the Chapman Ranch area, approximately 6.5 miles southwest of NOLF Cabaniss and 12 miles west of NOLF Waldron. Base officials will continue to monitor proposed wind developments in the area and work closely with local landowners, wind developers, CNATRA, as well as local, state, and federal governments to coordinate suitable locations for wind development where military activities would not be impacted.

5

LAND USE COMPATIBILITY ANALYSIS

5.1 PLANNING AUTHORITIES

Successful AICUZ land use compatibility implementation is the collective responsibility of the Navy, state and local governments, and private sector and non-profit organizations. This chapter discusses federal, state, and local planning authorities, regulations, and programs that encourage compatible land use.

This AICUZ Study presents data to encourage cooperative land use planning between NASCC and the surrounding communities so that operational impacts on adjacent lands are minimized and future growth and development are compatible with the operational missions.

NASCC's NOLF Cabaniss and NOLF Waldron are located within the City of Corpus Christi in Nueces County. The majority of the AICUZ footprint for each NOLF is located within the City of Corpus Christi. Development and control of land use outside the installation are beyond the jurisdiction of the Installation CO. Therefore, federal, state, and local land use planning programs; ordinances; and regulations manage this land. These programs, ordinances, and regulations often have specific coordination efforts and considerations related to NASCC, as described in the following sections.

5.1.1 CITY OF CORPUS CHRISTI

Corpus Christi City Council established comprehensive planning as a government function to guide, regulate, and manage development within the corporate limits and extraterritorial jurisdiction (ETJ) of the city to assure best uses of resources and public interest, as noted in the City Charter. The City Council adopted the Comprehensive Plan, called Plan CC, in September 2016. Plan CC provides a 20-year framework to guide planning in Corpus Christi and is comprised of several elements, including Comprehensive Policy Statements, Area Development Plans, Specific Area Plans, a Future Land Use Master Plan, a Transportation Master Plan, an Annexation Plan, and several utility master plans (City of Corpus Christi 2016).

State law and the City Charter require Comprehensive Plans to be approved and adopted as ordinances by the City Council. After adoption, future city improvements, ordinances, and regulations approved by City Council must be consistent with the Comprehensive Plan. The City's Planning Commission ("Commission") is an advisory board to the City Council and is responsible for reviewing land use activity and proposed development to ensure consistency with the Comprehensive Plan. Additionally, they make and amend a master plan for the physical development of the City, recommend to the City Council approval or disapproval of proposed changes in the zoning plan, and exercise control over platting or subdividing land within the corporate limits of the city and within an area extending 5 miles beyond city limits. The Commission has nine members appointed by the City Council for three-year staggered terms and may appoint an ex officio, non-voting representative from the Navy.

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For more information regarding the City of Corpus Christi's Comprehensive Plan and land use policies, visit **www.cctexas.com**

Zoning is an instrument granted by the State of Texas which allows cities to develop in a comprehensive and coordinated manner. In Corpus Christi, zoning ensures proper land use relationships; provides sufficient land area for each development type; and allows a change to more intensive uses only in areas with adequate facilities and services, such as streets, schools, recreation areas, and utility systems. The Development Services Department is responsible for administering a number of land development ordinances as well as providing information to the public on zoning and platting. The Corpus Christi Unified Development Code establishes the zoning regulations and districts that have been made in accordance with the City's Comprehensive Plan and for the purpose of promoting the public's general welfare and interest (City of Corpus Christi 2020[a]).

AIRPORT ZONING BOARD COMMISSION

The Corpus Christi Airport Zoning Board Commission works to preserve, protect, and maintain the importance of the operations of the Corpus Christi International Airport and military flight training mission NASCC. NASCC's CPLO coordinates and communicates with the Commission for updates that may affect the base.

MUNICIPAL AND COUNTY ZONING AUTHORITY AROUND AIRPORTS

In Texas, municipal zoning is limited to the extent of the city limits. County governments do not have zoning authority to control land use and development in the unincorporated areas except as provided for by the Texas Local Government Code 241, "Municipal and County Zoning Authority around Airports." Cities can enforce subdivision regulations through platting approval within their ETJ, which is the unincorporated area contiguous to the corporate boundaries of the municipality area of land. The extent of a city's ETJ varies from 0.5 mile to 5 miles, based on the number of inhabitants of the municipality, and cannot overlap the ETJ of another city. A city's platting authority is extended to their ETJ under the Texas Local Government Code Chapter 212.

Under House Bill 1640, Texas Local Government Code §397.005 was amended to require defense communities to notify the base of proposed development within 1.5 statute miles from the centerline of the runway and 5 miles from each end of the paved surface of the runway. This coordination helps the base communicate concerns to the communities regarding issues of compatibility with CZs and APZs that could result in mission impacts.

5.2 LAND USE, ZONING, AND PROPOSED DEVELOPMENT

The AICUZ land use compatibility analysis identifies existing land uses near NOLF Cabaniss and NOLF Waldron to determine compatibility conditions. Existing land use is assessed to determine current land use activities. To analyze and plan for potential growth areas in the city, future land use and zoning data was also analyzed on a more general level. The composite AICUZ footprints (Clear Zones, APZs, and noise contours) for NOLF Cabaniss and NOLF Waldron are used as the basis for the land use compatibility analysis (Figures 5-1 and 5-2, respectively). Recommended strategies for AICUZ implementation are based on the findings from the land use analysis.

5.2.1 EXISTING LAND USE

Existing land use and parcel data were evaluated to ensure an accurate account of land use activities regardless of conformity to zoning classifications or designated planning or permitted use. Zoning districts do not always indicate the actual land use. Typical land use categories include residential, commercial, public use, agricultural, parks/open space, and industrial. Additionally, local management plans, policies, ordinances, and zoning regulations were evaluated to determine the type and extent of land use allowed in specific areas. Land use data was provided by the City of Corpus Christi GIS Services parcel data and, then, verified through aerial photographs and land use maps from the City of Corpus Christi.

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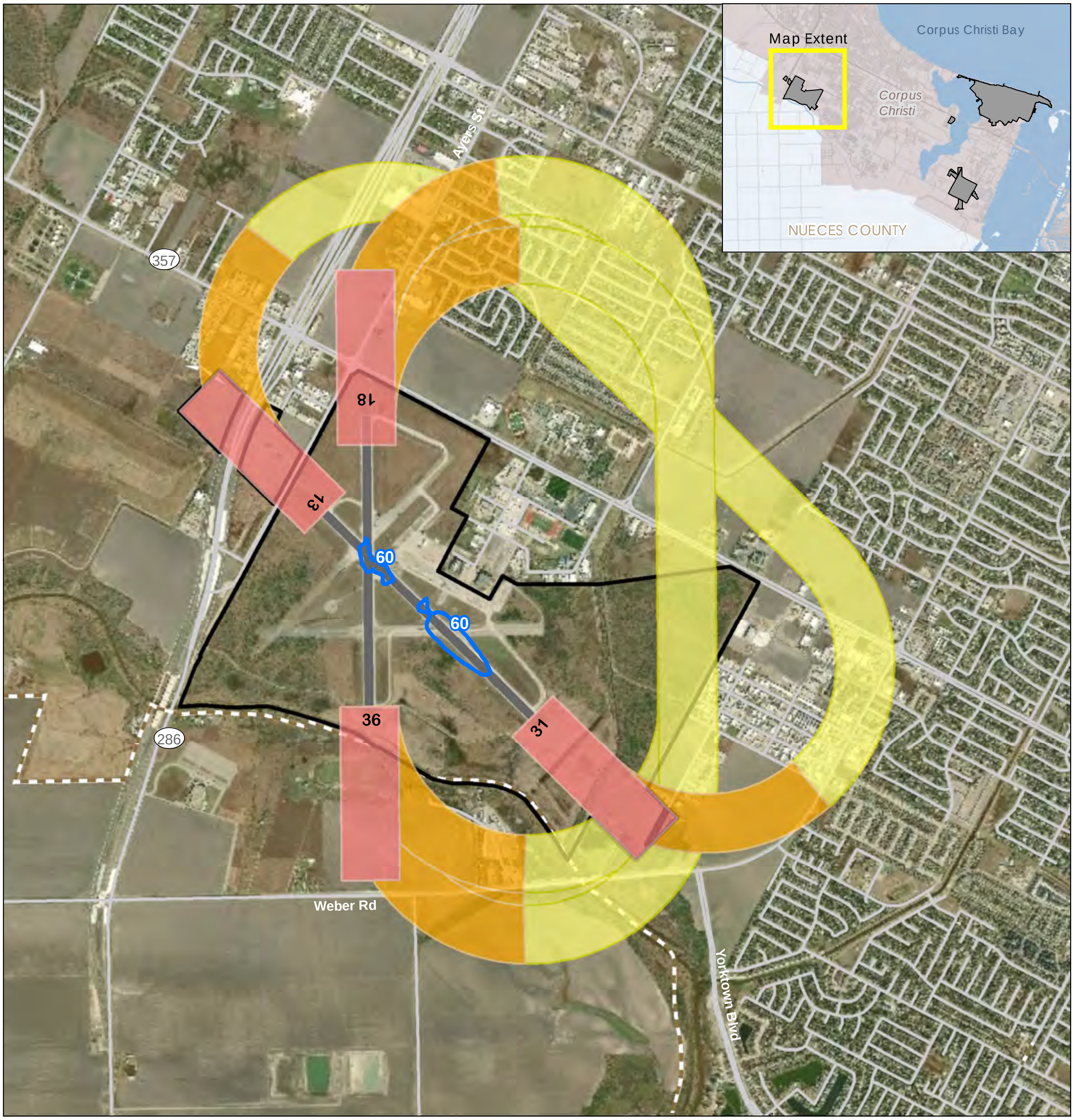
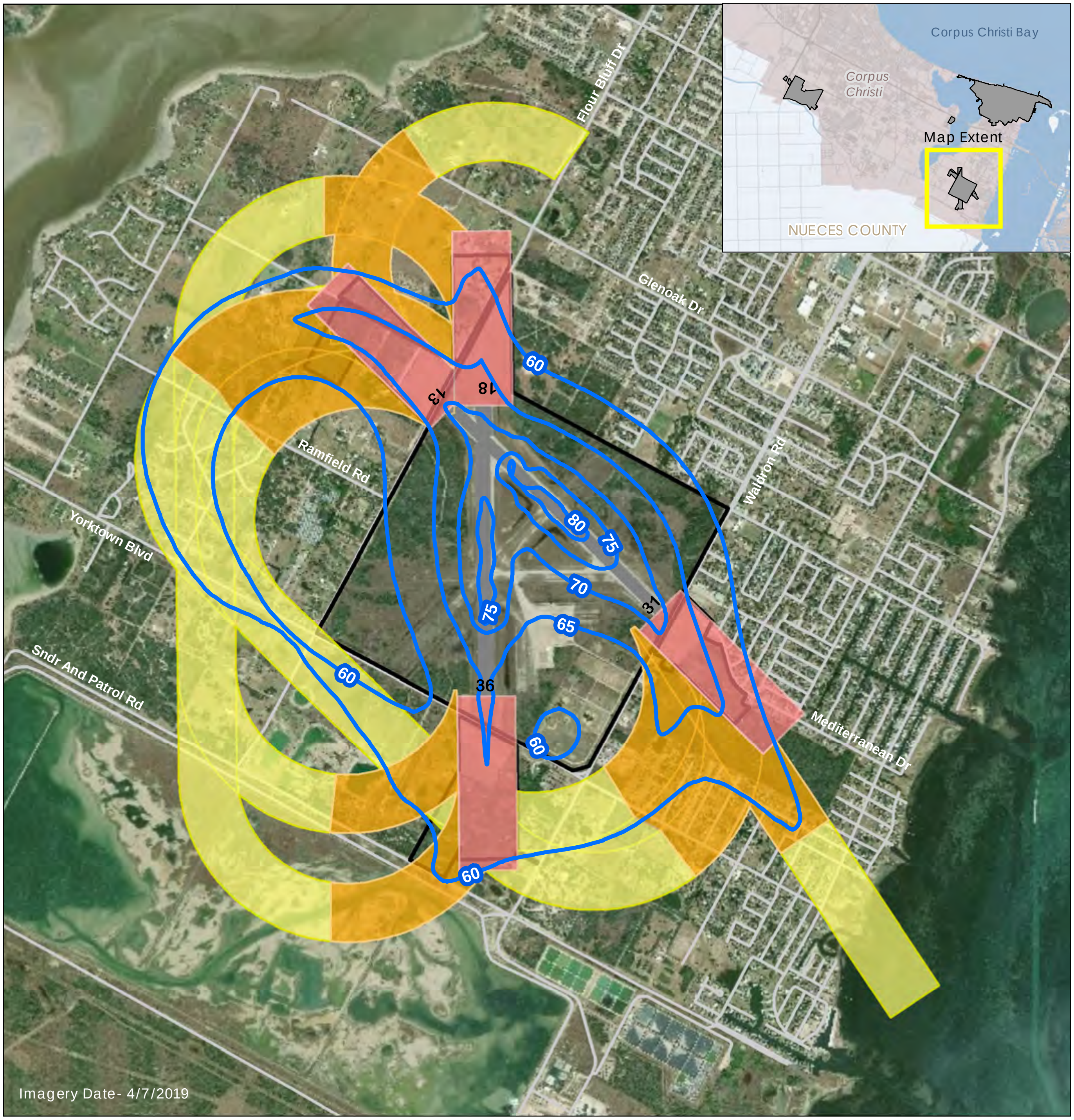


Source: ESRI 2018, Navy 2020, BRRC 2020
Ecology and Environment, Inc. 2020

Figure 5-1
2020 AICUZ Footprint,
NOLF Cabaniss

Naval Air Station
Corpus Christi, Texas

Path: L:\Buffalo\CorpusChristi_AICUZ\MAPS\MXDs\Report_AICUZ\Spring_2020\Figure 5-2.mxd 5/8/2020



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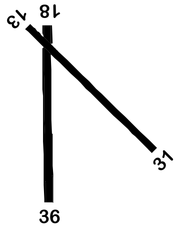

Legend

▭ NOLF Waldron

■ Runway

Road

2020 AICUZ Noise Contours (dB)

2020 AICUZ APZs

🟥 Clear Zone

🟧 APZ I

🟨 APZ II

Figure 5-2
2020 AICUZ Footprint, NOLF Waldron

Naval Air Station
Corpus Christi, Texas

Source: ESRI 2018, Navy 2020, BRRC 2020
Ecology and Environment, Inc. 2020

5.2.1.1 NOLF CABANISS

NOLF Cabaniss is located wholly within the City of Corpus Christi city limits. The southern border of the airfield, however, is also the edge of the city limits. Unincorporated Nueces County is located immediately south of the airfield. The area surrounding the airfield is a mix of rural, agricultural land to the south and more urban to the north, east, and west. Figure 5-3 illustrates the existing land uses surrounding NOLF Cabaniss.

North of the airfield are multiple public use areas, including schools. A high school and elementary school are located north of NOLF Cabaniss across Saratoga Boulevard. Additionally, Corpus Christi Independent School District recently broke ground on the new location of a high school. The high school is being rebuilt and moved from its current location on Weber Road, approximately 2.5 miles northeast of NOLF Cabaniss, to the corner of Saratoga Boulevard and Kostoryz Road (approximately 0.5 mile northeast of the airfield). Set to open in the fall of 2022, the new high school will occupy 60 acres. The Cabaniss Athletic Complex is located adjacent to the airfield along the north entrance road, Ranger Avenue. Other existing land uses north of the airfield include low and medium density residential, mobile home developments, agricultural land, and scattered commercial uses.

Other existing land uses surrounding the airfield include primarily commercial and light industrial uses directly to the east, agricultural lands to the south, and a mix of commercial and light industrial uses to the west. South of the airfield in unincorporated Nueces County, existing land uses are primarily agricultural with some scattered light industrial and residential estates. Table 5-1 lists the total acreage of existing land uses within the APZs of NOLF Cabaniss. As discussed in Section 3.3.1, NOLF Cabaniss 2020 Noise Contours, the noise contours of the airfield are located entirely on military land and therefore not listed in the table. An evaluation of specific land use compatibility concerns is discussed in Section 5.4.1, Compatibility Concerns.

TABLE 5-1 EXISTING LAND USES WITHIN THE NOLF CABANISS APZS

Existing Land Use	Clear Zone	APZ I	APZ II
Agriculture	39.38	154.96	177.29
Conservation/Preservation	-	1.92	30.05
Commercial	-	27.71	37.74
Drainage Corridor	-	0.92	18.34
Estate	<0.01	1.01	-
Light Industrial	0.08	40.27	25.28
Low Density Residential	-	32.19	99.26
Medium Density Residential	-	-	9.32
Mobile Home	-	10.73	26.68
Park	-	-	9.11
Professional Office	-	-	3.66
Public, Semi-Public	33.0	24.68	60.26
Vacant	4.33	30.51	80.25
Water	12.52	0.13	5.65
TOTAL[1]	**89.30**	**325.04**	**582.87**

Notes:

[1] Total acreage presented in Table 5-1 may differ from the off-station acreages presented in Table 4-1 due to available GIS polygons for road rights-of-way.

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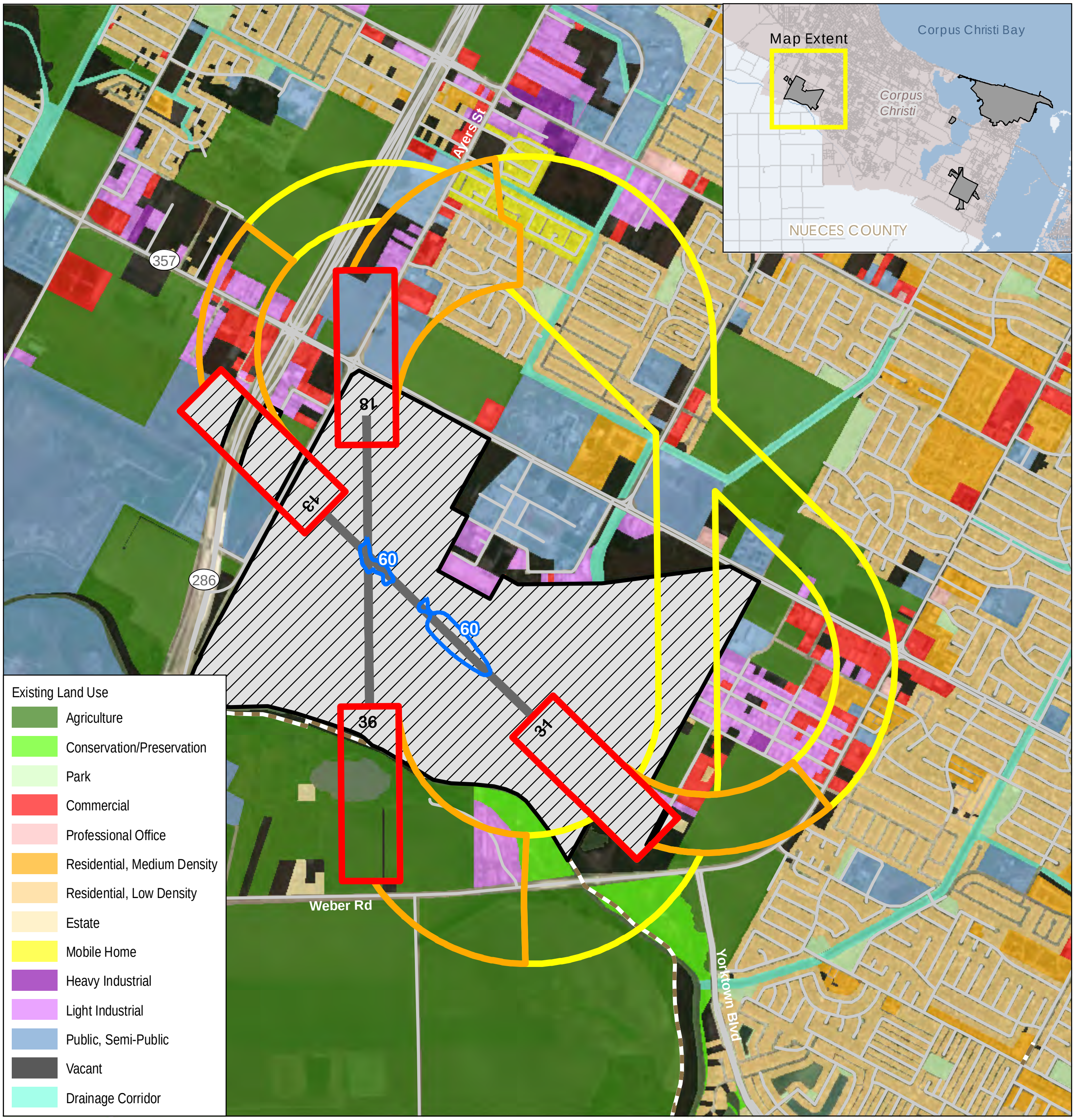
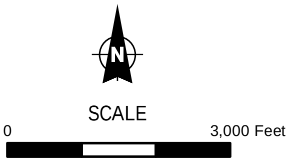
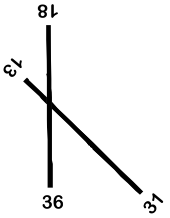






Legend

▨ NOLF Cabaniss

▬ Runway

⬚ City Limit

Road

2020 AICUZ Noise Contours (dB)

2020 AICUZ APZs

🟥 Clear Zone

🟧 APZ I

🟨 APZ II

Source: ESRI 2018, Navy 2020, BRRC 2020
City of Corpus Christi 2020, Nuces County 2020
Ecology and Environment, Inc. 2020

Figure 5-3
2020 AICUZ Footprint with Existing Land Use, NOLF Cabaniss

Naval Air Station
Corpus Christi, Texas

5.2.1.2 NOLF WALDRON

NOLF Waldron is located entirely within the city limits of Corpus Christi. Land uses surrounding the airfield and within the AICUZ footprint (see Table 5-2) are varied and include mostly low density residential, agricultural, estate, and scattered commercial. Figure 5-4 illustrates the existing land uses surrounding NOLF Waldron

North of the airfield, predominant existing land uses include low density residential between Flour Bluff Drive and Waldron Road; park space (Waldron Park); vacant; and agricultural. East of the airfield is also largely low density residential with areas of scattered medium density residential, commercial, public/semi-public, and vacant. As discussed further in Section 5.4.2, NOLF Waldron Land Use Compatibility Concerns, approximately 15 acres of low density residential uses are located within the Runway 31 Clear Zone. South of the airfield, land uses are more rural with large areas of agricultural land and scattered areas of mobile homes, estate lands, and vacant areas. West of NOLF Waldron existing land uses include agricultural areas, scattered commercial areas, and estate and vacant areas. As detailed in Section 3.3.3, NOLF Waldron 2020 Noise Contours, the noise contours included in Noise Zone 3 (i.e., those greater than or equal to 75 dB DNL) are contained on-station, and therefore are not included in Table 5-2. An evaluation of specific land use compatibility concerns is discussed in Section 5.4.1, Compatibility Concerns.

