AIR INSTALLATION COMPATIBLE USE ZONE STUDY




TRAVIS AIR FORCE BASE, CALIFORNIA

DECEMBER 2009

U.S. AIR FORCE

AIR MOBILITY COMMAND

60th AIR MOBILITY WING

349th AIR MOBILITY WING

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LIST OF ACRONYMS

60 AMW	60th Air Mobility Wing
349 AMW	349th Air Mobility Wing
AFB	Air Force Base
AFI	Air Force Instruction
AGL	above ground level
AICUZ	Air Installation Compatible Use Zone
ALUC	Airport Land Use Commission
AML	maximum A-weighted sound level or maximum sound level
AMW	Air Mobility Wing
AS	Airlift Squadron
APZ	Accident Potential Zone
ARS	Air Refueling Squadron
CFR	Code of Federal Regulations
CNEL	Community Noise Equivalent Level
cps	cycles per second
CZ	clear zone
dB	decibel
dBA	A-weighted sound level measured in decibels
DNL	Day-Night Average A-Weighted Sound Level
DoD	Department of Defense
FAA	Federal Aviation Administration
FAR	Federal Aviation Regulation
HUD	Housing and Urban Development
Hz	hertz
INM	Integrated Noise Model
ISO	International Organization for Standardization
LZ	landing zone
MSA	Metropolitan Statistical Area
NLR	Noise Level Reduction
NZ	noise zone
PUD	Planned Unit Development
SEL	Sound Exposure Level
SLUCM	Standard Land Use Coding Manual

LIST OF ACRONYMS (Continued)

the Base	Travis Air Force Base
UCLA	University of California at Los Angeles
UFC 3-260-01	Unified Facilities Criteria 3-260-01, *Airfield and Heliport Planning and Design*
U.S.	United States
UFC	Unified Facilities Criteria
USEPA	United States Environmental Protection Agency

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SECTION 1
PURPOSE AND NEED

1.1 INTRODUCTION

This study is an update of the 1995 Travis Air Force Base (AFB), California, Air Installation Compatible Use Zone (AICUZ) Study. The update presents and documents changes to the AICUZ amendment for the period 1995-2009 and is based on the April 2009 aircraft operations condition. This AICUZ Study is part of the United States (U.S.) Air Force's AICUZ Program (described below), and reaffirms Air Force policy of assisting local, regional, state, and federal officials in the areas neighboring Travis AFB (the Base) by promoting compatible development within the AICUZ area of influence; and protecting Air Force operational capability from the effects of land use incompatible with aircraft operations. Specifically, the report documents changes in aircraft operations since the last study and provides noise contours and compatible use guidelines for land areas neighboring Travis AFB based on April 2009 operations. This information is provided to assist local communities and to serve as a tool for future planning and zoning activities. Changes that have occurred at Travis AFB since the 1995 AICUZ Study include:

- The basing of C-17 aircraft and the addition of associated operations;
- The retirement of the C-141 aircraft and the elimination of related operations;
- The reduction in the number of C-5 aircraft and associated operations;
- A decrease in the number of based aircraft operations;
- The addition of Landing Zone (LZ) operations by C-17 and C-130 aircraft;
- The addition, elimination, and modification of aircraft flight tracks to correspond with changes in flying operations; and
- Technical improvements to the NOISEMAP computer modeling program.

1.2 PURPOSE AND NEED

The purpose of the long-standing AICUZ Program is to promote compatible land development in areas subject to aircraft noise and accident potential. As the nearby Cities of Fairfield, Suisun, Dixon, and Vacaville, and Solano County prepare and modify land use development plans, recommendations from this updated AICUZ Study should be included in the planning process to prevent incompatible land use that could compromise the ability of Travis AFB to fulfill its mission. Accident potential and aircraft noise should be major considerations in the planning process.