TABLE 5-2 EXISTING LAND USES WITHIN THE NOLF WALDRON AICUZ FOOTPRINT

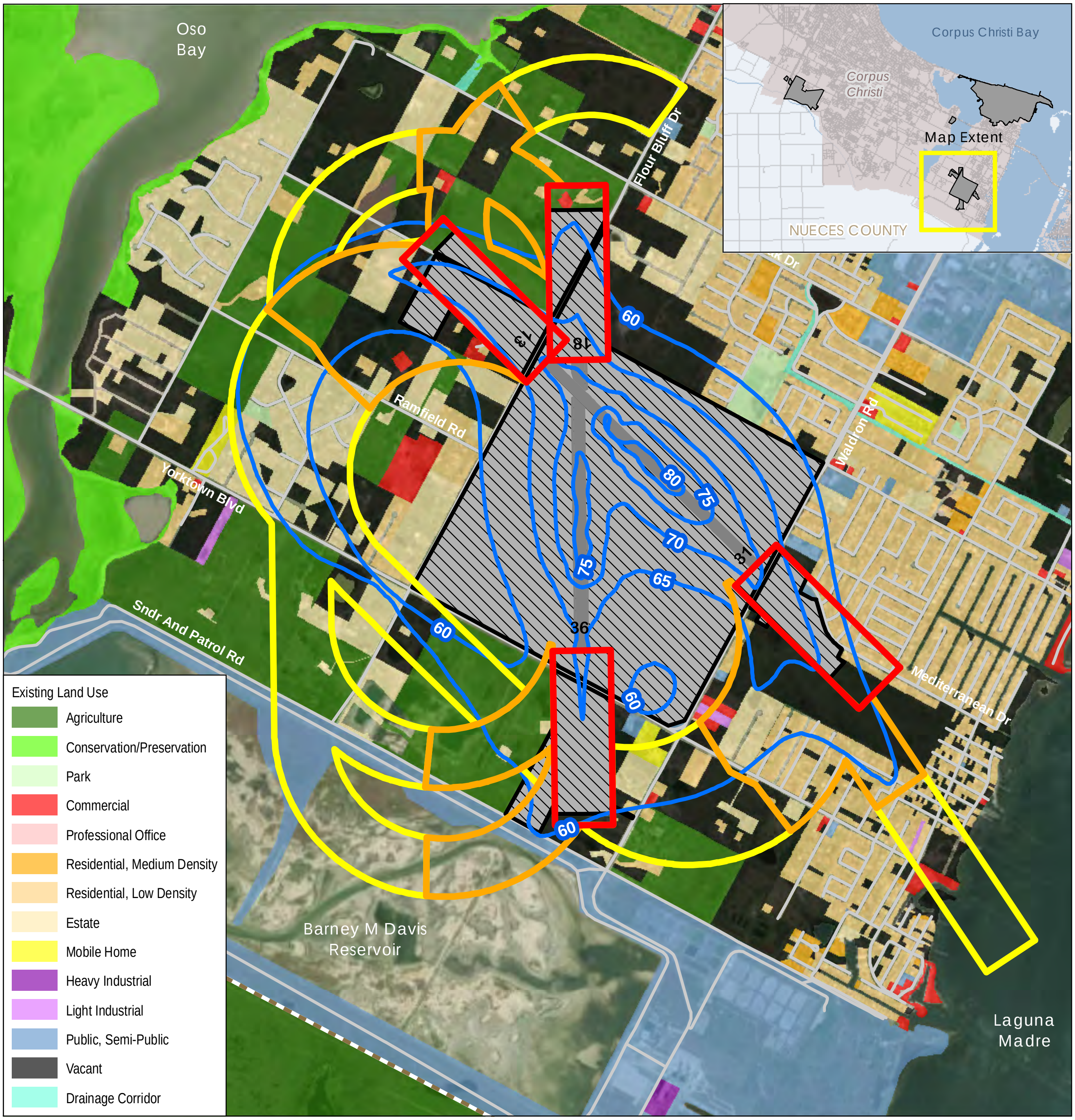
Existing Land Use	Clear Zone	APZ I	APZ II	Noise Zone 1 (60 to 64 dB DNL)[2]	Noise Zone 2 (65 to 74 dB DNL)
Agriculture	10.79	145.13	219.03	133.40	-
Conservation/Preservation	-	-	-	-	-
Commercial	1.10	7.89	3.92	7.03	-
Drainage Corridor	-	-	-	-	-
Estate	0.75	48.73	122.33	108.04	1.35
Light Industrial	-	1.49	0.87	2.35	-
Low Density Residential	15.13	58.65	35.42	53.06	0.77
Medium Density Residential	-	-	-	-	-
Mobile Home	-	-	4.17	6.28	-
Park	-	-	2.75	10.32	-
Professional Office	-	-	-	-	-
Public, Semi-Public	4.89	12.33	47.94	12.39	2.04
Vacant	15.63	166.71	181.91	197.73	17.78
Water	-	37.95	115.37	0.18	-
TOTAL[1]	**48.29**	**478.88**	**733.71**	**530.79**	**21.94**

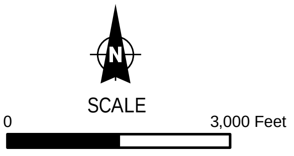
Notes:

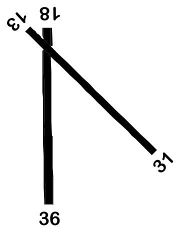
[1] Total acreage presented in Table 5-2 may differ from the off-station acreages presented in Tables 3-1 and 4-2 due to available GIS polygons for road rights-of-way.

[2] Existing land use acreage shown within Noise Zone 1 includes only the area within the 60-64 dB DNL. Noise Zone 1 is an area of low or no impact. There are no recommended land use controls for Noise Zone 1 and, as a result, it is not included in the Land Use Compatibility Analysis in Section 5.4.1.

Path: L:\Buffalo\CorpusChristi_AICUZ\MAPS\MXDs\Report_AICUZ\Spring_2020\Figure 5-4.mxd 7/22/2020







Legend

▨ NOLF Waldron

▬ Runway

▭ City Limit

Road

2020 AICUZ Noise Contours (dB)

2020 AICUZ APZs

🟥 Clear Zone

🟧 APZ I

🟨 APZ II

Figure 5-4

2020 AICUZ Footprint with Existing Land Use, NOLF Waldron

Naval Air Station
Corpus Christi, Texas

Source: ESRI 2018, Navy 2020, BRRC 2020
City of Corpus Christi 2020, Nuces County 2020
Ecology and Environment, Inc. 2020

5.2.2 ZONING

As discussed in Section 5.1.1, City of Corpus Christi, municipal zoning is limited to the extent of the city limits. County governments do not have zoning authority to control land use and development in the unincorporated areas except as provided for by the Texas Local Government Code 241, "Municipal and County Zoning Authority around Airports." The lands surrounding NOLF Cabaniss and NOLF Waldron have zoning classifications that mostly reflect the land uses. Establishing and/or enforcing zoning ordinances is the desired method to address AICUZ guidelines and compatibility at the airfields.

5.2.2.1 NOLF CABANISS

Corpus Christi zoning surrounding NOLF Cabaniss includes single-family residential, multifamily residential, general commercial, light industrial, industrial compatible, and farm rural (Figure 5-5[4]). The single-family residential districts are located north of the airfield along Saratoga Boulevard, and the light industrial and industrial compatible districts are located primarily north of the airfield near the Cabaniss Athletic Complex and east of the airfield along Weber Road. Commercial districts are located throughout the area, but are concentrated on Saratoga Boulevard and Weber Road.

5.2.2.2 NOLF WALDRON

Zoning districts surrounding NOLF Waldron largely mirror existing land uses. Single-family residential, farm rural, residential estate, general commercial, and industrial compatible districts are located immediately adjacent to the airfield (Figure 5-6). As currently zoned, areas of vacant or agricultural land in the area would be deemed primarily for single-family residential development. While zoned as heavy industrial, the Barney M. Davis Reservoir would likely remain as it currently is, a water reservoir area for the nearby energy center.

5.2.3 FUTURE LAND USE

Future development in the City of Corpus Christi is guided by the city's Plan CC. The Plan CC provides principles to manage growth and encourage efficient development patterns. It also identifies targeted areas for future growth. The plan provides direction for the city as a whole and is supported by area development plans, utility master plans, and, as needed, specific plans (such as neighborhood-level or street corridor plans).

5.2.3.1 NOLF CABANISS

Figure 5-7[5] illustrates future land uses anticipated surrounding NOLF Cabaniss. Vacant properties directly north of the airfield near the Cabaniss Athletic Complex are targeted growth areas for future development. These areas are primarily intended to be developed as light industrial uses, similar to the existing surrounding uses. Other areas north of the airfield that are currently utilized for agricultural purposes are targeted for future low and medium density residential developments, as well as commercial uses. Areas east of the airfield along Weber Road that are currently utilized for agricultural purposes are identified for future

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[4] At the time of publication, zoning data from the City of Corpus Christi has not been updated to reflect the new high school at the corner of Saratoga Boulevard and Kostoryz Road.

[5] At the time of publication, future land use data from the City of Corpus Christi have not been updated to reflect the new high school at the corner of Saratoga Boulevard and Kostoryz Road.

light industrial expansion as well. Other land uses around NOLF Cabaniss would generally remain as they are currently.

One exception is south of the airfield in unincorporated Nueces County. In the past several years, low density residential development in the area has predominantly occurred either on the southside of Corpus Christi or south of the city limits in Nueces County. Recently, the City of Corpus Christi has annexed areas south of NOLF Cabaniss:

- July 2019, 161 acres were annexed approximately 1.5 miles southwest of the airfield.
- November 2019, 446 acres were annexed approximately 2 miles west of the airfield.
- Separately in November 2019, an additional 281 acres were annexed approximately 1.2 mile south of the airfield (City of Corpus Christi 2019).

In total, Corpus Christi has annexed approximately 888 acres of land within 2 miles of NOLF Cabaniss over the last year. Known locally as the London area, land here will be developed primarily for residential uses. Developers have also planned for some commercial uses, as well as parks and churches for the new neighborhoods. Recent estimates have more than 3,000 homes being constructed in these newly annexed areas over the next 10 to 15 years. Additionally, the Final London Area Development Plan's (March 2020) future land use map includes commercial, institutional, and medium density residential development across Oso Creek from NOLF Cabaniss (City of Corpus Christi 2020[b]).

5.2.3.2 NOLF WALDRON

Future land uses surrounding NOLF Waldron are targeted predominately for low density residential development. As evident in Figure 5-8, most areas of either vacant or agricultural land are planned for residential development. Additionally, some vacant parcels are planned to remain vacant but would be classified as permanent open space, most notably the large area within the Runway 31 Clear Zone. The City of Corpus Christi is currently working to develop an Area Development Plan for the Flour Bluff neighborhood, including NOLF Waldron. Once developed, this plan will identify the community's vision for the future and guide the development of Flour Bluff.

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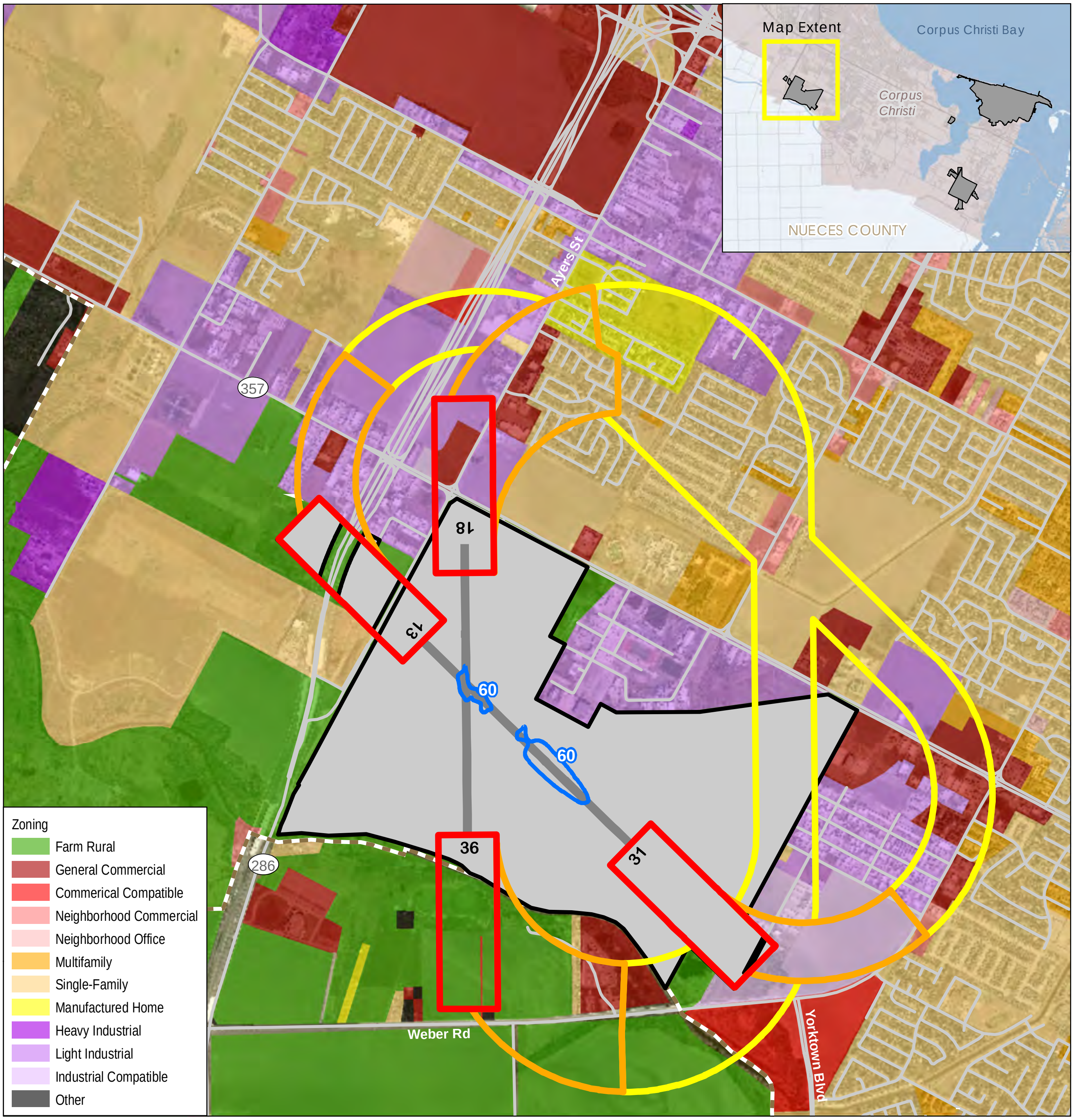


Source: ESRI 2018; Navy, 2020, BRRC 2020
City of Corpus Christi 2020, Nueces County 2020;
Ecology and Environment, Inc. 2020

Figure 5-5
2020 AICUZ Footprint
with Zoning,
NOLF Cabaniss

Naval Air Station
Corpus Christi, Texas

Path: L:\Buffalo\CorpusChristi_AICUZ\MAPS\MXDs\Report_AICUZ\07_2020_90_percent\FINAL\Figure 5-6.mxd 9/10/2020

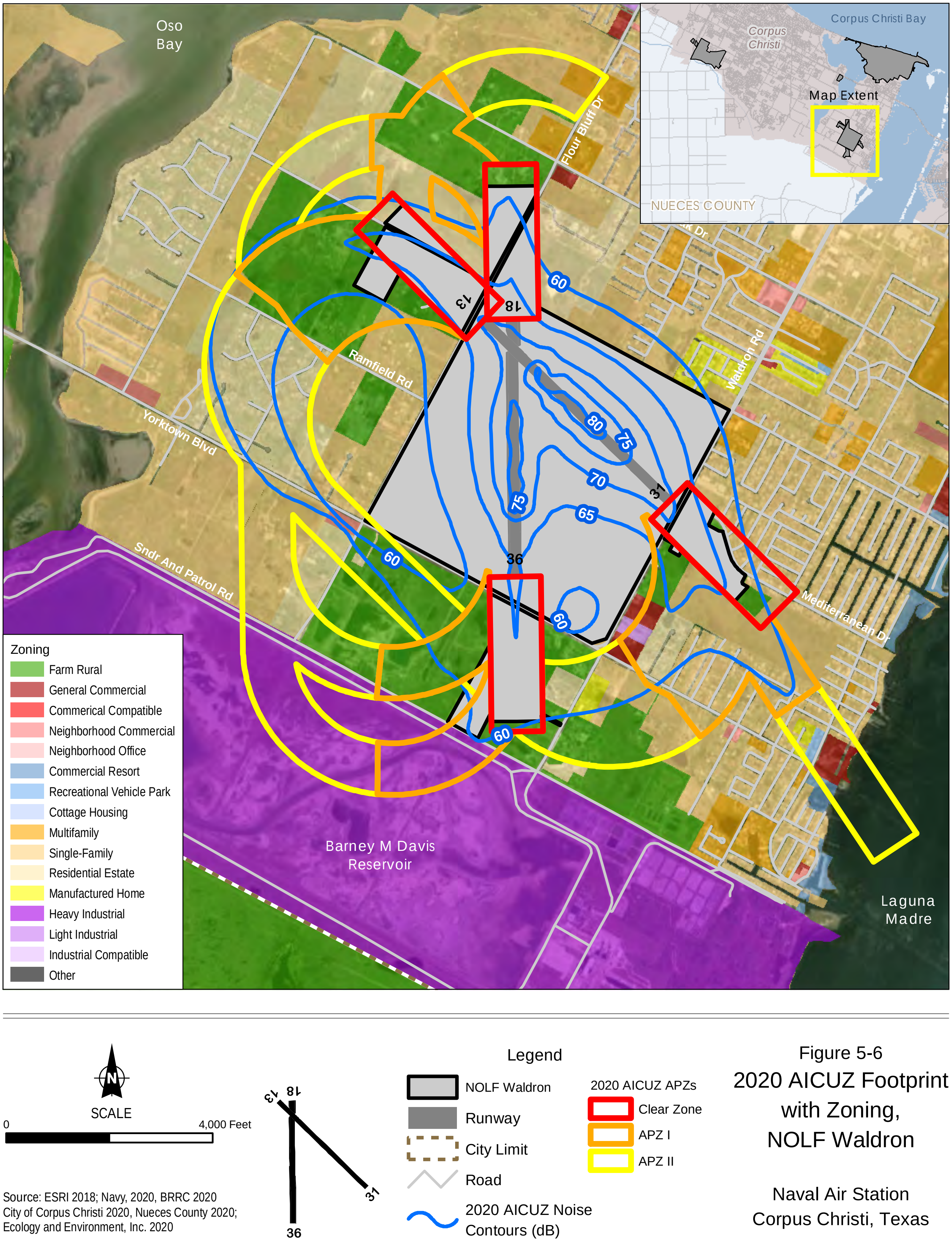
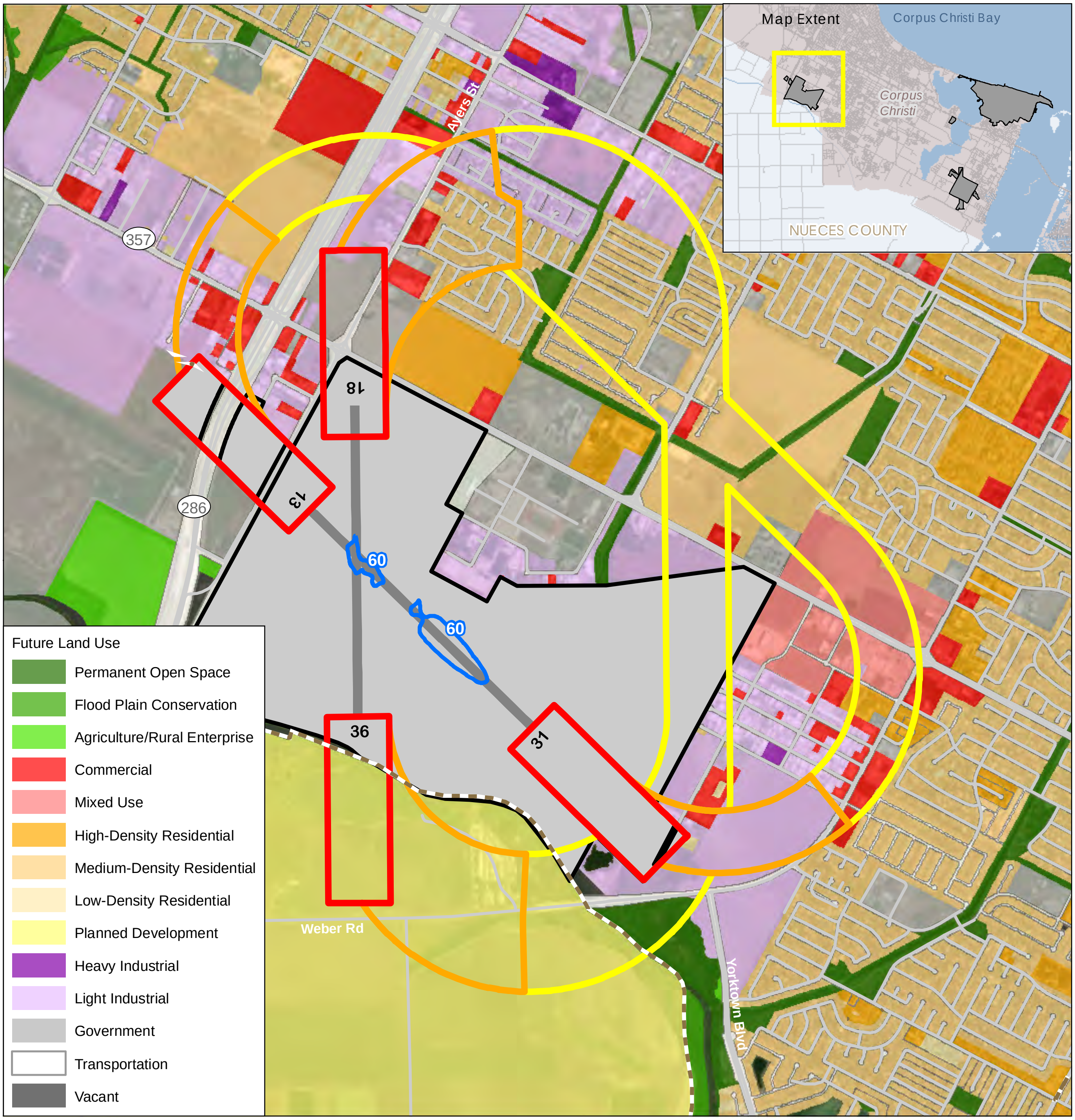


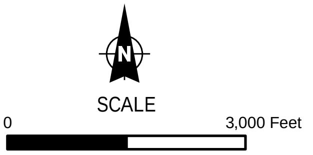
Figure 5-6
2020 AICUZ Footprint with Zoning, NOLF Waldron

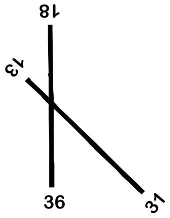
Naval Air Station
Corpus Christi, Texas

Source: ESRI 2018; Navy, 2020, BRRC 2020
City of Corpus Christi 2020, Nueces County 2020;
Ecology and Environment, Inc. 2020

Path: L:\Buffalo\CorpusChristi_AICUZ\MAPS\MXDs\Report_AICUZ\07_2020_90_percent\DRAFT_1\Figure 5-7.mxd 7/21/2020







Legend

- ▨ NOLF Cabaniss
- ▬ Runway
- ▭ City Limit
- Road
- 2020 AICUZ Noise Contours (dB)

2020 AICUZ APZs

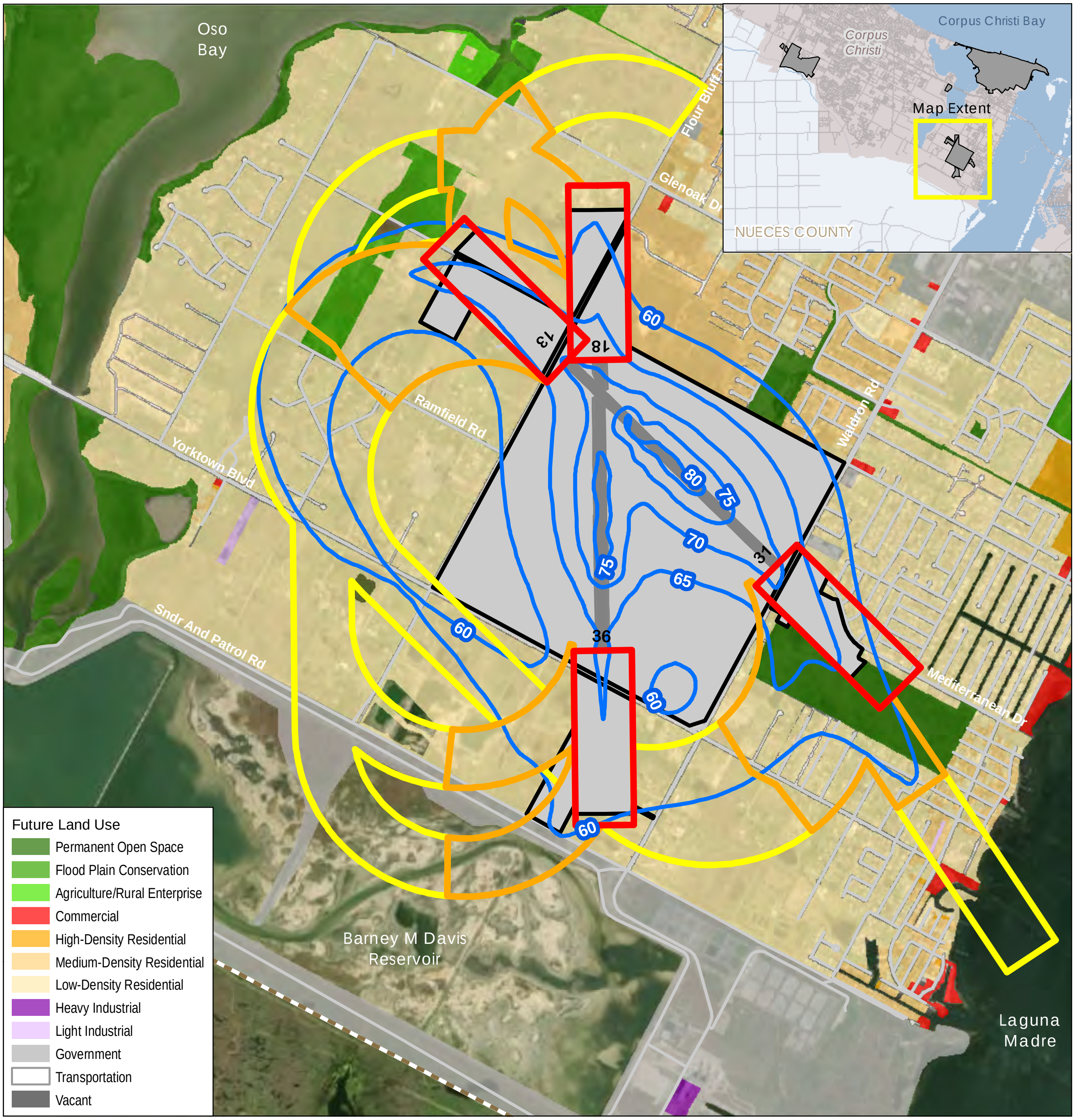
- 🟥 Clear Zone
- 🟧 APZ I
- 🟨 APZ II

Source: ESRI 2018; Navy, 2020, BRRC 2020
City of Corpus Christi 2020;
Ecology and Environment, Inc. 2020

Figure 5-7
2020 AICUZ Footprint with Future Land Use, NOLF Cabaniss

Naval Air Station
Corpus Christi, Texas

Path: L:\Buffalo\CorpusChristi_AICUZ\MAPS\MXDs\Report_AICUZ\07_2020_90_percent\DRAFT_1\Figure 5-8.mxd 7/21/2020



Source: ESRI 2018; Navy, 2020, BRRC 2020
City of Corpus Christi 2020, Nueces County 2020;
Ecology and Environment, Inc. 2020

Figure 5-8
2020 AICUZ Footprint with Future Land Use, NOLF Waldron

Naval Air Station
Corpus Christi, Texas

5.3 LAND USE COMPATIBILITY GUIDELINES AND CLASSIFICATIONS

The purpose of this section is to present the land use compatibility analysis that identifies any existing or planned land use, zoning, and development compatibility issues. Recommendations are provided in Chapter 6, Land Use Tools and Recommendations, to manage existing and future development within and around the AICUZ footprint to ensure long-term land use compatibility between local land development and the Navy's operational mission.

The AICUZ footprint is comprised of APZs and noise contours. The AICUZ footprint defines the minimum recommended area within which land use controls are needed to enhance the health, safety, and welfare of those living or working near a military airfield and to preserve the flying mission. The AICUZ footprints for NOLF Cabaniss and NOLF Waldron are the basis for the land use compatibility analysis. The AICUZ footprint, combined with the guidance and recommendations in this AICUZ Study, are the fundamental tools necessary for the planning process.

Certain land uses are incompatible with APZs and noise zones, while other land uses may be compatible or compatible under certain conditions (i.e., with restrictions). The Navy has developed land use compatibility recommendations for APZs and noise zones to foster land use compatibility. These recommendations, found in OPNAVINST 11010.36C (AICUZ Instruction), serve as guidelines for compatibility classifications with land use types surrounding the base. The guidelines recommend that noise-sensitive land uses (e.g., houses, churches, schools) be placed outside high noise zones, and that people-intensive uses (e.g., apartments, theaters, shopping centers, sports arenas) should not be placed in APZs. The land use compatibility analyses for both NOLF Cabaniss and NOLF Waldron are based on the Navy's land use compatibility recommendations, which are presented in Appendix B. To determine land use compatibility within the projected noise zones and APZs for the NOLFs, the Navy examined land use near the outlying fields.

OPNAVINST 11010.36C Recommendations

Noise-sensitive land uses (e.g., houses, churches, schools) should be placed outside high noise zones.

People-intensive uses (e.g., apartments, theaters, churches, shopping centers) should be placed outside APZs.

5.3.1 SUGGESTED LAND USE COMPATIBILITY FOR NOISE

As discussed in Section 3.1, Sound Metrics, DNL metrics present reliable measures of community sensitivity to aircraft noise. For land use planning purposes in AICUZ studies, noise exposure areas are divided into three noise zones, based on DNL measurements. Noise Zone 1 (<65 dB DNL) is an area of low or no impact. Noise Zone 2 (65 to <75 dB DNL) is an area of moderate impact where some land use controls are recommended. Noise Zone 3 (≥75 dB DNL) is the most impacted area where the greatest degree of compatible land use controls is recommended.

In addition to noise zones, areas of concern may be defined where noise levels are not normally considered to be objectionable (<65 dB DNL), but land use controls are recommended in that particular area.

It is important to note that the noise contours described in Chapter 3, Aircraft Noise, are not precise representations of noise perceived by individuals. A number of factors can influence the propagation of and reaction to noise, including geographic features, weather, and the receiver's perception of the source. A portion of the population could be annoyed even by the lower levels of noise in Noise Zone 1.

5.3.2 SUGGESTED LAND USE COMPATIBILITY FOR ACCIDENT POTENTIAL ZONES

For land use planning purposes, recommended land use compatibility guidelines for Clear Zones and APZs are shown in Appendix B. The Navy and local planning authorities use Clear Zones and APZs to ensure compatible uses and development in proximity to runway ends and slightly beyond. Although the likelihood of an accident is remote, the Navy recommends that land uses that concentrate large numbers of people, such as apartments, churches, and schools, are not located within Clear Zones and APZs.

5.3.3 STANDARD LAND USE CODING MANUAL

The Navy uses the Standard Land Use Coding Manual (SLUCM) classifications to assess compatibility with noise zones and APZs. The SLUCM reflects generic land use categories for illustrating a basic and high-level understanding of land use compatibility across some common land use types. Appendix B shows SLUCM generalized land use classifications and the associated land use compatibility with each land use designation for noise zones and APZs. However, it is important to note that the land uses provided in Appendix B do not represent the local community's land use designations. The city land use designations draw different distinctions between land uses and they employ different coding systems when compared to SLUCM's two- and four-digit coding system. With local coding systems, there may be multiple land use types per parcel (e.g., agricultural and residential use), whereas the SLUCM identifies parcels by a single type. Therefore, for the purposes of this analysis, each parcel within NOLF Cabaniss and NOLF Waldron's noise zones or APZs was compared to the closest and most reasonable SLUCM classification.

5.4 LAND USE COMPATIBILITY ANALYSIS

This section addresses land use compatibility within aircraft noise zones and APZs by examining existing and future land uses near NOLF Cabaniss and NOLF Waldron. The AICUZ footprint is the basis for the land use compatibility analysis. The AICUZ footprint for NOLF Cabaniss is largely located within the city limits of Corpus Christi, however the Clear Zone for Runway 18/36 and associated APZ I and APZ II extend outside of the city limits, extending over unincorporated Nueces County (Figure 5-1). NOLF Waldron's AICUZ footprint is located entirely within the city limits of Corpus Christi (Figure 5-2). As the City of Corpus Christi's existing land use data extends outside of city limits and within their ETJ, land uses within the off-installation AICUZ footprint for both NOLF Cabaniss and NOLF Waldron are under the jurisdiction of the City of Corpus Christi.

The land use compatibility analysis for this AICUZ Study is based on the Navy's land use compatibility guidelines, which are presented in Appendix B. Land use patterns in the vicinity of NOLF Cabaniss and NOLF Waldron are discussed in Section 5.2.1, Existing Land Use, and Section 5.2.3, Future Land Use.

5.4.1 COMPATIBILITY CONCERNS

Identifying and minimizing potential incompatible land uses within the AICUZ footprint are objectives of this AICUZ Study. It is essential to NASCC's mission that incompatible land uses are identified and minimized, where possible, and to promote compatible land uses within the AICUZ footprint. In determining land use compatibility within the AICUZ footprint, the Navy examined existing and future land use patterns near the airfield. Appendix B provides the Navy's complete land use compatibility classifications and the associated land use compatibility designations for noise zones and APZs from the AICUZ Instruction.

For analysis purposes, the areas surrounding NOLF Cabaniss and NOLF Waldron are divided into four main areas: north, east, south, and west. The existing compatibility issues and compatibility concerns associated with future land use plans and development pressures in these areas are discussed in the sections below and illustrated on corresponding figures. Recommendations are presented in Chapter 6, Land Use Tools and Recommendations, and address the specific land use compatibility issues identified.

To analyze whether current and future land use is compatible with aircraft operations, the 2020 AICUZ noise contours and APZs were overlaid on parcel data and land use classification information. The land use compatibility analysis was performed using the Navy's land use compatibility guidance and land use data from the City of Corpus Christi.

NOLF CABANISS LAND USE COMPATIBILITY CONCERNS

As discussed in Section 3.3.1, NOLF Cabaniss 2020 Noise Contours, the 2020 noise contours do not exceed 60 dB DNL and do not extend off the base boundary, therefore no land use incompatibilities exist. This section examines compatibility concerns with APZs in areas north, east, and south of the airfield. The AICUZ footprint is largely absent west of NOLF Cabaniss.

North and Northwest of NOLF Cabaniss

Within APZ I of the approach ends of Runway 18 and Runway 13, incompatible land uses include primarily low density residential and scattered commercial, light industrial, and public or semi-public developments. Many of these uses are located on or near Ayers Street north of the airfield as well as on Saratoga Boulevard.

In addition to these areas, approximately 11 acres of mobile home land uses are located within APZ I of the approach end of Runway 18, with an additional 27 acres located within APZ II of the same runway. Residential uses within APZ I, and mobile homes within APZ I or APZ II, are considered incompatible land uses per the Navy's AICUZ Instruction and should be prohibited. Future land use for the area with mobile homes is projected to be light industrial. Light industrial uses are incompatible or compatible with conditions, depending on floor area ratios of the buildings. Approximately 99 acres of low density residential uses are also located within APZ II, which can exceed the Navy's recommended one to two dwelling units/acre. The City of Corpus Christi defines low density residential uses as those containing up to three dwellings per acre. Much of this area of low density residential has a future land use forecasted to be medium density residential, which allows 4 to 13 units per acre (including two-family dwellings). Medium density residential would be incompatible within APZ I and APZ II per the AICUZ Instruction.

Additional current land use within APZ I of the approach end of Runway 13 includes vacant and agriculture uses. In future land use planning, vacant uses are projected to be light industrial and agriculture uses are projected to be medium density residential. Light industrial uses are incompatible or compatible with conditions, depending on floor area ratios of the buildings. Medium density residential uses are incompatible within APZ I.

North of NOLF Cabaniss, there is an elementary school located within APZ II of the approach end of Runway 18. Additionally, as previously discussed in Section 5.2.1, Existing Land Use, a new high school is being constructed on the corner of Saratoga Boulevard and Kostoryz Road, also within APZ II. Educational facilities are incompatible within APZ II per the AICUZ Instruction. Some scattered commercial uses are located within APZ II north of the airfield. Scattered commercial uses are also projected to be present in future land use planning. There are various types of specific commercial uses within the general land use category of commercial. The AICUZ Instruction provides guidance on the compatibility for different types of commercial uses. These areas are compatible with conditions, depending on the specific use. Refer to Appendix B for the suggested land use compatibility restrictions based on the SLUCM that reflects the site-specific land use.

Approximately 33 acres of public or semi-public uses are located within the Clear Zone of the approach end of Runway 18. While the City of Corpus Christi datasets classify this area as public or semi-public existing land uses, which is incompatible per the AICUZ Instruction, aerials show that this land is currently vacant or utilized for agricultural practices. NASCC officials are working to acquire this land through either fee simple acquisitions or restrictive use easements in order to maintain the land as undeveloped and compatible[6]. Figure 5-9 illustrates future land uses in relation to the 2020 AICUZ footprint.

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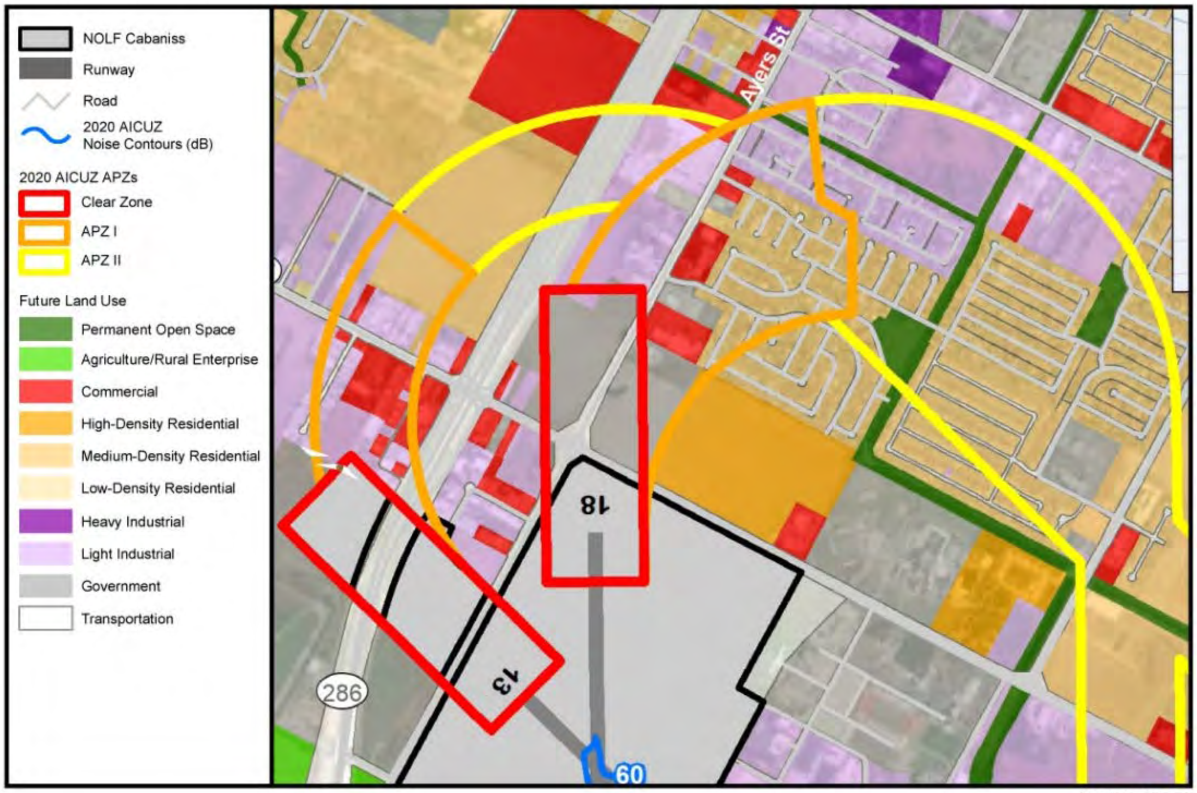
[6] Since preparation and publishing of this AICUZ Study, NASCC officials have acquired these parcels (February 9, 2021). This Study does not reflect the updated installation boundaries in figures.

In addition, while there is no land use dataset for State Highway 286, the road falls under the Clear Zone and a portion of APZ I of the approach end of Runway 13. Highways are incompatible with the Clear Zone per the AICUZ Instruction. Highways are compatible with conditions within APZ I, as passenger terminals or aboveground transmission lines are not recommended.

FIGURE 5-9 FUTURE LAND USES NORTH OF NOLF CABANISS



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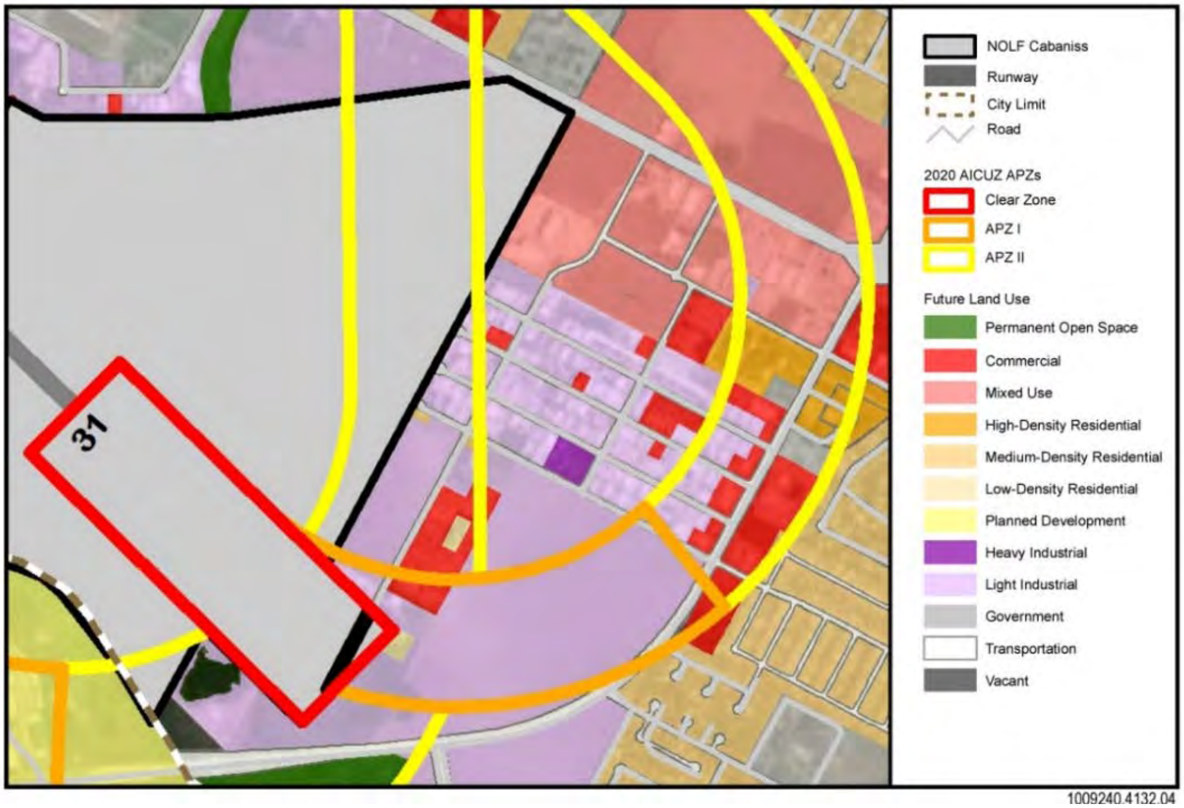
East of NOLF Cabaniss

An area of estate residential is located within the Clear Zone and APZ I associated with the approach end of Runway 31. This residence is located directly adjacent to the southeastern boundary of the airfield. This same APZ I also contain small areas of commercial, vacant, and light industrial uses also located on Brezina Road. There are also agriculture uses present in APZ I. Future land use for this area in APZ I is projected to still have low density residential use as well as commercial and light industrial uses. The current vacant area and agriculture land use within APZ I is projected to be light industrial in future land use planning. In addition, Brezina Road falls under the Clear Zone and APZ I. Highways are incompatible with the Clear Zone per the AICUZ Instruction. Highways are compatible with conditions within APZ I, as passenger terminals or aboveground transmission lines are not recommended.