Air Force AICUZ guidelines reflect land use recommendations for the clear zones (CZ), Accident Potential Zones (APZ) I and II, and the four noise zones (NZ) exposed to noise levels at or above 65 decibels (dB) Day-Night Average A-Weighted Sound Level (DNL). These guidelines were established on the basis of studies prepared and sponsored by several federal agencies, including the U.S. Department of Housing and Urban Development (HUD), U.S. Environmental Protection Agency (USEPA), U.S. Air Force, and state and local agencies. The guidelines recommend land uses that are compatible with airfield operations

while allowing maximum beneficial use of adjacent properties. The Air Force has no desire to recommend land use regulations that render property economically useless. It does, however, have an obligation to the inhabitants of the Travis AFB area of influence and the citizens of the U.S. to point out ways to protect the public investment in the installation and the people living in areas adjacent to the installation. The AICUZ area of influence includes the area within the DNL 65 dB and greater noise exposure area and the area within the CZs and APZs.

1.3 PROCESS, PROCEDURE, AND NOISE METRICS

Preparation and presentation of this Travis AFB AICUZ Study is part of the continuing Air Force participation in the local planning process. Guidance for the Air Force AICUZ Program is contained in Air Force Instruction (AFI) 32-7063, *Air Installation Compatible Use Zone Program*, which implements Department of Defense (DoD) Instruction 4165.57, *Air Installations Compatible Use Zones*. This AICUZ Study is accompanied by a Citizen's Brochure, which is a separate document that summarizes the Study.

As local communities prepare land use plans and zoning ordinances, the Air Force recognizes it has the responsibility to provide input on its activities relating to the community. This study is presented in the spirit of mutual cooperation and assistance by Travis AFB to assist in the planning process for land use around the Base.

The AICUZ program uses the latest technology to define noise levels in areas near Air Force installations with a flying mission. Aircraft operational data used in this study were collected at Travis AFB during the period November 2008-February 2009. The Air Force reviewed and validated the data in April 2009. Aircraft flight data were obtained to derive average daily operations by runway and type of aircraft. Analysis of Travis AFB's flying operations included the types of aircraft, flight patterns utilized, variations in altitude, power settings, number of operations, and hours of operations. These data were supplemented by flight track information (where we fly), flight profile information (how we fly), and ground runup information. After verification for accuracy, the data were input into the NOISEMAP computer program to produce DNL noise contours. The noise contours for Travis AFB were plotted on an area map and overlaid with the CZ and APZ areas for the airfield.

This 2009 AICUZ Study includes the projected operations for C-17 and C-130 aircraft on a LZ that will be constructed on the northeast portion of the Travis AFB airfield. It is estimated that aircraft operations on the LZ will begin in the spring of 2011. Landing zone operations are currently being conducted on an interim basis on Runway 21-L.

This 2009 AICUZ Study reflects the aircraft noise based on the aircraft operations as of April 2009 and does not contain noise contours for future planning conditions. Mission changes at Travis AFB could include aircraft operations conditions above the April 2009 level of operations. Increased aircraft operations could result in expanded noise exposure.

California standards for community noise use the Community Noise Equivalent Level (CNEL), in which a 5-dB penalty is added to each aircraft operation in the 7:00 p.m. to 10:00 p.m. period, and a 10-dB penalty to each operation in the 10:00 p.m. to 7:00 a.m. period. The Air Force uses the DNL metric, which is identical to the CNEL, except that the evening noise penalty is not added on this metric. The DNL metric includes the same 10-dB penalty for operations after 10:00 p.m. Both DNL and CNEL noise contours were developed from the

noise modeling accomplished for this AICUZ Study. Comparison of the DNL and CNEL noise contours indicated there is no discernable difference between the two contours. Air Force noise criteria, along with most other federal agency noise criteria, considers all land uses compatible with noise levels below DNL 65 dB. For the reasons in the two preceding sentences, DNL 65 dB and greater is used for land use analysis purposes in Section 5 of this AICUZ Study. However, contours beginning at DNL 60 dB are presented for informational purposes in Section 4 of this AICUZ Study because that is the noise level at which the State of California standards for community noise (*i.e.*, CNEL) begin.