Other incompatible areas east of the airfield include primarily scattered medium density residential developments within APZ II associated with Runway 13/31. The medium density residential areas are centered on Weber Road and include an apartment complex and a neighborhood with a mix of townhomes and duplexes. Medium density residential uses are incompatible per the AICUZ Instruction. The commercial uses in this area of APZ II are primarily retail or restaurant. Eating and drinking establishments are incompatible within APZ II; however, other forms of retail are compatible with conditions, such as limiting density in those particular uses. These residential and commercial uses are also present in the future land use planning for this area. Refer to Appendix B for the suggested land use compatibility restrictions based on the SLUCM that reflects the site-specific land use. Figure 5-10 illustrates these future land uses in relation to the 2020 AICUZ footprint.

FIGURE 5-10 FUTURE LAND USES EAST OF NOLF CABANISS



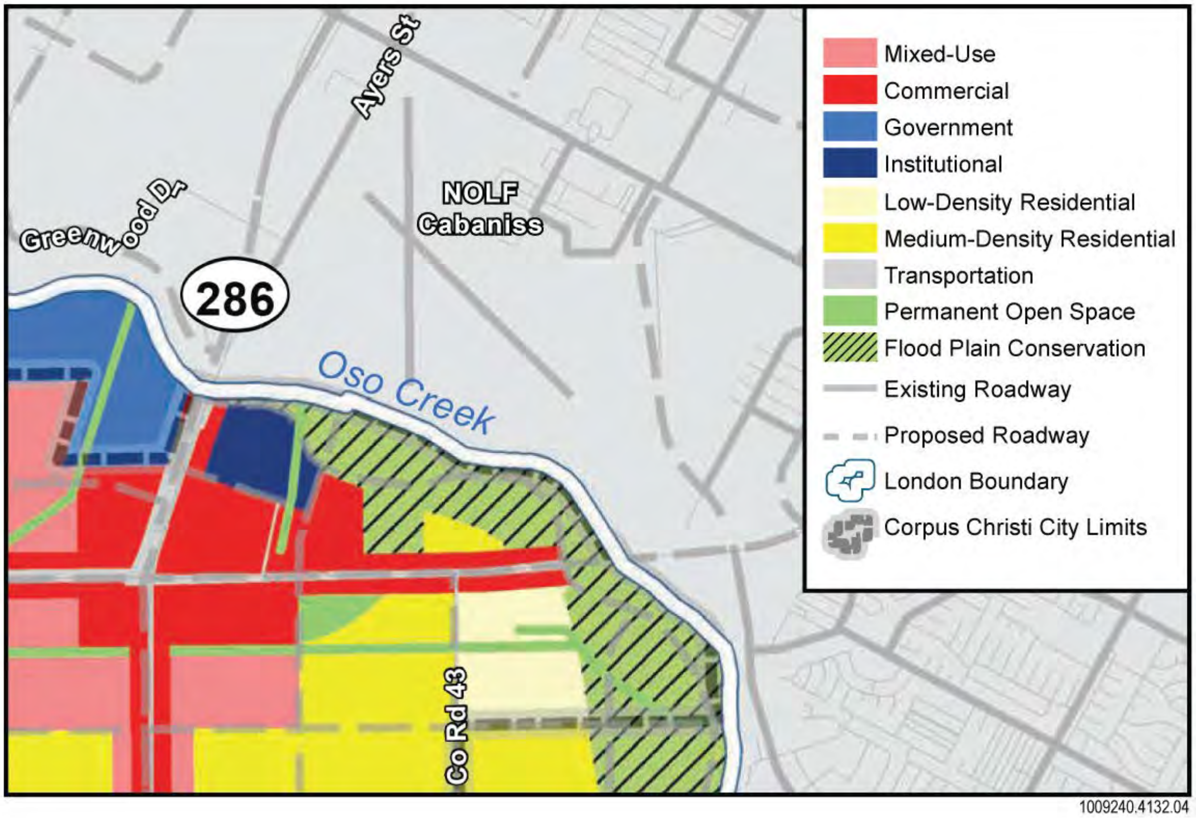
South of NOLF Cabaniss

South of Runway 36, across the Oso Creek in unincorporated Nueces County, approximately 39 acres of agricultural land are within the Clear Zone. While currently incompatible with AICUZ Instruction, there are additional compatibility concerns for future land use if the land within the Clear Zone is annexed by the City of Corpus Christi and allowed to develop per the Final London Area Development Plan's future land use map discussed in Section 5.2.3, Future Land Use. While most land within the Runway 36 Clear Zone would remain undeveloped as floodplain conservation, per the Final London Area Development Plan's future land use map, portions of the area within the Clear Zone could be developed with either commercial land uses or medium density residential, which are both incompatible. Figure 5-11 illustrates these current land uses in relation to the 2020 AICUZ footprint and Figure 5-12 shows future uses as shown in the City of Corpus Christi Final London Area Development Plan.

Other areas of current incompatible land uses south of the airfield include portions of light industrial uses within APZ I of Runway 36.

FIGURE 5-11 EXISTING LAND USES SOUTH OF NOLF CABANISS

FIGURE 5-12 LONDON AREA DEVELOPMENT PLAN FUTURE LAND USES



NOLF WALDRON LAND USE COMPATIBILITY CONCERNS

North of NOLF Waldron

Noise:

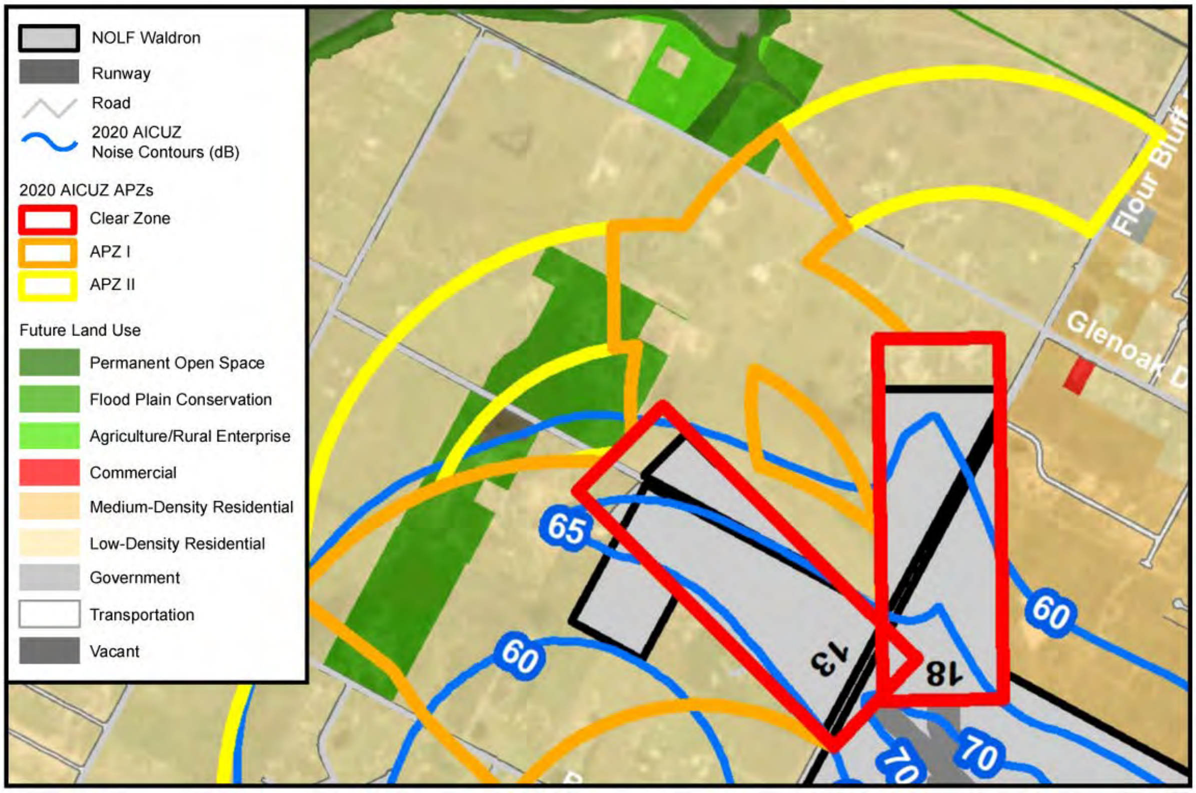
Current land uses north of NOLF Waldron are primarily compatible with the 2020 noise contours. To the north of Waldron, existing land uses include mostly vacant, agriculture, low density residential, estate residential, and small areas of commercial. A small area of estate residential is within Noise Zone 2 (65-75 dB DNL). This use is compatible with conditions. Residential use is discouraged in DNL 65-69 and measures to achieve outdoor to indoor Noise Level Reduction (NLR) of at least 25 dB in DNL 65-69 should be incorporated into building codes. The future land use for this minimal residential area is projected to remain as low density residential.

Clear Zones and APZs:

Areas of incompatibilities exist within the Clear Zone of the approach end of Runway 18, which includes, agriculture use, low density residential, and commercial development is located along Glenoak Road. The commercial development in this area is an equine center for therapy and rehabilitation. Riding stables within the Clear Zone are incompatible. There are also current incompatible land uses within the Clear Zone of the approach end of Runway 13, including agriculture, estate residential, and public and semi-public uses. These uses within the Clear Zone are not recommended per the AICUZ Instruction. Future land use within the Clear Zone of both Runway 18 and Runway 13 is projected to be low density residential which is incompatible.

Other areas of incompatible development north of NOLF Waldron include small pockets of low density residential and commercial, as well as areas of estate residential development within both Runway 18 and Runway 13's APZ I. Agriculture uses are present within APZ I. Agriculture use is compatible with conditions, such as it excludes feedlots and intensive animal husbandry. The AICUZ Instruction recommends that activities that attract concentrations of birds creating a hazard to aircraft operations should be excluded. Vacant land is located within APZ I and II north of NOLF Waldron. While vacant is compatible, future uses of these land uses include medium and low density residential use. Medium density residential is incompatible in these zones per the AICUZ Instruction. Low density residential is incompatible within APZ I and is compatible with conditions in APZ II (compatible if fewer than two dwelling units per acre). Other future uses for current vacant areas include flood plain conservation. Figure 5-13 illustrates these future land uses in relation to the 2020 AICUZ footprint.

FIGURE 5-13 FUTURE LAND USES NORTH OF NOLF WALDRON



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East of NOLF Waldron

Noise:

East of the airfield, small areas of low density residential uses and vacant uses are located within Noise Zone 2 (65-75 dB DNL) on Waldron Road. The area is currently zoned as farm rural and single family residential. Future uses are projected to be low density residential and permanent open space. Residential uses within Noise Zone 2 are incompatible per the Navy's AICUZ Instruction and should be discouraged through community outreach and education and the enforcement of zoning ordinances. However, residential uses may be considered compatible if they meet specific standards to achieve outdoor to indoor NLR by incorporating noise attenuation into the design and construction of the structures (see footnote 28 of Table 5-1 in Section 5.3.3, Standard Land Use Coding Manual).

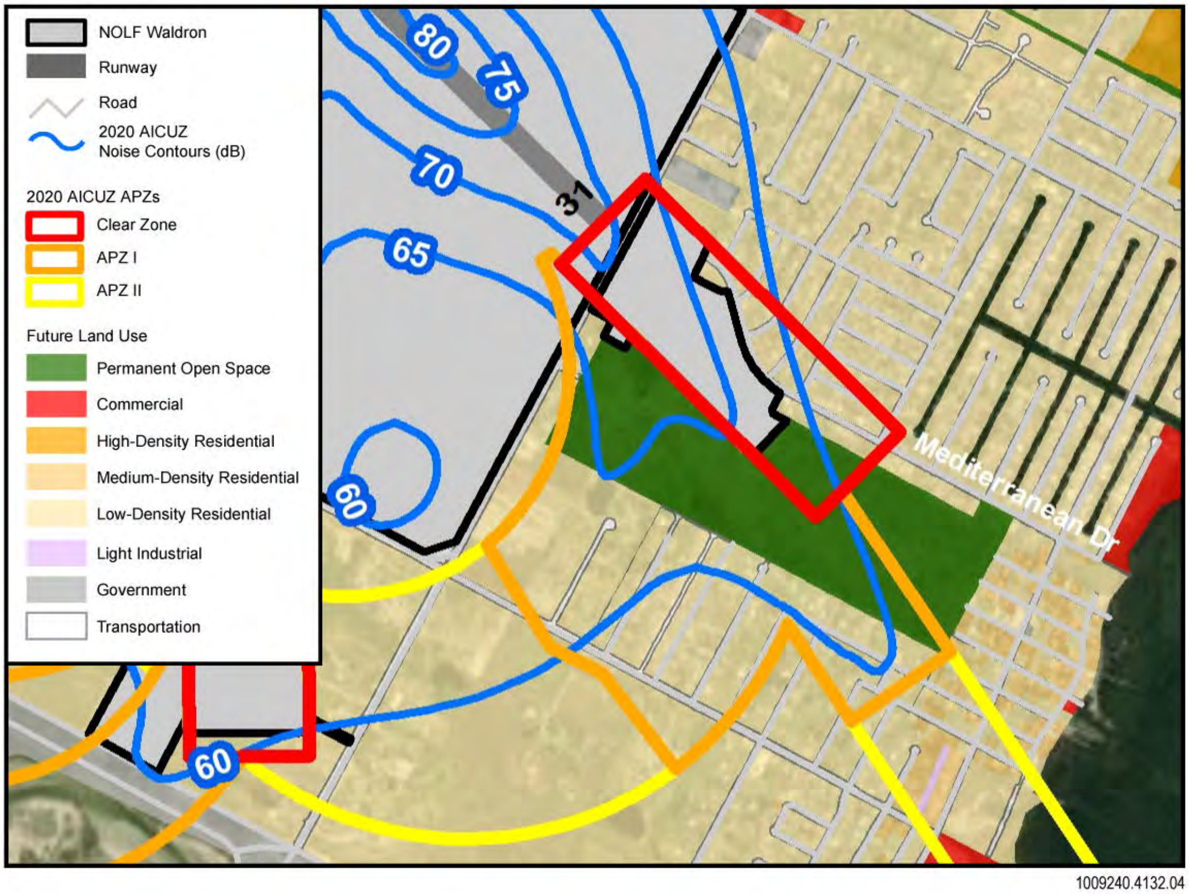
Clear Zones and APZs:

A low density residential neighborhood is located east of the airfield within the Clear Zone of the approach end of Runway 31. The neighborhood is comprised of single-family residential homes. While the majority of the undeveloped area of the Clear Zone is under the management of the Navy, a small public use area is also located within the Clear Zone. Based on aerial imagery, this area appears to be a small basketball court for the neighborhood to utilize. NASCC officials are working on a land exchange deal with the City of Corpus Christi for this area. Once the land exchange occurs, this public use area within the Clear Zone would be within the Navy's possession. Residences within a Clear Zone present a significant safety concern and should be addressed, as circumstances allow, with cooperation between the Navy and the City of Corpus Christi.

Other areas of incompatible current land uses east of NOLF Waldron include low density residential and estate residential areas within APZ I along Yorktown Boulevard southeast of the airfield. Small areas of commercial and light industrial uses are also within APZ I of this area along Waldron Road directly adjacent to the airfield. Low density residential uses within APZ II are also incompatible due to the allowed density of three dwelling units per acre, per the City of Corpus Christi's land use regulations (the Navy recommends only one to two dwellings units per acre within APZ II). Within APZ II, there are both current uses and areas zoned for mobile homes, which are incompatible within APZ II per the AICUZ Instruction. Land within APZ I and APZ II of the approach end of Runway 31 are projected to be low density residential uses in future land use. Figure 5-14 illustrates these future land uses in relation to the 2020 AICUZ footprint.

Of note, there are vacant land uses to the east of NOLF Waldron off the approach end of Runway 13/31 and Runway 18/36, much of it located within their respective Clear Zones, APZ I, and APZ II. While vacant land use is compatible, future uses of the area include low density residential use. Low density residential is incompatible within the Clear Zone and APZ I and is compatible with conditions in APZ II (compatible if fewer than two dwelling units per acre). A portion of vacant land located within the approach end of Runway 31 Clear Zone and APZ I shows future use designated as permanent open space. This would be compatible with conditions, depending on the uses, e.g., large public gatherings are discouraged in those areas.

FIGURE 5-14 FUTURE LAND USES EAST OF NOLF WALDRON



South of NOLF Waldron

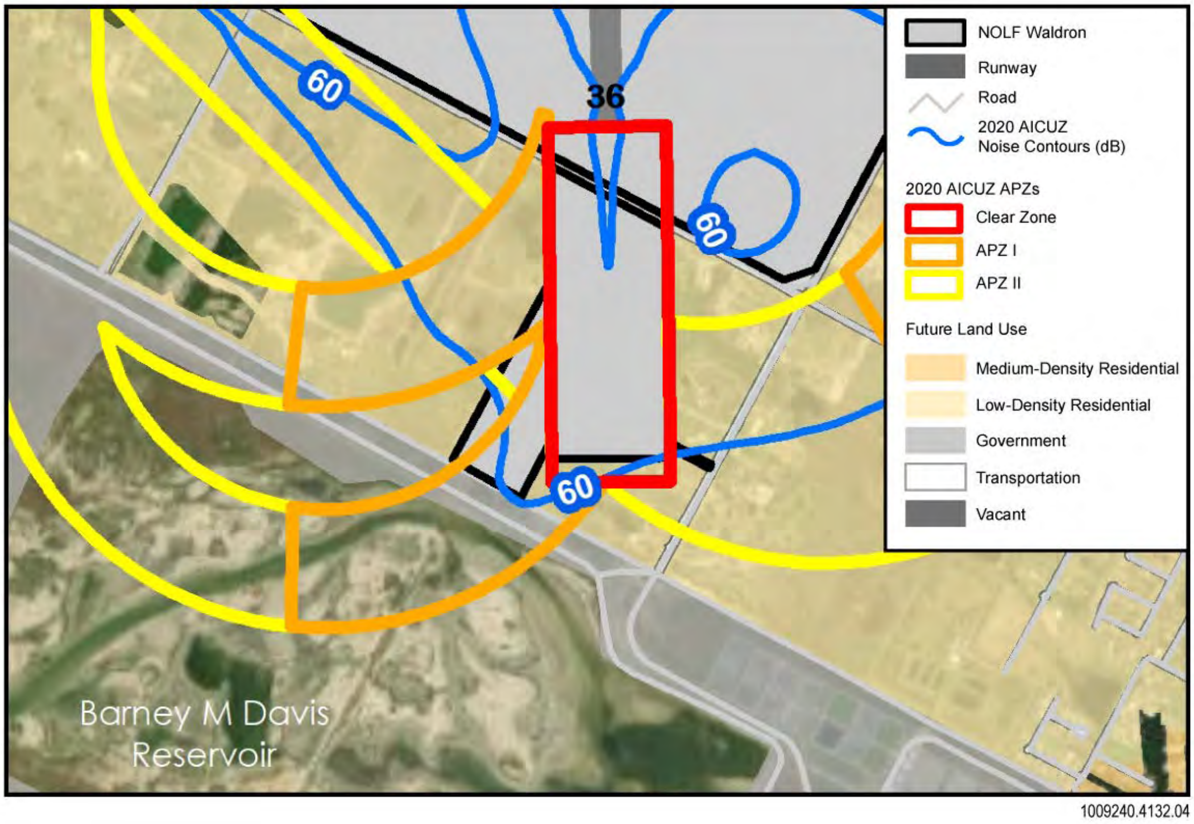
Noise:

Current land uses south of NOLF Waldron are primarily compatible with the 2020 noise contours. Refer to Appendix B for the suggested land use compatibility restrictions based on the SLUCM that reflects the site-specific land use.

Clear Zones and APZs:

Small areas of estate residential and low density residential development are located in APZ I south of the airfield, as well as a small mobile home park in APZ II, near the intersection of Waldron Road and Yorktown Boulevard. These areas are projected to be low density residential uses according to future land use data. Current agricultural uses within the approach end of Runway 36 are also projected to be low density residential uses in the future. These residential uses are incompatible per the AICUZ Instruction. Figure 5-15 illustrates these future land uses in relation to the 2020 AICUZ footprint.

FIGURE 5-15 FUTURE LAND USES SOUTH OF NOLF WALDRON



West of NOLF Waldron

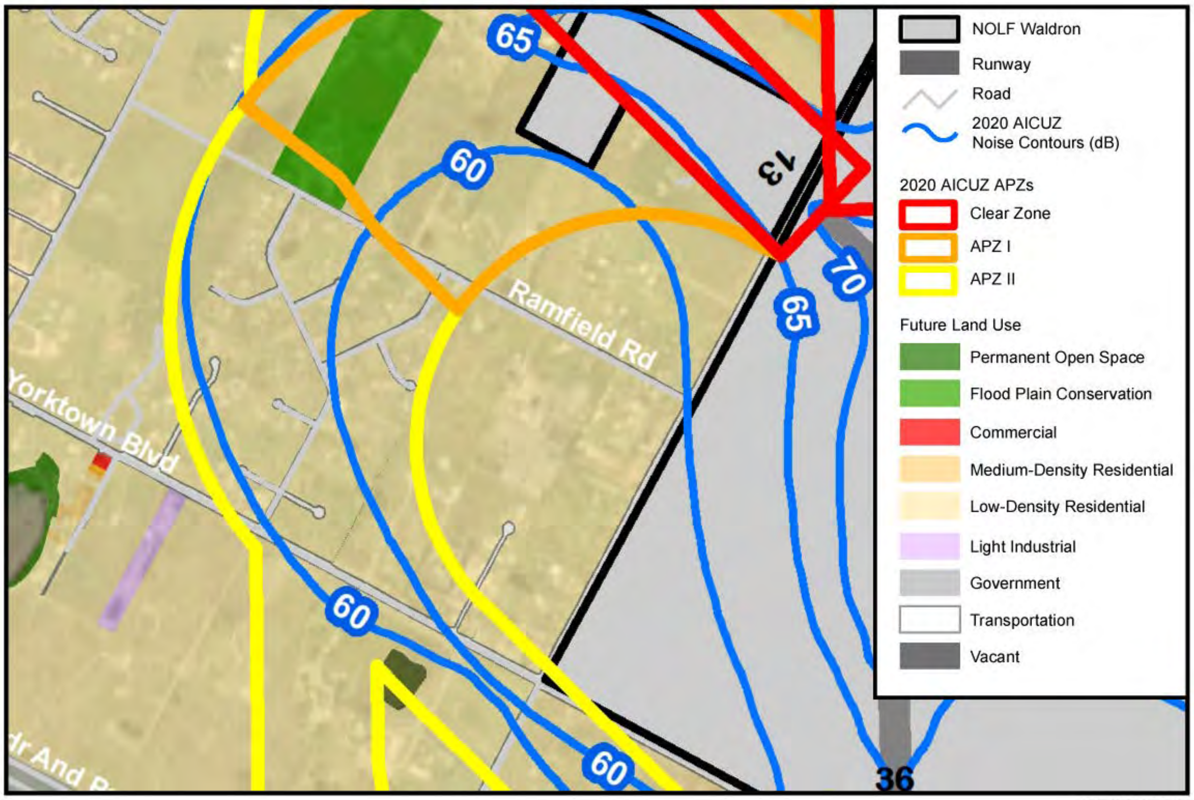
Noise:

West of NOLF Waldron, small areas of estate residential existing land uses are located within Noise Zone 2 (65-75 dB DNL) off Caribbean Drive. Although local conditions regarding the need for housing may require residential use in this zone, residential use is discouraged in Noise Zone 2 per the AICUZ Instruction. These residential areas are also located within an APZ I.

Clear Zones and APZs:

Additional incompatible current land uses with the 2020 APZs for NOLF Waldron include small pockets of commercial, estate, and low density residential uses within APZ I along with estate residential uses in APZ II. The zoning designations for this area are similar to current uses and include farm rural, residential estate, and single family residential. Future land use planning for the areas within APZ I and APZ II are projected to be low density residential. Low density residential is incompatible within APZ I and is compatible with conditions in APZ II (compatible if fewer than two dwelling units per acre). Figure 5-16 illustrates these future land uses in relation to the 2020 AICUZ footprint.

FIGURE 5-16 FUTURE LAND USES WEST OF NOLF WALDRON



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6

LAND USE TOOLS AND RECOMMENDATIONS

This chapter discusses tools and recommendations that can be implemented to manage existing and future development within and around the AICUZ footprint. Successful AICUZ land use compatibility implementation is the collective responsibility of the Navy, federal, state, and regional governments, citizens, business owners, and real estate professionals. This chapter provides tools and recommendations that, when implemented, will continue to advance NASCC and community partners to achieve their shared goal, "to protect the health, safety, and welfare of those living near military airfields, while preserving the defense flying mission."

6.1 FEDERAL/NAVY TOOLS AND RECOMMENDATIONS

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

6.1.1 FEDERAL/NAVY TOOLS

NATIONAL ENVIRONMENTAL POLICY ACT

Under the National Environmental Policy Act (NEPA), federal agencies, including the Navy, are required to consider the impacts of any federal project that could significantly impact the environment. NEPA mandates full disclosure of the environmental effects resulting from proposed federal actions, approvals, or funding. Generally, an EA or environmental impact statement will document the impacts of the action. The environmental impact review process provides an opportunity for the public and the Navy to comment on federal agency projects that may affect land use decisions on NASCC, the NOLFs, or the surrounding area.

HOUSING AND URBAN DEVELOPMENT

Under U.S. Department of Housing and Urban Development (HUD) Circular 1390.2, "Noise Abatement and Control," HUD established noise standards and polices for approving noise attenuation measures and HUD-assisted housing projects in high noise areas. The HUD regulations set forth a discretionary policy to withhold funds for housing projects when noise exposure exceeds prescribed levels. The HUD regulations allow for new housing construction assisted or supported by HUD within a noise area of 65 dB DNL or less. Construction within a 65 to 75 dB DNL noise area is subject to appropriate sound attenuation measures (e.g., dense wall material [concrete, brick], cavity partitions [airspace between two walls], acoustical blankets [insolation], double-paned windows, solid core wood doors), and construction within an area exceeding 75 dB DNL is not acceptable. Due to the discretionary framework of the HUD policy, variances may be permitted, depending on regional interpretation and local conditions. HUD regulations include policies that prohibit funding for HUD-assisted projects sited in Clear Zones and APZs unless the project is compatible with the AICUZ. Additionally, the approval of all mortgage loans from the Federal Housing Administration or the Veterans Administration is subject to the standards and polices of HUD noise regulations (HUD 24 CFR 51, Subpart D).

MILITARY AVIATION AND INSTALLATION ASSURANCE SITING CLEARINGHOUSE

The Military Aviation and Installation Assurance Siting Clearinghouse, commonly known as the Clearinghouse, works with industry to overcome risks to national security while promoting compatible energy development. Energy production facilities and transmission projects involving tall structures, such as wind turbines, solar power towers and panels, and electrical transmission towers, have the potential to degrade military operations. The DOD's Mission Compatibility Evaluation process provides a timely, clear, and science-based analysis of potential impacts to military operations. Once impacts are identified, the DOD works to identify mitigation strategies to minimize those impacts. The Clearinghouse serves as a single point of contact for federal agencies; state, tribal, and local governments; developers; and landowners. The website is a central location to provide information and to assist interested users in understanding the mission impacts of proposed energy projects near military activities, and the DOD's Mission Compatibility Evaluation process, procedures, and mitigation opportunities. In addition, NASCC officials will continue to monitor proposed wind developments in the area and work closely with local landowners, wind developers, CNATRA, as well as local, state, and federal governments to coordinate suitable locations for wind development where military activities would not be impacted.

Military Aviation and Installation Assurance Siting Clearinghouse Website: https://www.acq.osd.mil/dodsc/index.html

READINESS AND ENVIRONMENTAL PROTECTION INTEGRATION

The National Defense Authorization Act of 2004 granted the DOD the authority to enter into agreements (or partnerships) with private conservation organizations or state and local governments to establish buffers around military training and testing areas to restrict incompatible land use. Funding for the compatible land use efforts is provided to the DOD by Congress under the Readiness and Environmental Protection Integration (REPI) Program. REPI Program funding will support service agreements that, as authorized by 10 United States Code §2684a, seek to:

1. Limit any development or use of property that would be incompatible with the mission of the installations; or

2. Preserve off-installation habitat to relieve current or future environmental restrictions on military operations.

The REPI Program helps military installations sustain operational capabilities and ensure the future use of military training areas. Under the REPI Program, the DOD provides funding to military services in support of cost-sharing partnerships with non-federal organizations to purchase easements or acquire an interest in land. Land acquisition initiatives must be negotiated with a willing seller. Through partnerships, military services work with local and state agencies or conservation organizations to identify areas where land acquisition or conservation easements would be mutually beneficial for all parties. The partnership obtains property interest with the goal of controlling growth, preserving open space, and ultimately preventing future encroachment. The protected land obtained through REPI Program funding is not owned by the military or used for military training or testing.

6.1.2 FEDERAL/NAVY ACTION RECOMMENDATIONS

The Navy has the responsibility to communicate and collaborate with local governments on land use planning, zoning, and compatibility concerns that affect its mission. The following include both general and specific recommendations for the Navy and NASCC to consider:

- Continue to implement an AICUZ Program for the air installation and associated outlying landing fields, while also working with state and local planning officials to implement the objectives of the AICUZ Study;
- Continue participation in the ongoing Joint Land Use Study (JLUS) implementation efforts;
- Continue to explore the REPI program as a tool to further promote compatible land use surrounding NOLF Cabaniss and NOLF Waldron.
- Continue to provide local real estate agencies with AICUZ related materials and meet with the local Board of Realtors to discuss the importance of real estate disclosure when buying or selling property within or near the AICUZ footprint;
- Promote attendance at AICUZ seminars by COs, executive officers, Air Operations officers, ATC facility officers, the CPLO, and other aviation-related staff to increase awareness of current trends and techniques for AICUZ Program development and implementation; and
- Notify the chain-of-command in the AICUZ Program office whenever local conditions merit update or review of the AICUZ Study.
- Formalize or provide advertisement for the noise complaint process to the public.

In addition to the above recommendations, NASCC should also consider the following:

- Representatives (i.e., CPLO, Public Affairs Officer [PAO], and CO) should continue to attend public hearings (meetings) and provide comments on actions that affect AICUZ planning for NASCC, including continuing to send a member to represent the base on the Corpus Christi Planning Commission; and

- Continue to provide community decision makers with the information necessary to make informed decisions regarding the impacts of their actions on mission readiness though continued communication and outreach as well as utilizing tools such as the AICUZ Study outreach or the Clearinghouse website;

6.2 STATE/REGIONAL TOOLS AND RECOMMENDATIONS

6.2.1 STATE/REGIONAL TOOLS

In addition to the planning entities identified in Section 5.1, Planning Authorities, there are other state organizations and/or policies that provide land use controls and manage growth around NASCC as well as help promote their mission.

TEXAS MILITARY PREPAREDNESS COMMISSION

Established in 2003, the mission of the Texas Military Preparedness Commission (TMPC) is to preserve, protect, expand, and attract new military missions, assets, and installations in the state of Texas. The TMPC offers assistance and leadership on defense-related issues to defense communities, military installations, and related businesses. The TMPC consists of 13 members appointed by the governor of Texas with the mission to preserve military installations in the state. Base commanders can request TMPC assistance to coordinate with state agencies to prepare base evaluation criteria for incoming missions and tenants.

TEXAS COMMANDERS COUNCIL

The Texas Commanders Council (TCC) is a coalition of major military installations that provides an information-sharing forum to formulate comprehensive resolutions for encroachment concerns among the bases in Texas. The TCC provides the installations with an effective avenue to communicate and coordinate with state legislators. The TCC works jointly in cooperation with the State of Texas to ensure the sustainability of the military missions and operating bases in the state, and for the continued preservation of the vital combat training ranges and flying airspace.

COASTAL BEND COUNCIL OF GOVERNMENTS

The Coastal Bend Council of Governments (CBCOG) is a volunteer association of local governments, cities and counties, and other public and private entities and was formed in March 1966, by the authority of the State of Texas. There are 11 member counties and 33 member cities, along with staff. The CBCOG plans, coordinates and implements regional projects and provides technical assistance within the region. It is one of 24 Council of Governments in Texas, all legally defined as political subdivisions of the state. The CBCOG is a governmental agency with legal responsibility for multijurisdictional planning in program areas such as emergency communication systems, criminal justice, solid waste management, environmental protection, and homeland security planning, in addition to being the designated Area Agency on Aging and Economic Development District (CBCOG 2020).

REAL ESTATE DISCLOSURE

Real estate disclosures are used in Texas to notify potential homebuyers of conditions affecting the property that they should be aware prior to purchase. State of Texas legislation requires real estate disclosures for all real estate transactions within the Military Influence Areas.

The Texas Legislature passed House Bill 890 during the 85th Regular Session (amending Section 1, Chapter 397 of the Texas Local Government Code) which implements providing information to the public and purchasers of real property on the impact of military installations. The legislation requires counties and cities in which a military installation is located to work to ensure the public availability of the most recent AICUZ or JLUS. A Seller's Disclosure Notice must also acknowledge if a property may be near a military installation and subject to high noise, APZs, or other operations. Legislation only pertains to resale of existing homes and became effective Sept 1, 2017.

SENATE BILL (SB) 277

SB 277 was passed in 2017 and focusses on specific property's eligibility to acquire certain ad valorem tax incentives related to wind-powered energy devices (e.g., wind farms). SB 277 eliminates property tax exemptions for wind projects that are located within 25 nautical miles of military aviation facilities in the state (State of Texas 2017). As many wind farms have been developed in south Texas, and many wind developers seek out tax exemptions in their developments, SB 277 is crucial for maintaining obstruction free airspaces for Navy flight training (see Section 4.5, Other Potential Compatibility Concerns, for additional information on wind farm development in the area).

6.2.2 STATE RECOMMENDATIONS

The Navy should continue to work with the TMPC, the TCC, and the CBCOG to propose state-wide and regional regulations that promote compatible development surrounding NASCC. NASCC should provide these organizations with information regarding Navy air operations and the AICUZ Program.

6.3 LOCAL GOVERNMENT TOOLS AND RECOMMENDATIONS

Local governments have the authority to implement regulations and programs to control development and direct growth to ensure land use activity is compatible within the AICUZ footprint. Local governments should recognize their responsibility in providing land use controls in those areas encumbered by the AICUZ footprint by incorporating AICUZ information into their planning policies and regulations. The following tools and recommendations will support compatible development practices within the vicinity of the installation.

6.3.1 LOCAL AND REGIONAL GOVERNMENT TOOLS

NAS CORPUS CHRISTI JOINT LAND USE STUDY

A JLUS is a cooperating planning initiative between an installation and the surrounding cities/counties. Sponsored by the DOD's Office of Economic Adjustment, the JLUS helps introduce AICUZ technical data into local planning and recommends cooperative implementation actions for the community and installation to address current and future land use compatibility.

NASCC and the City of Corpus Christi prepared and adopted a JLUS in 2013 that called for land use changes to ensure compatibility with military and civilian aviation. The JLUS was aimed to guide planning and development in the areas surrounding NASCC's Truax Field, Cabaniss Field, Waldron Field, and Corpus Christi International Airport. The purpose of the JLUS is to identify goals, policies, and implementation strategies necessary to achieve greater land use compatibility surrounding the Navy airfields, including NOLF Cabaniss and NOLF Waldron. The study prioritized compatibility concerns by high, medium, low, and awareness factors and provided recommendations and proposed implementation strategies.

BUILDING CODES

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

LAND ACQUISITION PROGRAM

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

6.3.2 LOCAL AND REGIONAL GOVERNMENT RECOMMENDATIONS

COMMUNICATION AND PLANNING PARTNERSHIPS WITH NASCC

NASCC is responsible for informing and educating community decision makers about the AICUZ Program; however, local governments (Nueces County and the City of Corpus Christi) should continue to actively inform and request input from NASCC regarding land use decisions that could impact the readiness of the Navy. Before local governments make land use decisions for areas near the installation and the AICUZ footprint, they should consider the following:

- Decisions may influence the capabilities of NASCC and potentially have a negative impact on military readiness and national security;
- Decisions may decrease the capabilities of the airfield, thereby increasing the chances of the local commands having to relocate resources to ensure training is completed;
- Noise contours and APZs that comprise the AICUZ footprint are dynamic and may change over time; and
- A proactive approach to planning with the Navy will serve the local population by mitigating, in advance, potential problems with noise and safety concerns.

The Navy recommends that local government websites include information about the AICUZ Program and provide a link to the NASCC website. Local governments are recommended to coordinate with NASCC on aircraft operations and work to ensure the safety of all parties.

ADOPT AICUZ GUIDELINES INTO LOCAL LAND USE PLANS AND REGULATIONS

- The Navy recommends that the AICUZ Study, particularly the projected noise contours and APZs, be adopted into individual county and city planning studies, Comprehensive Plans, zoning ordinances and regulations, and development processes to best guide compatible development around the installation.
- The AICUZ Study is intended to support local government land use planning programs and processes by providing scientifically based technical information on military activities. Local governments should, to the extent possible, adhere to the land use recommendations in the AICUZ Instruction to reduce noise exposure, safety, height obstructions, and incompatible development within AICUZ footprint.
- Consider including the AICUZ footprint and real estate disclosures in zoning ordinances and regulations for new and existing homes.

LOCAL INTERGOVERNMENTAL COORDINATION

- The Corpus Christi Planning Commission should continue to invite NASCC representatives to participate in the local development review staff process as a way to integrate the military's missions with the local government's planning and development review processes.
- The review process presents an opportunity for a military representative to work with a local government's development review team to identify issues and opportunities associated with the development application. As a major stakeholder in the community, the military is able to offer valuable insight to decision makers so that they can consider a development proposal's full impact on all stakeholders.
- The City of Corpus Christi should include information about the AICUZ Program on websites and provide a link to the NASCC website.
- Developers should utilize resources such as the AICUZ Study, local planning documents, and tools such as the Clearinghouse website to ensure their proposed development is compatible with NASCC's mission.

6.4 PRIVATE CITIZENS/REAL ESTATE PROFESSIONALS TOOLS AND RECOMMENDATIONS

Private citizens, real estate professionals, and businesses should recognize their responsibility in adhering to and complying with land use controls in those areas encumbered by the AICUZ footprint.

6.4.1 PRIVATE CITIZENS/REAL ESTATE PROFESSIONALS TOOLS

LENDING PRACTICES

Lending institutions should consider whether to limit financing for real estate purchases or construction that is incompatible with the AICUZ Program. This strategy encourages evaluation of noise and safety potential as part of a lender's investigation of potential loans to private interests for real estate acquisition and development. Diligent lending practices will promote compatible development of the area surrounding NASCC and protect lenders and developers alike.

REAL ESTATE PROFESSIONALS BEST PRACTICES

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.

PRIVATE CITIZENS

Citizens have the responsibility to do their due diligence to avoid purchasing property and/or investing in construction projects on property within high noise zones and/or APZs.

6.4.2 PRIVATE CITIZENS/REAL ESTATE PROFESSIONALS RECOMMENDATIONS

Businesses, real estate professionals, and private citizens, should recognize their responsibility in adhering to and complying with land use controls in those areas encumbered by the AICUZ footprint. The list below provides actions, procedures, and recommendations that community groups can use or consider to help control development within the 2020 AICUZ footprint.

- Local banking and financial institutions should be encouraged to incorporate a due diligence review of all loan applications to determine possible noise and/or safety impacts on the mortgaged property.
- Real estate professionals should continue to ensure that prospective buyers or lessees have all available and required information concerning the noise environment and accident potential zones surrounding the NOLFs prior to purchasing or leasing property in the area.
- Residents considering purchasing, renting, or leasing properties near NASCC should ask local real estate professionals, lending institutions, city planning personnel, county appraisal personnel, and/or a Navy representative if the property is within an APZ and/or noise zone.

- Residents of the local communities should become informed about the AICUZ Program and learn about the program's goals and objectives, its value in protecting the health, safety, and welfare of the population, the limits of the program, and the positive community aspects of a successful AICUZ Program.

6.5 REFERENCE FOR IMPLEMENTING LAND USE TOOLS AND RECOMMENDATIONS FOR AREAS OF COMPATIBILITY CONCERN

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

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

Table 6-1 provides a list of areas of compatibility concern related to NOLF Cabaniss and NOLF Waldron as well as land use tools and recommendations that are available for stakeholders to implement. The table is effective in highlighting examples of compatibility concerns that have been raised throughout this AICUZ Study and provides a suite of cumulative tools and recommendations that can be used to address these areas of concern.

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

To use this overview effectively, it is important to first understand the compatibility criteria that were explained in detail in Section 3.3, AICUZ Noise Contours, and Section 4.2, AICUZ Clear Zones and APZs. The compatibility criteria, along with the land use compatibility guidelines for the AICUZ footprint explained in Section 5.3, Land Use Compatibility Guidelines and Classifications, provide a basis to then identify the compatibility concerns at NOLF Cabaniss and NOLF Waldron. This section provides a reference of the tools and recommendations for various groups of stakeholders to address the concerns that were identified throughout Section 5.4.1, Compatibility Concerns.

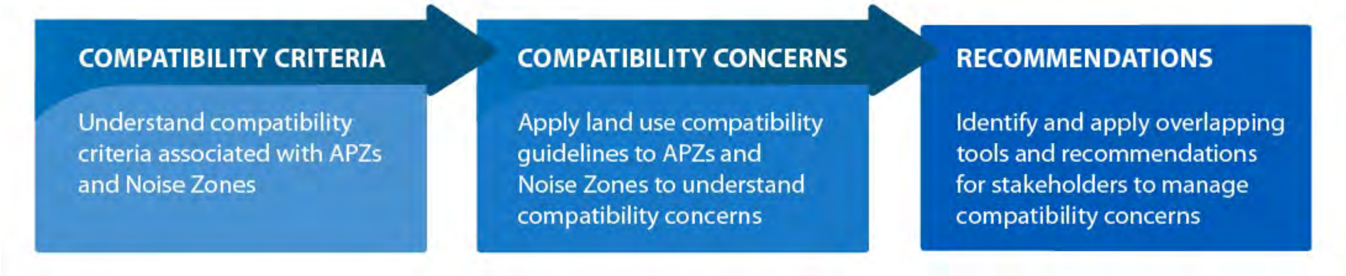

Table 6-1 is not a comprehensive list of compatibility concerns and recommendations but rather, for reference purposes, it provides an abbreviated list of the issues and recommendations that could be implemented to address compatibility concerns holistically. Each land use tool and recommendation are linked with multiple or specific areas of compatibility concern and provides a summary of recommended actions and options that could reduce the overall compatibility concerns at NASCC's NOLF Cabaniss and NOLF Waldron. Minimizing current compatibility concerns and alleviating future concerns involves active participation from several stakeholders often implementing one or more of the recommendations that address a specific or broader area of concern. Managing compatibility concerns is an ongoing process that requires monitoring, maintenance, and targeted planning. To support the ongoing implementation process that addresses compatibility concerns, the tools and recommendations listed in Table 6-1 can be applied to 16 areas of concern within the AICUZ footprint. The numbers listed in the "Land Use Tools and Recommendations" column serve to link the tools and concerns more specifically.