1.4 COMPUTERIZED NOISE EXPOSURE MODELS

The Air Force adopted the NOISEMAP computer program to describe noise impacts created by aircraft operations. NOISEMAP is one of two USEPA-approved computer programs; the other is the Integrated Noise Model (INM) used by the Federal Aviation Administration (FAA) for noise analysis at civil airports. The NOISEMAP and INM programs are similar; however, NOISEMAP is specifically designed to model aircraft noise operations at military airfields.

NOISEMAP is a suite of computer programs and components developed by the Air Force to predict noise exposure in the vicinity of an airfield due to aircraft flight and ground runup operations. The components of NOISEMAP are:

- BASEOPS is the input module for NOISEMAP and is used to enter detailed aircraft flight track and profile and ground maintenance operational data.
- NOISEFILE is a comprehensive dataBase of measured military and civil aircraft noise data. Aircraft operational information is matched with the noise measurements in the NOISEFILE after the detailed aircraft flight and ground maintenance operational data have been entered into BASEOPS.
- NMAP is the computational module in NOISEMAP. NMAP takes BASEOPS input and uses the NOISEFILE database to calculate noise levels caused by aircraft events at specified grid points in the airbase vicinity. The output of NMAP is a series of georeferenced data points, specific grid point locations, and corresponding noise levels.
- NMPLOT is the program for viewing and editing the sets of georeferenced data points. NMPLOT plots the NMAP output in a noise contour grid that can be exported as files that can be used in mapping programs for analyzing the noise impacts.

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SECTION 2
INSTALLATION DESCRIPTION

2.1 DESCRIPTION OF TRAVIS AIR FORCE BASE

Travis AFB is located in Solano County in central California, approximately three miles east of the City of Fairfield, midway between Sacramento and San Francisco in northern California. The Base is on approximately 6,260 acres of land (see Figure 2.1). Access to the Base from the west is gained via Air Base Parkway and Peabody Road from the north. Travis AFB has two main runways and a future LZ, which will be shorter and will parallel the main runways.

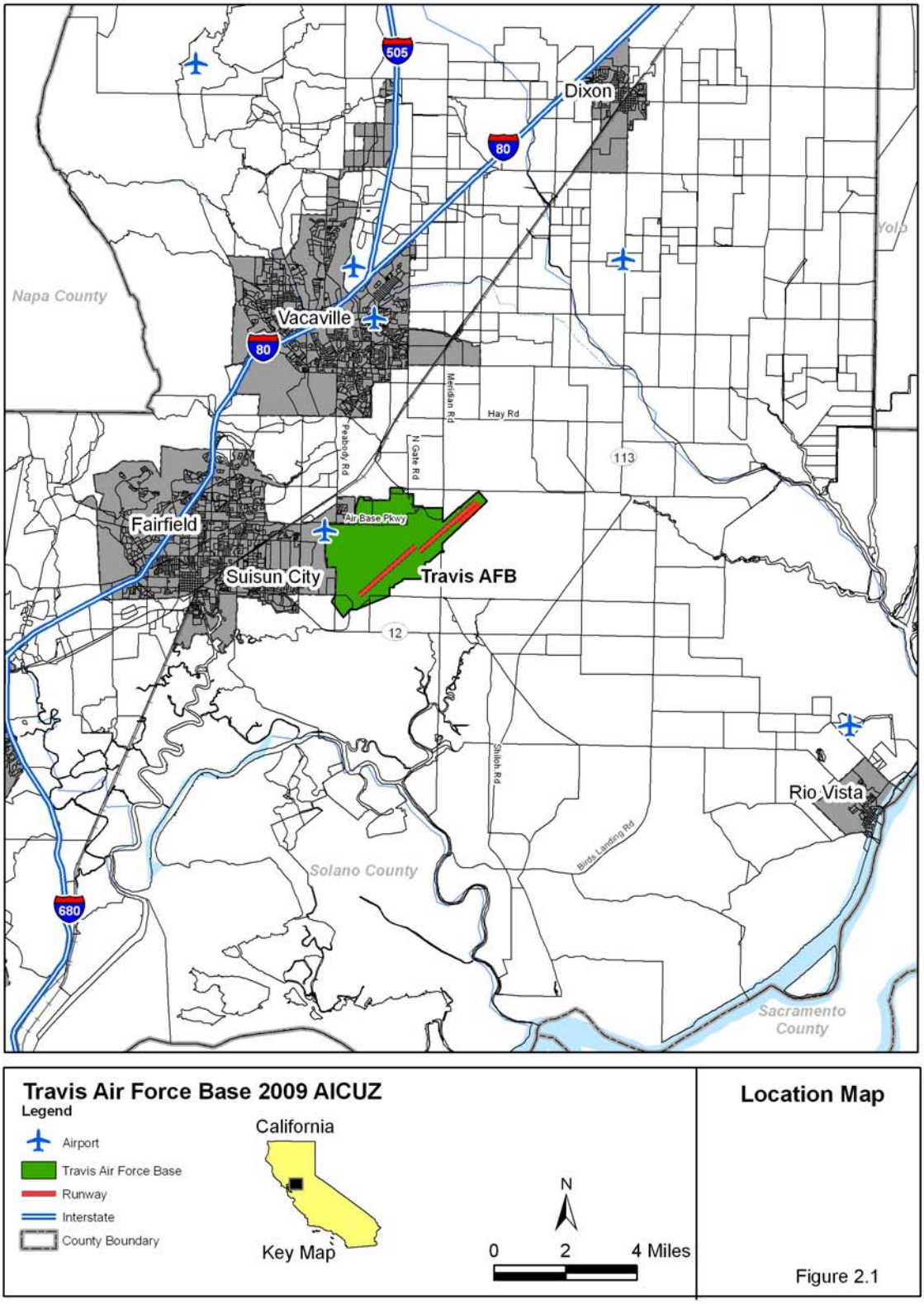
2.2 MISSION

The 60th Air Mobility Wing (60 AMW) is the host unit at Travis AFB and reports to the Air Mobility Command headquartered at Scott AFB, Illinois. The mission of the 60 AMW is to provide strategic airlift and air refueling missions circling the globe providing Global Reach for the Air Force. During wartime, the 60 AMW is responsible for deployment and resupply of the major combat units of the U.S. The 60 AMW also provides administrative, logistical, and medical support to 60 AMW units, tenant units, and retirees and their families who live in the Travis AFB community. The organizational structure of the 60 AMW consists of four groups: Maintenance, Mission Support, Operations, and Medical. The 60 AMW works jointly with the Air Force Reserve Command's 349 AMW to employ C-5, C-17 and KC-10 aircraft worldwide. Major tenant units at the Base include the 349 AMW (Air Force Reserve), 15th Expeditionary Mobility Task Force, and 615th Contingency Response Wing.

The 60th Operations Group is home to the wing's primary flying units, the 21st Airlift Squadron (AS), the 22 AS, the 6th Air Refueling Squadron (ARS) and the 9 ARS. Flying squadrons assigned to the 349 AMW include the 301 AS and 312 AS, 76 ARS, and 78 ARS. As an Air Force Reserve Associate unit, the 349 AMW possesses no aircraft and flies aircraft assigned to the 60 AMW. The 349 AMW is the largest associate wing in the U.S. Air Force Reserve. As the host unit, the 60 AMW provides support services to numerous tenant units besides the 349 AMW. In addition, the U.S. Navy operates E-6B aircraft from Travis AFB.