TABLE 6-1 OVERVIEW OF INCOMPATIBLE LAND USE AND TOOLS AND RECOMMENDATIONS

Area of Compatibility Concern	Land Use Tools and Recommendations	Stakeholder	AICUZ Section for Additional Information
The areas and communities within the NOLF Cabaniss AICUZ footprint: Located within Clear Zones and APZs: 1. Approximately 997 acres of land off-base are within the projected Clear Zones (89.29 acres), APZ I (325.04 acres), and APZ II (582.8 acres) for NOLF Cabaniss. 2. Predominant land uses within the Clear Zones include agriculture, public/semi-public, and vacant.	Continue to implement the AICUZ Program for the installation and associated outlying landing fields, while also working with state and local planning officials to implement the objectives of the AICUZ Study. (1-14)	Federal/Navy	6.1
	Continue to engage in the local planning process by maintaining routine communication, attending public meetings, and providing input in the early stages of long-range planning items. (1-14)	Federal/Navy	6.1
	Notify the chain-of-command in the AICUZ Program office whenever local conditions merit update or review of the AICUZ Study. (1-14)	Federal/Navy	6.1
	Provide local real estate agencies with AICUZ related materials and meet with the local Board of Realtors to discuss the importance of real estate disclosure when buying or selling property within or near the AICUZ footprint. (1-14)	Federal/Navy	6.1

TABLE 6-1 OVERVIEW OF INCOMPATIBLE LAND USE AND TOOLS AND RECOMMENDATIONS

Area of Compatibility Concern	Land Use Tools and Recommendations	Stakeholder	AICUZ Section for Additional Information
3. Predominant land use within APZ I is agriculture, light industrial, vacant, low density residential, and commercial. 4. Land uses within APZ II mostly include agriculture, low density residential, and vacant land. 5. The areas identified as incompatible or mostly incompatible are residential uses and to a lesser degree, public/semi-public uses. **The areas and communities within the NOLF Waldron AICUZ footprint:** Exposure to aircraft noise: 6. 2020 projected noise contours extend off installation, including Noise Zone 2 (22 acres). 7. Noise Zone 1 is an area of low or no impact. Off-station land uses within Noise Zone 1 are mostly vacant, agriculture, estate residential, and low density residential. 8. Off-station land areas within Noise Zone 2 are mostly vacant areas, with small areas of residential. 9. Areas within Noise Zone 3 are contained on installation. Located within Clear Zones and APZs: 10. Approximately 1,261 acres of land off-base are within the projected Clear Zones (48.3 acres), APZ I (478.9 acres), and APZ II (733.7 acres) for NOLF Waldron. 11. Most of the land use in Clear Zones includes low density residential, agriculture, and vacant uses.	Continue participation in the ongoing JLUS implementation efforts in order to promote compatibility and mission sustainment efforts, including strategies such as participating in the REPI Program, as applicable. (1-14)	Federal/Navy	6.1
	Formalize or provide advertisement for the noise complaint process to the public. (6-9)	Federal/Navy	6.1
	TMPC, the TCC, and the CBCOG to continue to work with Navy to propose state-wide and regional regulations that promote compatible development surrounding NASCC. (1-14)	State/Regional	6.2
	Continue to actively inform and request input from NASCC regarding land use decisions that could impact the readiness of the Navy. (1-14)	Local Government	6.3
	Include information about the AICUZ Program on websites and provide a link to the NASCC website. (1-14)	Local Government	6.3
	Continue to have military representatives participate on the local planning/development boards as a way to integrate the military's missions with the local government's planning and development review processes. (1-14)	Local Government	6.3
	City of Corpus Christi should adopt projected noise contours and APZs into individual planning studies, Comprehensive Plans, zoning ordinances and regulations, and development processes to best guide compatible development around the installation. (1-14)	Local Government	6.3
	Developers should utilize resources such as the AICUZ Study, local planning documents and tools such as the Clearinghouse website to ensure their proposed development is compatible with NASCC's mission. (1-14)	Local Business	6.4
	Local banking and financial institutions should be encouraged to incorporate a due diligence review" of all loan applications to determine possible noise and/or safety impacts on the mortgaged property. (1-14)	Local Businesses	6.4
	Acknowledge the AICUZ Program for NASCC on real estate websites and provide a link to the NASCC website for more information on aircraft operations and the AICUZ Program. (1-14)	Real Estate Professionals	6.4
	Become informed about the AICUZ Program and how it could affect property owners/renters/lessees. (1-14)	Private Citizens/ Real Estate Professionals/ Businesses	6.4

TABLE 6-1 OVERVIEW OF INCOMPATIBLE LAND USE AND TOOLS AND RECOMMENDATIONS

Area of Compatibility Concern	Land Use Tools and Recommendations	Stakeholder	AICUZ Section for Additional Information
12. Land uses within APZ I are predominantly vacant, agriculture, and residential (estate and low density) 13. APZ II mostly includes agriculture, vacant, and estate residential uses. 14. Areas identified as incompatible are mostly residential uses with limited public/semi-public and commercial uses.	When purchasing, renting, or leasing properties near NOLF Cabaniss and/or NOLF Waldron, ask real estate professionals and lending institution representatives if the property is within the AICUZ footprint. (1-14)	Private Citizens/ Real Estate Professionals/ Businesses	6.4
	Provide sufficient and accurate information when registering a noise complaint to aid in determining the source of the noise and potential remedies for future actions. (6-9)	Private Citizens/ Real Estate Professionals/ Businesses	6.4
15. Bird/animal aircraft strike hazard (BASH)	Continue progress of the BASH program, including the efforts of two full-time wildlife biologists, an up to date BASH Plan, and Methods outlined in the plan to reduce BASH risk at the airfield including habitat management, bird dispersal, depredation, and bird avoidance.	Federal/Navy	6.1
16. Cranes and wind energy development near NASCC, including NOLF Cabaniss and NOLF Waldron	Continue to engage in the local planning process by maintaining routine communication, attending public meetings, and providing input in the early stages of long-range planning items.	Federal/Navy	6.1
	NASCC should continue to provide community decision makers with the information necessary to make informed decisions regarding the impacts of their actions on mission readiness though continued communication and outreach as well as utilizing tools such as the AICUZ Study outreach or the Clearinghouse website.	Federal/Navy	6.1
	Developers should utilize resources such as the AICUZ Study, local planning documents and tools such as the Clearinghouse website to ensure their proposed development is compatible with NASCC's mission. (1-16)	Local Business	6.4

Key:

AICUZ = Air Installations Compatible Use Zones
APZ = accident potential zones
BASH = Bird/animal aircraft strike hazards
CBCOG = Coastal Bend Council of Governments
NASCC = Naval Air Station Corpus Christi
NOLF = Naval Outlying Landing Field
TCC = Texas Commanders Council
TMPC = Texas Military Preparedness Commission

7

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APPENDIX A

DISCUSSION OF NOISE AND ITS EFFECTS ON THE ENVIRONMENT

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

FINAL

WR 13-11
January 2014

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

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

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January 2014

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Acronyms & Abbreviations

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

(Continued on next page)

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

Appendix A

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

A.1 Basics of Sound

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

A.1.1 Sound Waves and Decibels

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

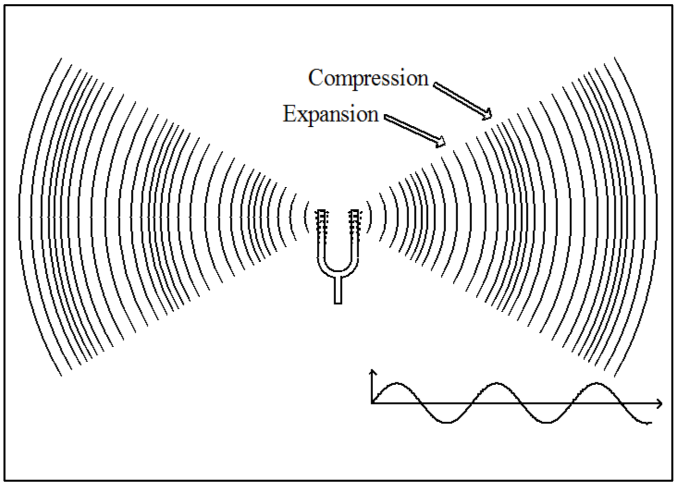


Figure A-1. Sound Waves from a Vibrating Tuning Fork

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

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

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

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

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

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

60 dB + 60 dB = 63 dB, and

80 dB + 80 dB = 83 dB.

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

60.0 dB + 70.0 dB = 70.4 dB.

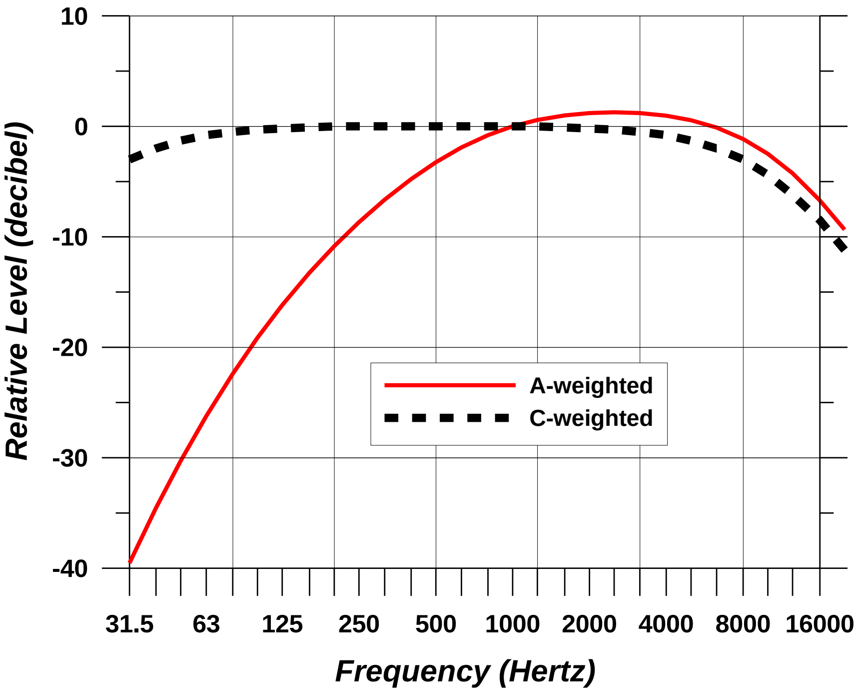
Because the addition of sound levels is different than that of ordinary numbers, this process is often referred to as "decibel addition."

The minimum change in the sound level of individual events that an average human ear can detect is about 3 dB. On average, a person perceives a change in sound level of about 10 dB as a doubling (or halving) of the sound's loudness. This relation holds true for loud and quiet sounds. A decrease in sound level of 10 dB actually represents a 90% decrease in sound intensity but only a 50% decrease in perceived loudness because the human ear does not respond linearly.

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

Sounds with different spectra are perceived differently even if the sound levels are the same. Weighting curves have been developed to correspond to the sensitivity and perception of different types of sound. A-weighting and C-weighting are the two most common weightings. These two curves, shown in Figure A-2, are adequate to quantify most environmental noises. A-weighting puts emphasis on the 1,000 to 4,000 Hz range.

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



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

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

A.1.2 Sound Levels and Types of Sounds

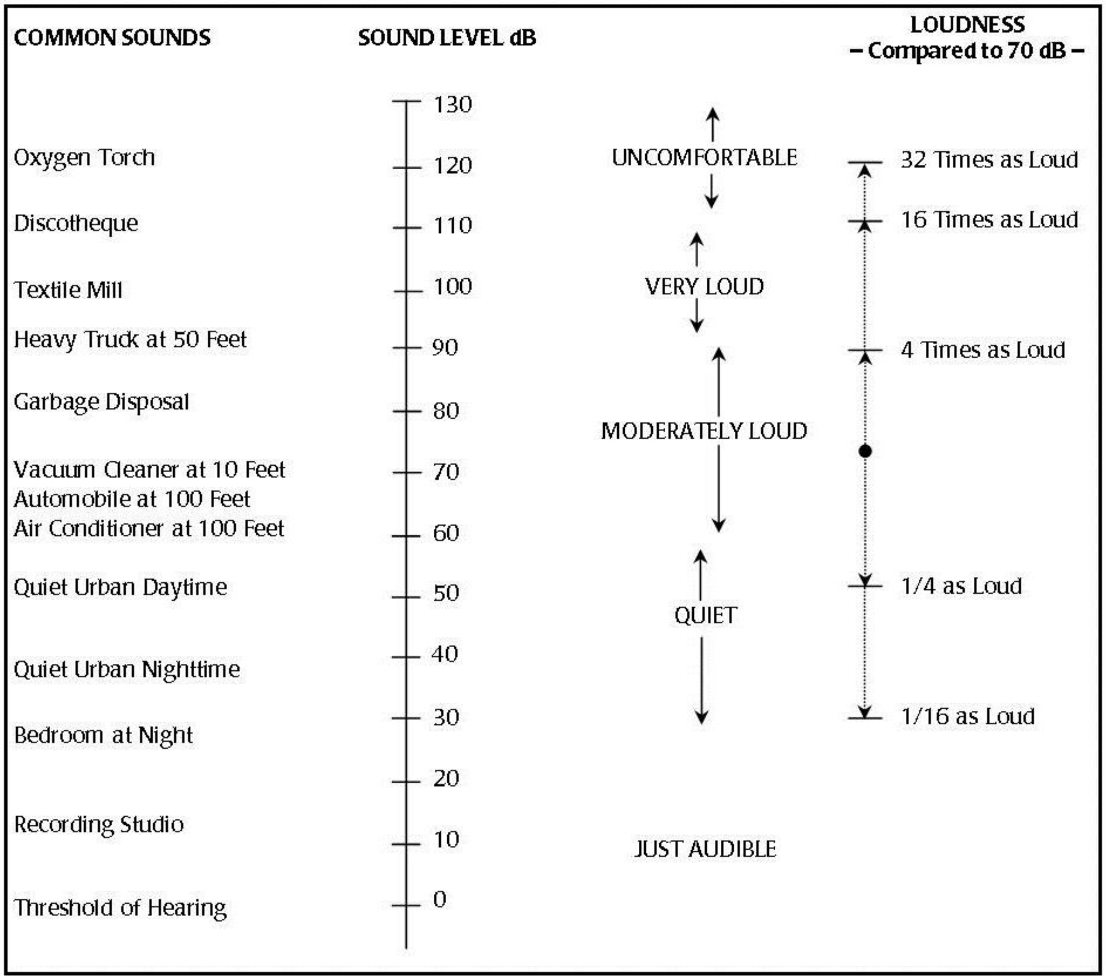
Most environmental sounds are measured using A-weighting. They're called A-weighted sound levels, and sometimes use the unit dBA or dB(A) rather than dB. When the use of A-weighting is understood, the term "A-weighted" is often omitted and the unit dB is used. Unless otherwise stated, dB units refer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

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

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

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

Impulsive noises are generally short, loud events. Their single-event duration is usually less than 1 second. Examples of impulsive noises are small-arms gunfire, hammering, pile driving, metal impacts during rail-yard shunting operations, and riveting. Examples of high-energy impulsive sounds are quarry/mining explosions, sonic booms, demolition, and industrial processes that use high explosives, military ordnance (e.g., armor, artillery and mortar fire, and bombs), explosive ignition of rockets and missiles, and any other explosive source where the equivalent mass of dynamite exceeds 25 grams (American National Standards Institute [ANSI] 1996).

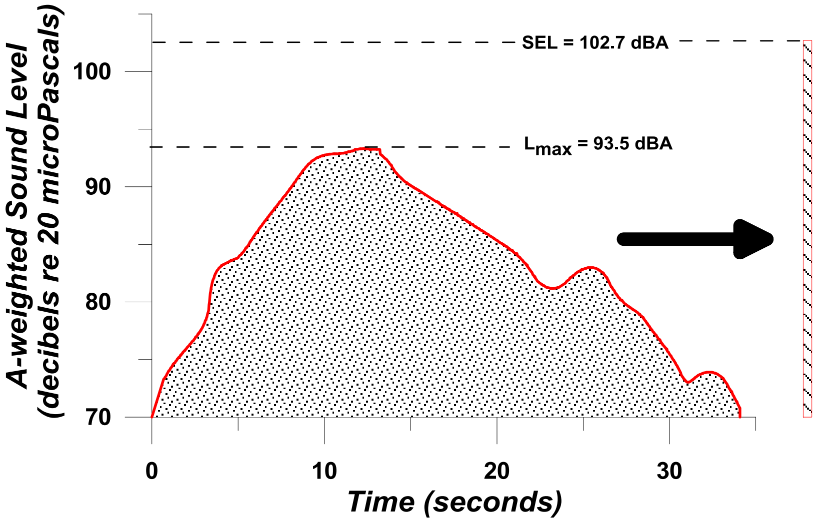


Sources: Harris 1979; Federal Interagency Committee on Aviation Noise (FICAN) 1997.

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

A.2 Noise Metrics

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



Source: Wyle Laboratories

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

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

A.2.1 Single-events

Maximum Sound Level (L_{max})

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

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

Peak Sound Pressure Level (L_{pk})

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

Sound Exposure Level (SEL)

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

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

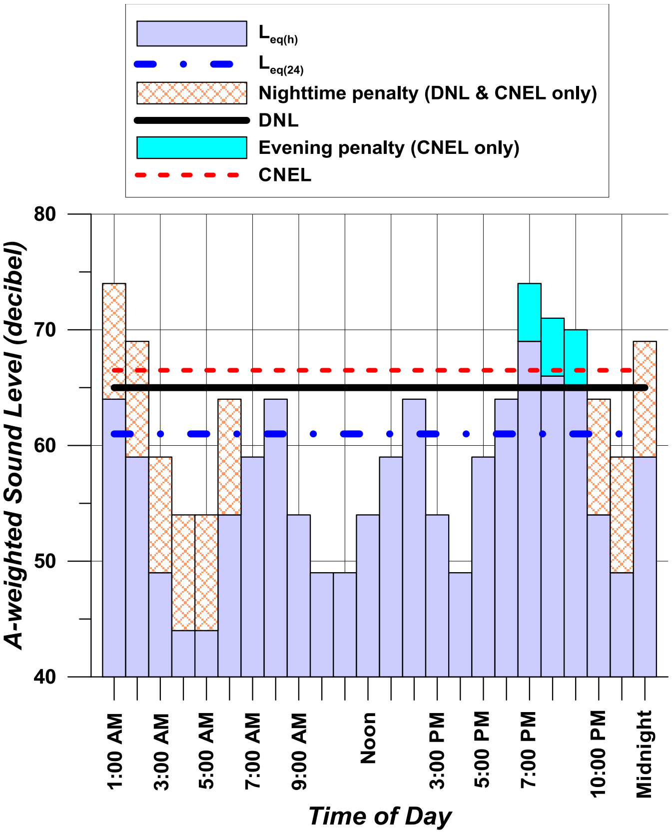
A.2.2 Cumulative Events

Equivalent Sound Level (L_{eq})

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

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

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



Source: Wyle Laboratories

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

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

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

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

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

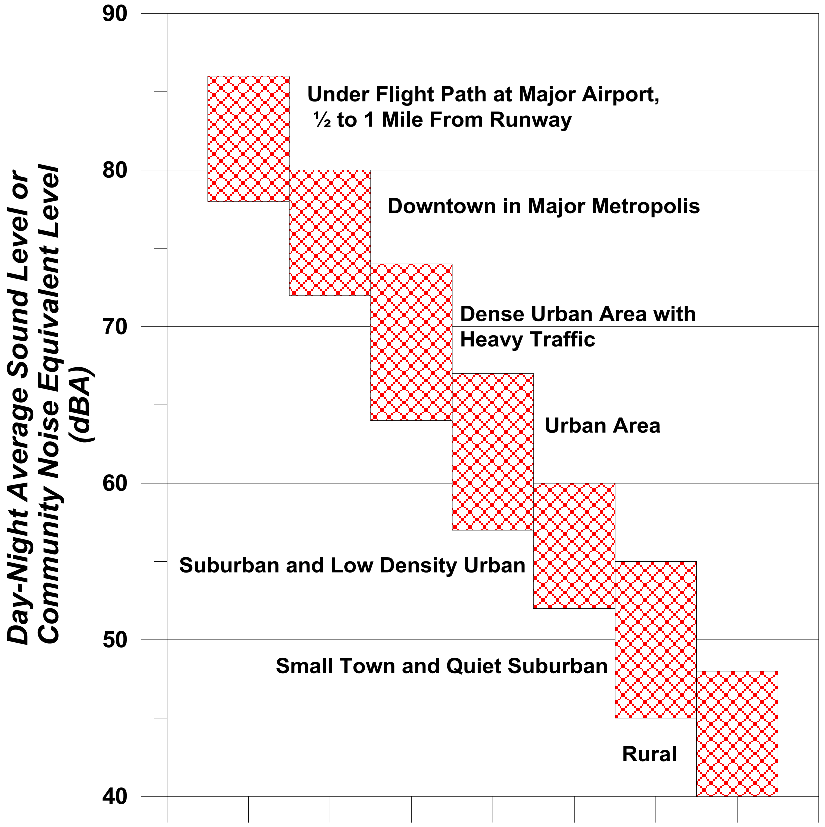
Figure A-5 gives an example of DNL and CNEL using notional hourly average noise levels ($L_{eq(h)}$) for each hour of the day as an example. Note the $L_{eq(h)}$ for the hours between 10 p.m. and 7 a.m. have a 10 dB penalty assigned. For CNEL the hours between 7p.m. and 10 p.m. have a 4.8 dB penalty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

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

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

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

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



Source: DOD 1978.

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

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

Military aircraft utilizing Special Use Airspace (SUA) such as Military Training Routes (MTRs), Military Operations Areas (MOAs), and Restricted Areas/Ranges generate a noise environment that is somewhat different from that around airfields. Rather than regularly occurring operations like at airfields, activity in SUAs is highly sporadic. It is often seasonal, ranging from 10 per hour to less than 1 per week. Individual military overflight events also differ from typical community noise events in that noise from a low-altitude, high-airspeed flyover can have a rather sudden onset, with rates of up to 150 dB per second.

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

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

A.2.3 Supplemental Metrics

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

The Number-of-Events Above (NA) metric gives the total number of events that exceed a noise level threshold (L) during a specified period of time. Combined with the selected threshold, the metric is denoted NAL. The threshold can be either SEL or L_{max}, and it is important that this selection is shown in the nomenclature. When labeling a contour line or point of interest (POI), NAL is followed by the number of events in parentheses. For example, where 10 events exceed an SEL of 90 dB over a given period of time, the nomenclature would be NA90SEL(10). Similarly, for L_{max} it would be NA90L_{max}(10). The period of time can be an average 24-hour day, daytime, nighttime, school day, or any other time period appropriate to the nature and application of the analysis.

NA is a supplemental metric. It is not supported by the amount of science behind DNL/CNEL, but it is valuable in helping to describe noise to the community. A threshold level and metric are selected that best meet the need for each situation. An L_{max} threshold is normally selected to analyze speech interference, while an SEL threshold is normally selected for analysis of sleep disturbance.

The NA metric is the only supplemental metric that combines single-event noise levels with the number of aircraft operations. In essence, it answers the question of how many aircraft (or range of aircraft) fly over a given location or area at or above a selected threshold noise level.

Time Above (TA) a Specified Level (L)

The Time Above (TA) metric is the total time, in minutes, that the A-weighted noise level is at or above a threshold. Combined with the threshold level (L), it is denoted TAL. TA can be calculated over a full 24-hour annual average day, the 15-hour daytime and 9-hour nighttime periods, a school day, or any other time period of interest, provided there is operational data for that time.

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

TA helps describe the noise exposure of an individual event or many events occurring over a given time period. When computed for a full day, the TA can be compared alongside the DNL in order to determine the sound levels and total duration of events that contribute to the DNL. TA analysis is usually conducted along with NA analysis so the results show not only how many events occur, but also the total duration of those events above the threshold.

A.3 Noise Effects

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

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

A.3.1 Annoyance

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

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

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

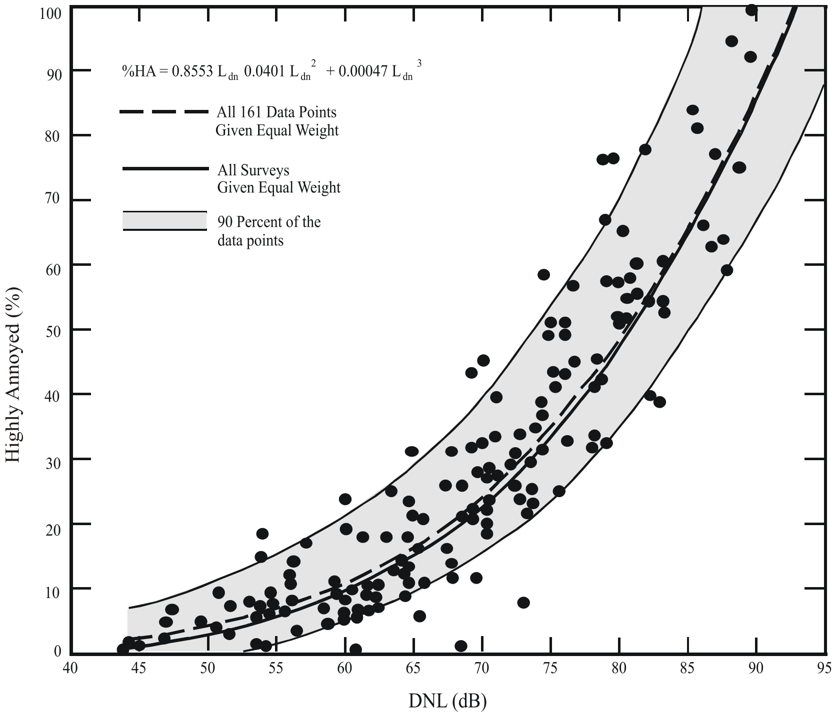


Figure A-7. Schultz Curve Relating Noise Annoyance to DNL (Schultz 1978)

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

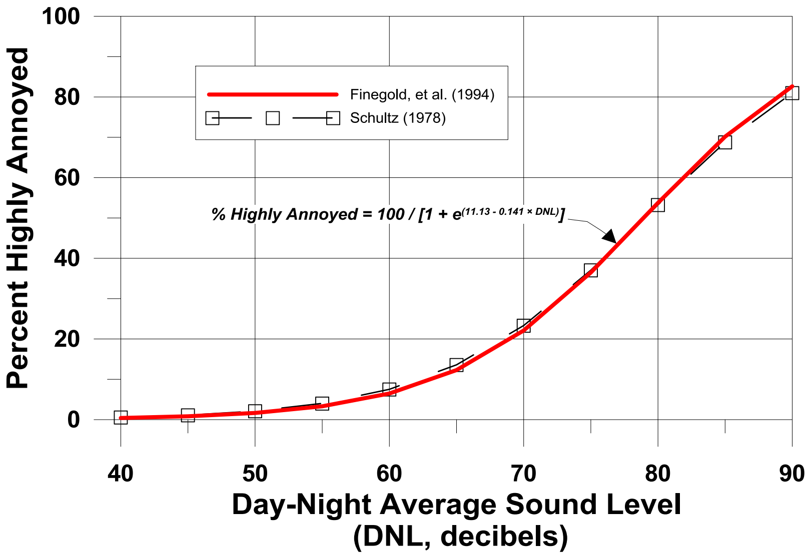


Figure A-8. Response of Communities to Noise; Comparison of Original Schultz (1978) with Finegold et al (1994)

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

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

Emotional Variables
Feeling about the necessity or preventability of the noise;
Judgement 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;
Predicitabiltiy of the noise;
Control over the noise source; and
Length of time individual is exposed to a noise.

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

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

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

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

DNL (dB)	Percent Hightly Annoyed (%HA)			
	Miedema and Vos			Schultz Combined
	Air	Road	Rail	
55	12	7	4	3
60	19	12	7	6
65	28	18	11	12
70	37	29	16	22
75	48	40	22	36

Source: Miedema and Vos 1998.

As noted by the World Health Organization (WHO), however, even though aircraft noise seems to produce a stronger annoyance response than road traffic, caution should be exercised when interpreting synthesized data from different studies (WHO 1999).

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

A.3.2 Speech Interference

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

There are two measures of speech comprehension:

1. *Word Intelligibility* - the percent of words spoken and understood. This might be important for students in the lower grades who are learning the English language, and particularly for students who have English as a Second Language.
2. *Sentence Intelligibility* – the percent of sentences spoken and understood. This might be important for high-school students and adults who are familiar with the language, and who do not necessarily have to understand each word in order to understand sentences.

U.S. Federal Criteria for Interior Noise

In 1974, the USEPA identified a goal of an indoor $L_{eq(24)}$ of 45 dB to minimize speech interference based on sentence intelligibility and the presence of steady noise (USEPA 1974). Figure A-9 shows the effect of steady indoor background sound levels on sentence intelligibility. For an average adult with normal hearing and fluency in the language, steady background indoor sound levels of less than 45 dB L_{eq} are expected to allow 100% sentence intelligibility.

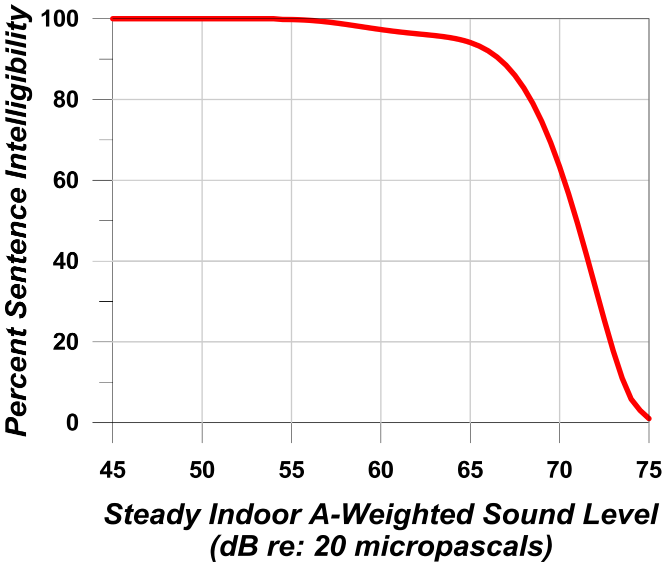


Figure A-9. Speech Intelligibility Curve (digitized from USEPA 1974)

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

Classroom Criteria

For teachers to be understood, their regular voice must be clear and uninterrupted. Background noise has to be below the teacher's voice level. Intermittent noise events that momentarily drown out the teacher's voice need to be kept to a minimum. It is therefore important to evaluate the steady background level, the level of voice communication, and the single-event level due to aircraft overflights that might interfere with speech.

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

For eligibility for noise insulation funding, the Federal Aviation Administration (FAA) guidelines state that the design objective for a classroom environment is 45 dB L_{eq} during normal school hours (FAA 1985).

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

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

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

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

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

Table A-3. Indoor Noise Level Criteria Based on Speech Intelligibility

Source	Metric/Level (dB)	Effects and Notes
U.S. FAA (1985)	$L_{eq(during\ school\ hours)}$ = 45 dB	Federal assistance criteria for school sound insulation; supplemental single-event criteria may be used.
Lind et al. (1998), Sharp and Plotkin (1984), Wesler (1986)	L_{max} = 50 dB / SIL 45	Single event level permissible in the classroom.
WHO (1999)	L_{eq} = 35 dB L_{max} = 50 dB	Assumes average speech level of 50 dB and recommends signal to noise ratio of 15 dB.
U.S. ANSI (2010)	L_{eq} = 35 dB, based on Room Volume (e.g., cubic feet)	Acceptable background level for continuous and intermittent noise.
U.K. DFES (2003)	$L_{eq(30min)}$ = 30-35 dB L_{max} = 55 dB	Minimum acceptable in classroom and most other learning environs.

A.3.3 Sleep Disturbance

Sleep disturbance is a major concern for communities exposed to aircraft noise at night. A number of studies have attempted to quantify the effects of noise on sleep. This section provides an overview of the major noise-induced sleep disturbance studies. Emphasis is on studies that have influenced U.S. federal noise policy. The studies have been separated into two groups:

1. Initial studies performed in the 1960s and 1970s, where the research was focused on sleep observations performed under laboratory conditions.
2. Later studies performed in the 1990s up to the present, where the research was focused on field observations.

Initial Studies

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

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

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

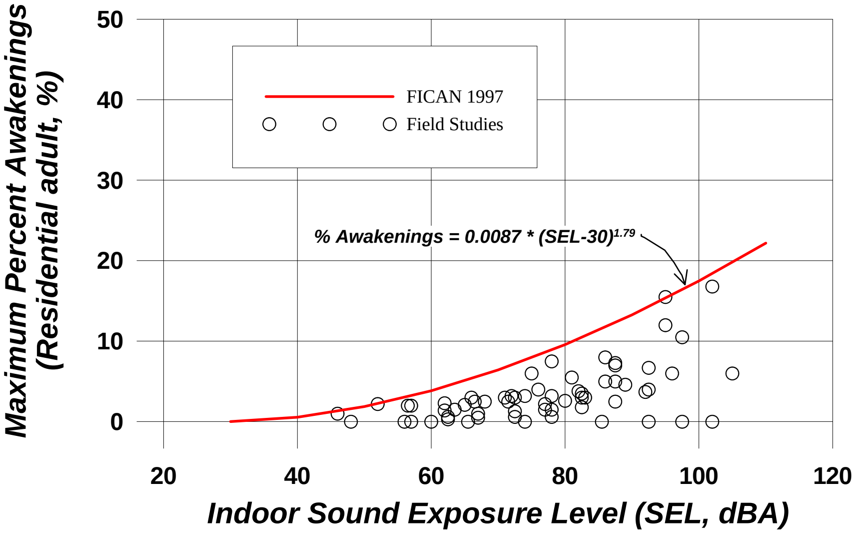
Recent Sleep Disturbance Research – Field and Laboratory Studies

It was noted that early sleep laboratory studies did not account for some important factors. These included habituation to the laboratory, previous exposure to noise, and awakenings from noise other than aircraft. In the early 1990s, field studies in people's homes were conducted to validate the earlier laboratory work conducted in the 1960s and 1970s. The field studies of the 1990s found that 80-90% of sleep disturbances were not related to outdoor noise events, but rather to indoor noises and non-noise factors. The results showed that, in real life conditions, there was less of an effect of noise on sleep than had been previously reported from laboratory studies. Laboratory sleep studies tend to show more sleep disturbance than field studies because people who sleep in their own homes are used to their environment and, therefore, do not wake up as easily (FICAN 1997).

FICAN

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

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



Source: FICAN 1997

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

Number of Events and Awakenings

It is reasonable to expect that sleep disturbance is affected by the number of events. The German Aerospace Center (DLR Laboratory) conducted an extensive study focused on the effects of nighttime aircraft noise on sleep and related factors (Basner 2004). The DLR study was one of the largest studies to examine the link between aircraft noise and sleep disturbance. It involved both laboratory and in-home field research phases. The DLR investigators developed a dose-response curve that predicts the number of aircraft events at various values of L_{max} expected to produce one additional awakening over the course of a night. The dose-effect curve was based on the relationships found in the field studies.

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

Currently, there are no established criteria for evaluating sleep disturbance from aircraft noise, although recent studies have suggested a benchmark of an outdoor SEL of 90 dB as an appropriate tentative criterion when comparing the effects of different operational alternatives. The corresponding indoor SEL would be approximately 25 dB lower (at 65 dB) with doors and windows closed, and approximately 15 dB lower (at 75 dB) with doors or windows open. According to the ANSI (2008) standard, the probability of awakening from a single aircraft event at this level is between 1 and 2% for people habituated to the noise sleeping in bedrooms with windows closed, and 2-3% with windows open. The probability of the exposed population awakening at least once from multiple aircraft events at noise levels of 90 dB SEL is shown in Table A-4.

Table A-4. Probability of Awakening from NA90SEL

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

Source: DOD 2009b.

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

Summary

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

A.3.4 Noise-Induced Hearing Impairment

Residents in surrounding communities express concerns regarding the effects of aircraft noise on hearing. This section provides a brief overview of hearing loss caused by noise exposure. The goal is to provide a sense of perspective as to how aircraft noise (as experienced on the ground) compares to other activities that are often linked with hearing loss.

Hearing Threshold Shifts

Hearing loss is generally interpreted as a decrease in the ear's sensitivity or acuity to perceive sound (i.e., a shift in the hearing threshold to a higher level). This change can either be a Temporary Threshold Shift (TTS) or a Permanent Threshold Shift (PTS) (Berger et al. 1995).

TTS can result from exposure to loud noise over a given amount of time. An example of TTS might be a person attending a loud music concert. After the concert is over, there can be a threshold shift that may last several hours. While experiencing TTS, the person becomes less sensitive to low-level sounds, particularly at certain frequencies in the speech range (typically near 4,000 Hz). Normal hearing eventually returns, as long as the person has enough time to recover within a relatively quiet environment.

PTS usually results from repeated exposure to high noise levels, where the ears are not given adequate time to recover. A common example of PTS is the result of regularly working in a loud factory. A TTS can eventually become a PTS over time with repeated exposure to high noise levels. Even if the ear is given time to recover from TTS, repeated occurrence of TTS may eventually lead to permanent hearing loss. The point at which a TTS results in a PTS is difficult to identify and varies with a person's sensitivity.

Criteria for Permanent Hearing Loss

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

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

Hearing Loss and Aircraft Noise

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

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

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

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

$L_{eq(24)}$	Ave. NIPTS (dB)*	10th Percentile NIPTS (dB)*
75-76	1.0	4.0
76-77	1.0	4.5
77-78	1.6	5.0
78-79	2.0	5.5
79-80	2.5	6.0
80-81	3.0	7.0
81-82	3.5	8.0
82-83	4.0	9.0
83-84	4.5	10.0
84-85	5.5	11.0
85-86	6.0	12.0
86-87	7.0	13.5
87-88	7.5	15.0
88-89	8.5	16.5
89-90	9.5	18.0

** rounded to the nearest 0.5 dB*

Source: DOD 2012.

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

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

Summary

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

A.3.5 Non-auditory Health Effects

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

Kryter and Poza (1980) noted, "It is more likely that noise related general ill-health effects are due to the psychological annoyance from the noise interfering with normal everyday behavior, than it is from the noise eliciting, because of its intensity, reflexive response in the autonomic or other physiological systems of the body."

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

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

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

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

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

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

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

Summary

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

A.3.6 Performance Effects

The effect of noise on the performance of activities or tasks has been the subject of many studies. Some of these studies have found links between continuous high noise levels and performance loss. Noise-induced performance losses are most frequently reported in studies where noise levels are above 85 dB. Little change has been found in low-noise cases. Moderate noise levels appear to act as a stressor for more sensitive individuals performing a difficult psychomotor task.

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

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

A.3.7 Noise Effects on Children

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

A.3.7.1 Effects on Learning and Cognitive Abilities

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

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

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

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

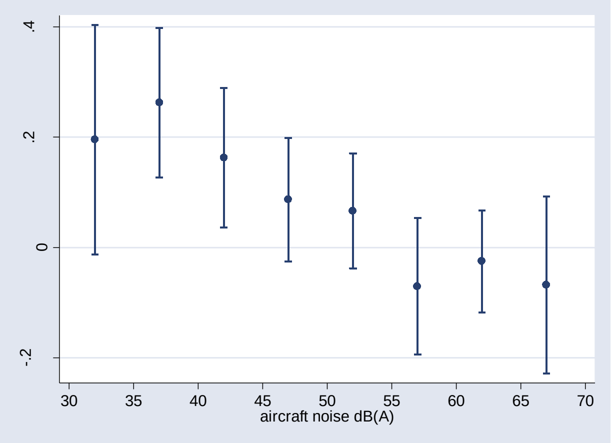


Figure A-11. RANCH Study Reading Scores Varying with L_{eq}

Sources: Stansfeld et al. 2005; Clark et al. 2006

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

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

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

While there are many factors that can contribute to learning deficits in school-aged children, there is increasing awareness that chronic exposure to high aircraft noise levels may impair learning. This awareness has led WHO and a North Atlantic Treaty Organization (NATO) working group to conclude that daycare centers and schools should not be located near major sources of noise, such as highways, airports, and industrial sites (NATO 2000; WHO 1999). The awareness has also led to the classroom noise standard discussed earlier (ANSI 2002).

A.3.7.2 Health Effects

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

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

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

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

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

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

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

Sleep Disturbance. A sub-study of RANCH in a Swedish sample used sleep logs and the monitoring of rest/activity cycles to compare the effect of road traffic noise on child and parent sleep (Ohrstrom et al. 2006). An exposure-response relationship was found for sleep quality and daytime sleepiness for children. While this suggests effects of noise on children's sleep disturbance, it is difficult to generalize from one study.

Hearing loss. A few studies have examined hearing loss from exposure to aircraft noise. Noise-induced hearing loss for children who attended a school located under a flight path near a Taiwan airport was greater than for children at another school far away (Chen et al. 1997). Another study reported that hearing ability was reduced significantly in individuals who lived near an airport and were frequently exposed to aircraft noise (Chen and Chen 1993). In that study, noise exposure near the airport was greater than 75 dB DNL and L_{max} were about 87 dB during overflights. Conversely, several other studies reported no difference in hearing ability between children exposed to high levels of airport noise and children located in quieter areas (Andrus et al. 1975; Fisch 1977; Wu et al. 1995). It is not clear from those results whether children are at higher risk than adults, but the levels involved are higher than those desirable for learning and quality of life.

Ludlow and Sixsmith (1999) conducted a cross-sectional pilot study to examine the hypothesis that military jet noise exposure early in life is associated with raised hearing thresholds. The authors concluded that there were no significant differences in audiometric test results between military personnel who as children had lived in or near stations where fast jet operations were based, and a similar group who had no such exposure as children.

A.3.8 Property Values

Noise can affect the value of homes. Economic studies of property values based on selling prices and noise have been conducted to find a direct relation.

The value-noise relation is usually presented as the Noise Depreciation Index (NDI) or Noise Sensitivity Depreciation Index (NSDI), the percent loss of value per dB (measured by the DNL metric). An early study by Nelson (1978) at three airports found an NDI of 1.8-2.3% per dB. Nelson also noted a decline in NDI over time which he theorized could be due to either a change in population or the increase in commercial value of the property near airports. Crowley (1978) reached a similar conclusion. A larger study by Nelson (1980) looking at 18 airports found an NDI from 0.5 to 0.6% per dB.

In a review of property value studies, Newman and Beattie (1985) found a range of NDI from 0.2 to 2% per dB. They noted that many factors other than noise affected values.

Fidell et al. (1996) studied the influence of aircraft noise on actual sale prices of residential properties in the vicinity of a military base in Virginia and one in Arizona. They found no meaningful effect on home values. Their results may have been due to non-noise factors, especially the wide differences in homes between the two study areas.

Recent studies of noise effects on property values have recognized the need to account for non-noise factors. Nelson (2004) analyzed data from 33 airports, and discussed the need to account for those factors and the need for careful statistics. His analysis showed NDI from 0.3 to 1.5% per dB, with an average of about 0.65% per dB. Nelson (2007) and Andersson et al. (2013) discuss statistical modeling in more detail.

Enough data is available to conclude that aircraft noise has a real effect on property values. This effect falls in the range of 0.2 to 2.0% per dB, with the average on the order of 0.5% per dB. The actual value varies from location to location, and is very often small compared to non-noise factors.

A.3.9 Noise-Induced Vibration Effects on Structures and Humans

High noise levels can cause buildings to vibrate. If high enough, building components can be damaged. The most sensitive components of a building are the windows, followed by plaster walls and ceilings. Possibility of damage depends on the peak sound pressures and the resonances of the building. In general, damage is possible only for sounds lasting more than one second above an unweighted sound level of 130 dB (CHABA 1977). That is higher than expected from normal aircraft operations. Even low altitude flyovers of heavy aircraft do not reach the potential for damage (Sutherland 1990).

Noise-induced structural vibration may cause annoyance to dwelling occupants because of induced secondary vibrations, or "rattle", of objects within the dwelling – hanging pictures, dishes, plaques, and bric-a-brac. Loose window panes may also vibrate noticeably when exposed to high levels of airborne noise, causing homeowners to fear breakage. In general, rattling occurs at peak unweighted sound levels that last for several seconds at levels above 110 dB, which is well above that considered normally compatible with residential land use Thus, assessments of noise exposure levels for compatible land use will also be protective of noise-induced rattle.

The sound from an aircraft overflight travels from the exterior to the interior of the house in one of two ways: through the solid structural elements and directly through the air. Figure A-12 illustrates the sound transmission through a wall constructed with a brick exterior, stud framing, interior finish wall, and absorbent material in the cavity. The sound transmission starts with noise impinging on the wall exterior. Some of this sound energy will be reflected away and some will make the wall vibrate. The vibrating wall radiates sound into the airspace, which in turn sets the interior finish surface vibrating, with some energy lost in the airspace. This surface then radiates sound into the dwelling interior. As the figure shows, vibrational energy also bypasses the air cavity by traveling through the studs and edge connections.

Normally, the most sensitive components of a structure to airborne noise are the windows, followed by plastered walls and ceilings. An evaluation of the peak sound pressures impinging on the structure is normally sufficient to determine the possibility of damage. In general, at unweighted sound levels above 130 dB, there is the possibility of structural damage. While certain frequencies (such as 30 Hertz for window breakage) may be of more concern than other frequencies, conservatively, only sounds lasting more than one second above a unweighted sound level of 130 dB are potentially damaging to structural components (von Gierke and Ward 1991).

In the assessment of vibration on humans, the following factors determine if a person will perceive and possibly react to building vibrations:

1. Type of excitation: steady state, intermittent, or impulsive vibration.
2. Frequency of the excitation. International Organization for Standardization (ISO) standard 2631-2 (ISO 1989) recommends a frequency range of 1 to 80 Hz for the assessment of vibration on humans.
3. Orientation of the body with respect to the vibration.
4. The use of the occupied space (i.e., residential, workshop, hospital).
5. Time of day.

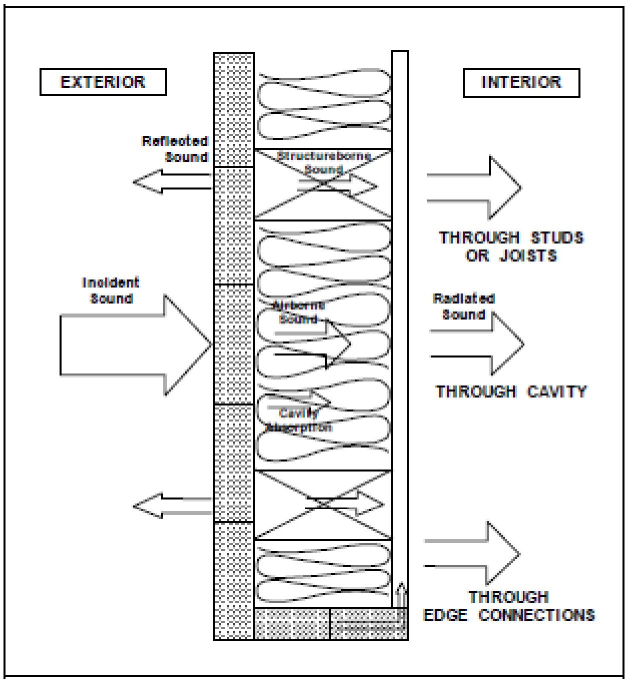


Figure A-12. Depiction of Sound Transmission through Built Construction

Table A-6 lists the whole-body vibration criteria from ISO 2631-2 for one-third octave frequency bands from 1 to 80 Hz.

Table A-6. Vibration Criteria for the Evaluation of Human Exposure to Whole-Body Vibration

	RMS Acceleration (m/s/s)		
Frequency (Hz)	Combined Criteria Base Curve	Residential Night	Residential Day
1.00	0.0036	0.0050	0.0072
1.25	0.0036	0.0050	0.0072
1.60	0.0036	0.0050	0.0072
2.00	0.0036	0.0050	0.0072
2.50	0.0037	0.0052	0.0074
3.15	0.0039	0.0054	0.0077
4.00	0.0041	0.0057	0.0081
5.00	0.0043	0.0060	0.0086
6.30	0.0046	0.0064	0.0092
8.00	0.0050	0.0070	0.0100
10.00	0.0063	0.0088	0.0126
12.50	0.0078	0.0109	0.0156
16.00	0.0100	0.0140	0.0200
20.00	0.0125	0.0175	0.0250
25.00	0.0156	0.0218	0.0312
31.50	0.0197	0.0276	0.0394
40.00	0.0250	0.0350	0.0500
50.00	0.0313	0.0438	0.0626
63.00	0.0394	0.0552	0.0788
80.00	0.0500	0.0700	0.1000

Source: ISO 1989.

A.3.10 Noise Effects on Terrain

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

A.3.11 Noise Effects on Historical and Archaeological Sites

Historical buildings and sites can have elements that are more fragile than conventional structures. Aircraft noise may affect such sites more severely than newer, modern structures. In older structures, seemingly insignificant surface cracks caused by vibrations from aircraft noise may lead to greater damage from natural forces (Hanson et al. 1991). There are few scientific studies of such effects to provide guidance for their assessment.

One study involved measurements of noise and vibration in a restored plantation house, originally built in 1795. It is located 1,500 feet from the centerline at the departure end of Runway 19L at Washington Dulles International Airport. The aircraft measured was the Concorde. There was special concern for the building's windows, since roughly half of the 324 panes were original. No instances of structural damage were found. Interestingly, despite the high levels of noise during Concorde takeoffs, the induced structural vibration levels were actually less than those induced by touring groups and vacuum cleaning (Wesler 1977).

As for conventional structures, noise exposure levels for normally compatible land uses should also be protective of historic and archaeological sites. Unique sites should, of course, be analyzed for specific exposure.

A.3.12 Effects on Domestic Animals and Wildlife

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

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

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

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

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

Animal species differ greatly in their responses to noise. Noise effects on domestic animals and wildlife are classified as primary, secondary, and tertiary. Primary effects are direct, physiological changes to the auditory system, and most likely include the masking of auditory signals. Masking is defined as the inability of an individual to hear important environmental signals that may arise from mates, predators, or prey. There is some potential that noise could disrupt a species' ability to communicate or could interfere with behavioral patterns (Manci et al. 1988). Although the effects are likely temporal, aircraft noise may cause masking of auditory signals within exposed faunal communities. Animals rely on hearing to avoid predators, obtain food, and communicate with, and attract, other members of their species. Aircraft noise may mask or interfere with these functions. Other primary effects, such as ear drum rupture or temporary and permanent hearing threshold shifts, are not as likely given the subsonic noise levels produced by aircraft overflights.

Secondary effects may include non-auditory effects such as stress and hypertension; behavioral modifications; interference with mating or reproduction; and impaired ability to obtain adequate food, cover, or water. Tertiary effects are the direct result of primary and secondary effects, and include population decline and habitat loss. Most of the effects of noise are mild enough that they may never be detectable as variables of change in population size or population growth against the background of normal variation (Bowles 1995). Other environmental variables (e.g., predators, weather, changing prey base, ground-based disturbance) also influence secondary and tertiary effects, and confound the ability to identify the ultimate factor in limiting productivity of a certain nest, area, or region (Smith et al. 1988). Overall, the literature suggests that species differ in their response to various types, durations, and sources of noise (Manci et al. 1988).

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

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

A.3.12.1 Domestic Animals

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

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

Cattle

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

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

A study examined the causes of 1,763 abortions in Wisconsin dairy cattle over a 1-year time period and none were associated with aircraft disturbances (U.S. Air Force 1993). In 1987, researchers contacted seven livestock operators for production data, and no effects of low-altitude and supersonic flights were noted. Of the 43 cattle previously exposed to low-altitude flights, 3 showed a startle response to an F/A-18 aircraft flying overhead at 500 feet above ground level (AGL) and 400 knots by running less than 10 meters (m). They resumed normal activity within 1 minute (U.S. Air Force 1994a). Beyer (1983) found that helicopters caused more reaction than other low-aircraft overflights, and that the helicopters at 30-60 feet overhead did not affect milk production and pregnancies of 44 cows in a 1964 study (U.S. Air Force 1994a).

Additionally, Beyer (1983) reported that five pregnant dairy cows in a pasture did not exhibit fright-flight tendencies or disturb their pregnancies after being overflown by 79 low-altitude helicopter flights and 4 low-altitude, subsonic jet aircraft flights. A 1956 study found that the reactions of dairy and beef cattle to noise from low-altitude, subsonic aircraft were similar to those caused by paper blowing about, strange persons, or other moving objects (U.S. Air Force 1994a).

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

Horses

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

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

Swine

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

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

Domestic Fowl

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

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

Between 1956 and 1988, there were 100 recorded claims against the Navy for alleged damage to domestic fowl. The number of claims averaged three per year, with peak numbers of claims following publications of studies on the topic in the early 1960s. Many of the claims were disproved or did not have sufficient supporting evidence. The claims were filed for the following alleged damages: 55% for panic reactions, 31% for decreased production, 6% for reduced hatchability, 6% for weight loss, and less than 1% for reduced fertility (U.S. Air Force 1994b).

The review of the existing literature suggests that there has not been a concerted or widespread effort to study the effects of aircraft noise on commercial turkeys. One study involving turkeys examined the differences between simulated versus actual overflight aircraft noise, turkey responses to the noise, weight gain, and evidence of habituation (Bowles et al. 1990). Findings from the study suggested that turkeys habituated to jet aircraft noise quickly, that there were no growth rate differences between the experimental and control groups, and that there were some behavioral differences that increased the difficulty in handling individuals within the experimental group.

Low-altitude overflights were shown to cause turkey flocks that were kept inside turkey houses to occasionally pile up and experience high mortality rates due to the aircraft noise and a variety of disturbances unrelated to aircraft (U.S. Air Force 1994b).

A.3.12.2 Wildlife

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

Mammals

Terrestrial Mammals

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

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

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

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

Marine Mammals

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

In 1980, the Acoustical Society of America held a workshop to assess the potential hazard of manmade noise associated with proposed Alaska Arctic (North Slope-Outer Continental Shelf) petroleum operations on marine wildlife and to prepare a research plan to secure the knowledge necessary for proper assessment of noise impacts (Acoustical Society of America 1980). Since 1980 it appears that research on responses of aquatic mammals to aircraft noise and sonic booms has been limited. Research conducted on northern fur seals, sea lions, and ringed seals indicated that there are some differences in how various animal groups receive frequencies of sound. It was observed that these species exhibited varying intensities of a startle response to airborne noise, which was habituated over time. The rates of habituation appeared to vary with species, populations, and demographics (age, sex). Time of day of exposure was also a factor (Muyberg 1978 in Manci et al. 1988).

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

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

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

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

Manatees appear relatively unresponsive to human-generated noise to the point that they are often suspected of being deaf to oncoming boats [although their hearing is actually similar to that of pinnipeds (Bullock et al. 1980)]. Little is known about the importance of acoustic communication to manatees, although they are known to produce at least ten different types of sounds and are thought to have sensitive hearing (Richardson et al. 1995). Manatees continue to occupy canals near Miami International Airport, which suggests that they have become habituated to human disturbance and noise (Metro-Dade County 1995). Since manatees spend most of their time below the surface and do not startle readily, no effect of aircraft overflights on manatees would be expected (Bowles et al. 1993).

Birds

Auditory research conducted on birds indicates that they fall between the reptiles and the mammals relative to hearing sensitivity. According to Dooling (1978), within the range of 1,000 to 5,000 Hz, birds show a level of hearing sensitivity similar to that of the more sensitive mammals. In contrast to mammals, bird sensitivity falls off at a greater rate to increasing and decreasing frequencies. Passive observations and studies examining aircraft bird strikes indicate that birds nest and forage near airports. Aircraft noise in the vicinity of commercial airports apparently does not inhibit bird presence and use.

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

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

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

A cooperative study between the DOD and the U.S. Fish and Wildlife Service (USFWS), assessed the response of the red-cockaded woodpecker to a range of military training noise events, including artillery, small arms, helicopter, and maneuver noise (Pater et al. 1999). The project findings show that the red-cockaded woodpecker successfully acclimates to military noise events. Depending on the noise level that ranged from innocuous to very loud, the birds responded by flushing from their nest cavities. When the noise source was closer and the noise level was higher, the number of flushes increased proportionately. In all cases, however, the birds returned to their nests within a relatively short period of time (usually within 12 minutes). Additionally, the noise exposure did not result in any mortality or statistically detectable changes in reproductive success (Pater et al. 1999). Red-cockaded woodpeckers did not flush when artillery simulators were more than 122 m away and SELs were 70 dB.

Lynch and Speake (1978) studied the effects of both real and simulated sonic booms on the nesting and brooding eastern wild turkey in Alabama. Hens at four nest sites were subjected to between 8 and 11 combined real and simulated sonic booms. All tests elicited similar responses, including quick lifting of the head and apparent alertness for 10-20 seconds. No apparent nest failure occurred as a result of the sonic booms. Twenty-one brood groups were also subjected to simulated sonic booms. Reactions varied slightly between groups, but the largest percentage of groups reacted by standing motionless after the initial blast. Upon the sound of the boom, the hens and poults fled until reaching the edge of the woods (approximately 4-8 m). Afterward, the poults resumed feeding activities while the hens remained alert for a short period of time (approximately 15-20 seconds). In no instances were poults abandoned, nor did they scatter and become lost. Every observation group returned to normal activities within a maximum of 30 seconds after a blast.

Raptors

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

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

Short-term behavior responses were also noted. Overflights at a distance of 150 m or less produced few significant responses and no severe responses. Typical responses consisted of crouching or, very rarely, flushing from the perch site. Significant responses were most evident before egg laying and after young were "well grown." Incubating or brooding adults never burst from the nest, thus preventing egg breaking or knocking chicks out of the nest. Jet passes and sonic booms often caused noticeable alarm; however, significant negative responses were rare and did not appear to limit productivity or re-occupancy. Due to the locations of some of the nests, some birds may have been habituated to aircraft noise. There were some test sites located at distances far from zones of frequent military aircraft usage, and the test stimuli were often closer, louder, and more frequent than would be likely for a normal training situation (Ellis et al. 1991).

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

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

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

Osprey. A study by Trimper et al. (1998), in Goose Bay, Labrador, Canada, focused on the reactions of nesting osprey to military overflights by CF-18 Hornets. Reactions varied from increased alertness and focused observation of planes to adjustments in incubation posture. No overt reactions (e.g., startle response, rapid nest departure) were observed as a result of an overflight. Young nestlings crouched as a result of any disturbance until 1 to 2 weeks prior to fledging. Helicopters, human presence, float planes, and other ospreys elicited the strongest reactions from nesting ospreys. These responses included flushing, agitation, and aggressive displays. Adult osprey showed high nest occupancy rates during incubation regardless of external influences. The osprey observed occasionally stared in the direction of the flight before it was audible to the observers. The birds may have been habituated to the noise of the flights; however, overflights were strictly controlled during the experimental period. Strong reactions to float planes and helicopter may have been due to the slower flight and therefore longer duration of visual stimuli rather than noise-related stimuli.

Red-tailed Hawk. Anderson et al. (1989), conducted a study that investigated the effects of low-level helicopter overflights on 35 red-tailed hawk nests. Some of the nests had not been flown over prior to the study. The hawks that were naïve (i.e., not previously exposed) to helicopter flights exhibited stronger avoidance behavior (9 of 17 birds flushed from their nests) than those that had experienced prior overflights. The overflights did not appear to affect nesting success in either study group. These findings were consistent with the belief that red-tailed hawks habituate to low-level air traffic, even during the nesting period.

Migratory Waterfowl

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

The study also investigated the reproductive success of captive ducks, which indicated that duckling growth and survival rates at Piney Island, North Carolina, were lower than those at a background location. In contrast, observations of several other reproductive indices (i.e., pair formation, nesting, egg production, and hatching success) showed no difference between Piney Island and the background location. Potential effects on wild duck populations may vary, as wild ducks at Piney Island have presumably acclimated to aircraft overflights. It was not demonstrated that noise was the cause of adverse impacts. A variety of other factors, such as weather conditions, drinking water and food availability and variability, disease, and natural variability in reproduction, could explain the observed effects. Fleming noted that drinking water conditions (particularly at Piney Island) deteriorated during the study, which could have affected the growth of young ducks. Further research would be necessary to determine the cause of any reproductive effects (Fleming et al. 1996).

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

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

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

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

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

Wading and Shorebirds

Black et al. (1984), studied the effects of low-altitude (less than 500 feet AGL) military training flights with sound levels from 55 to 100 dB on wading bird colonies (i.e., great egret, snowy egret, tricolored heron, and little blue heron). The training flights involved three or four aircraft, which occurred once or twice per day. This study concluded that the reproductive activity--including nest success, nestling survival, and nestling chronology--was independent of F-16 overflights. Dependent variables were more strongly related to ecological factors, including location and physical characteristics of the colony and climatology.

Another study on the effects of circling fixed-wing aircraft and helicopter overflights on wading bird colonies found that at altitudes of 195 to 390 feet, there was no reaction in nearly 75% of the 220 observations. Approximately 90% displayed no reaction or merely looked toward the direction of the noise source. Another 6% stood up, 3% walked from the nest, and 2% flushed (but were without active nests) and returned within 5 minutes (Kushlan 1978). Apparently, non-nesting wading birds had a slightly higher incidence of reacting to overflights than nesting birds. Seagulls observed roosting near a colony of wading birds in another study remained at their roosts when subsonic aircraft flew overhead (Burger 1981). Colony distribution appeared to be most directly correlated to available wetland community types and was found to be distributed randomly with respect to military training routes. These results suggest that wading bird species presence was most closely linked to habitat availability and that they were not affected by low-level military overflights (U.S. Air Force 2000).

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

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

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

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

Fish, Reptiles, and Amphibians

The effects of overflight noise on fish, reptiles, and amphibians have been poorly studied, but conclusions regarding their expected responses have involved speculation based upon known physiologies and behavioral traits of these taxa (Gladwin et al. 1988). Although fish do startle in response to low-flying aircraft noise, and probably to the shadows of aircraft, they have been found to habituate to the sound and overflights. Reptiles and amphibians that respond to low frequencies and those that respond to ground vibration, such as spadefoot toads, may be affected by noise. Limited information is available on the effects of short-duration noise events on reptiles. Dufour (1980) and Manci et al. (1988), summarized a few studies of reptile responses to noise. Some reptile species tested under laboratory conditions experienced at least temporary threshold shifts or hearing loss after exposure to 95 dB for several minutes. Crocodilians in general have the most highly developed hearing of all reptiles. Crocodile ears have lids that can be closed when the animal goes under water. These lids can reduce the noise intensity by 10 to 12 dB (Wever and Vernon 1957). On Homestead Air Reserve Station, Florida, two crocodilians (the American alligator and the spectacled caiman) reside in wetlands and canals along the base runway suggesting that they can coexist with existing noise levels of an active runway including a DNL of 85 dB.

A.3.12.3 Summary

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

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

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

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

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

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APPENDIX B

LAND USE COMPATIBILITY RECOMMENDATIONS

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TABLE 1 AIR INSTALLATIONS COMPATIBLE USE ZONES SUGGESTED LAND USE COMPATIBILITY IN NOISE ZONES

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

TABLE 1 AIR INSTALLATIONS COMPATIBLE USE ZONES SUGGESTED LAND USE COMPATIBILITY IN NOISE ZONES

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+**
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
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

TABLE 1 AIR INSTALLATIONS COMPATIBLE USE ZONES SUGGESTED LAND USE COMPATIBILITY IN NOISE ZONES

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+**
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
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

TABLE 1 AIR INSTALLATIONS COMPATIBLE USE ZONES SUGGESTED LAND USE COMPATIBILITY IN NOISE ZONES

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+
82	Agriculture 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

Source: U.S. Department of the Navy 2008.

Key to Table 1:

SLUCM = Standard Land Use Coding Manual, U.S. Department of Transportation
Y (Yes) = Land use and related structures compatible without restrictions.
N (No) = Land use and related structures are not compatible and should be prohibited.
Y^x (Yes with restrictions) = The land use and related structures are generally compatible. However, see note(s) indicated by the superscript.
N^x (No with exceptions) = The land use and related structures are generally incompatible. However, see notes indicated by the superscript.
NLR (Noise Level Reduction) = Noise Level Reduction (outdoor to indoor) to be achieved through incorporation of noise attenuation into the design and construction of the structure.
25, 30, or 35 = The numbers refer to NLR levels. Land use and related structures generally compatible however, measures to achieve NLR of 25, 30, or 35 must be incorporated into design and construction of structures. However, measures to achieve an overall noise reduction do not necessarily solve noise difficulties outside the structure and additional evaluation is warranted. Also, see notes indicated by superscripts where they appear with one of these numbers.
DNL = Day Night Average Sound Level.
CNEL = Community Noise Equivalent Level (normally within a very small decibel difference of DNL)
Ldn = Mathematical symbol for DNL.

Notes for Table 1:

1. General:
    a. Although local conditions regarding the need for housing may require residential use in these zones, residential use is discouraged in DNL 65 to 69 and strongly discouraged in DNL 70 to 74. The absence of viable alternative development options should be determined and an evaluation should be conducted locally prior to local approvals indicating that a demonstrated community need for the residential use would not be met if development were prohibited in these zones.
    b. Where the community determines that these uses must be allowed, measures to achieve an outdoor to indoor NLR of at least 25 decibels (dB) in DNL 65 to 69 and NLR of 30 dB in DNL 70 to 74 should be incorporated into building codes and be in individual approvals; for transient housing a NLR of at least 35 dB should be incorporated in DNL 75 to 79.
    c. Normal permanent construction can be expected to provide a NLR of 20 dB, thus the reduction requirements are often stated as 5, 10 or 15 dB over standard construction and normally assume mechanical ventilation, upgraded sound transmission class ratings in windows and doors and closed windows year round. Additional consideration should be given to modifying NLR levels based on peak noise levels or vibrations.
    d. NLR criteria will not eliminate outdoor noise problems. However, building location and site planning, design and use of berms and barriers can help mitigate outdoor noise exposure particularly from ground level sources. Measures that reduce noise at a site should be used wherever practical in preference to measures that only protect interior spaces.
2. Measures to achieve NLR of 25 must be incorporated into the design and construction of portions of these buildings where the public is received, office areas, noise sensitive areas or where the normal noise level is low.
3. Measures to achieve NLR of 30 must be incorporated into the design and construction of portions of these buildings where the public is received, office areas, noise sensitive areas or where the normal noise level is low.

TABLE 1 AIR INSTALLATIONS COMPATIBLE USE ZONES SUGGESTED LAND USE COMPATIBILITY IN NOISE ZONES

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+

4. Measures to achieve NLR of 35 must be incorporated into the design and construction of portions of these buildings where the public is received, office areas, noise sensitive areas or where the normal noise level is low.
5. If project or proposed development is noise sensitive, use indicated NLR; if not, land use is compatible without NLR.
6. No buildings.
7. Land use compatible provided special sound reinforcement systems are installed.
8. Residential buildings require a NLR of 25.
9. Residential buildings require a NLR of 30.
10. Residential buildings not permitted.
11. Land use not recommended, but if community decides use is necessary, hearing protection devices should be worn.

TABLE 2 AIR INSTALLATIONS COMPATIBLE USE ZONES SUGGESTED LAND USE COMPATIBILITY IN ACCIDENT POTENTIAL ZONES

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

TABLE 2 AIR INSTALLATIONS COMPATIBLE USE ZONES SUGGESTED LAND USE COMPATIBILITY IN ACCIDENT POTENTIAL ZONES

SLUCM No.	Land Use Name	CLEAR ZONE Recommendation	APZ I Recommendation	APZ II Recommendation	Density Recommendation
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
485	Solid waste disposal (Landfills, incineration, etc.)	N	N	N	
49	Other transportation, comm., and utilities	N	Y[5]	Y	See Note 5 below
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 below
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,	N	Y	Y	Max FAR of 0.14 in APZ I &

TABLE 2 AIR INSTALLATIONS COMPATIBLE USE ZONES SUGGESTED LAND USE COMPATIBILITY IN ACCIDENT POTENTIAL ZONES

SLUCM No.	Land Use Name	CLEAR ZONE Recommendation	APZ I Recommendation	APZ II Recommendation	Density Recommendation
	aircraft and accessories				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	

TABLE 2 AIR INSTALLATIONS COMPATIBLE USE ZONES SUGGESTED LAND USE COMPATIBILITY IN ACCIDENT POTENTIAL ZONES

SLUCM No.	Land Use Name	CLEAR ZONE Recommendation	APZ I Recommendation	APZ II Recommendation	Density Recommendation
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
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: U.S. Department of the Navy 2008.

TABLE 2 AIR INSTALLATIONS COMPATIBLE USE ZONES SUGGESTED LAND USE COMPATIBILITY IN ACCIDENT POTENTIAL ZONES

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

Key to Table 2:

SLUCM = Standard Land Use Coding Manual, U.S. Department of Transportation
Y (Yes) = Land use and related structures are normally compatible without restriction.
N (No) = Land use and related structures are not normally compatible and should be prohibited.
Y^x (Yes with restrictions) = The land use and related structures are generally compatible. However, see notes indicated by the superscript.
N^x (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 for Table 2:

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 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 I and 0.40 in APZ II. For hardware/paint and farm equipment stores, SLUCM Code 525, the Max FARs are 0.12 in APZ I 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 clubs, home improvement superstores, office supply superstores, and electronics superstores. The Max recommended FAR for SLUCM 53 should be applied to the gross leasable area of the shopping center rather than 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.
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.