2.3 ECONOMIC IMPACT

The Economic Impact Region for Travis AFB is the geographic area subject to significant Base-generated economic impacts, and is defined as the area within a 50-mile radius of the Base. This area includes the California County of Solano, and Cities of Dixon, Fairfield, Suisun, and Vacaville. The Vallejo-Fairfield Metro Area Metropolitan Statistical Area (MSA) is composed of Solano County.


Travis Air Force Base 2009 AICUZ
Legend
Airport
Travis Air Force Base
Runway
Interstate
County Boundary
California
Key Map
N
0
2
4 Miles
Location Map
Figure 2.1
Napa County
Solano County
Sacramento County
Yolo
Vacaville
Dixon
Fairfield
Suisun City
Travis AFB
Rio Vista
505
80
680
12
113
Hay Rd
Meridian Rd
Peabody Rd
N Gate Rd
Air Base Pkwy
Shiloh Rd
Birds Landing Rd

2.3.1 Local Economic Characteristics

As shown in Table 2.1, the Vallejo-Fairfield Metro Area MSA had a population of 394,542 in 2000. This was an increase of nearly 54,121 people (14 percent) from 1990. The Vallejo-Fairfield Metro Area MSA is expected to grow in population to 411,680 by 2010. Table 2.1 also displays the population for the Cities of Dixon, Fairfield, Suisun, and Vacaville and Solano County, which fall within the Vallejo-Fairfield Metro Area MSA.

Table 2.1 Historic and Projected Population

Area	1990	2000	2010 projection
Dixon	10,401	16,103	17,531
Fairfield	77,211	96,178	104,897
Suisun	6,693	26,118	26,917
Vacaville	22,627	88,625	92,691
Vallejo-Fairfield MSA	340,421	394,542	411,680

Source: U.S. Census Bureau, December 2008

In 2006, employment in Solano County was estimated to be nearly 108,851 people, with an estimated unemployment rate of 6.8 percent. Table 2.2 presents the 2006 Solano County employment by industry group.

Table 2.2 Solano County Employment Estimates by Industry Group, 2006

Industry	Employees
Retail Trade	18,423
Services (Accommodations and Food)	10,887
Manufacturing	10,343
Transportation & Warehousing	3,477
Information	1,537
Construction	13,509
Wholesale Trade	5,343
Finance & Insurance	3,742
Real Estate	2,162
Utilities	499
Professional, Scientific, Administrative, & Waste Mgt	10,552
Management of Companies	1,189
Forestry, Fishing, and Agriculture Support	99
Mining	206
Education	1,334
Health Care	18,241
Arts, Entertainment, & Recreation	2,614
Unclassified	10
Other Services (except Public Administration)	4,684
Total	**108,851**

Source: 2006 County Business Patterns (NAICS), Solano County, U.S. Census Bureau

2.3.2 Base Impact

The geographic area subject to significant Base-generated economic impacts is defined as the area within a 50-mile radius of Travis AFB. As shown in Table 2.3, Travis AFB directly employs over 13,000 personnel. The annual payroll of the installation is over $275 million (Table 2.4). As a result of payroll expenditures, annual expenses, and the estimated value of indirect jobs in the local area, Travis AFB has an estimated total economic impact of over

$485 million. The majority of this economic impact was attributed to the payroll and contracts provided by the installation.

Table 2.3 Personnel by Classification

Classification	Total
Active Duty Military	7,393
Military Reserve	3,268
Total Military	**10,661**
Civilians	1,197
Non-Appropriated Fund Civilian	447
Contract Civilians	564
Base Exchange Employees	435
Private Business Employees	52
Total Civilian Personnel	**2,695**
Grand Total	**13,356**

Source: Travis AFB, November 2008

Table 2.4 Annual Payroll

Category	($)
Total Annual Payroll	275,620,766
Annual Expenses for Construction Services and Procurement	131,908,634
Estimated Value of Indirect Jobs	78,293,120
Total	**485,822,520**

Source: Travis AFB Fact Sheet, September 30, 2007

SECTION 3
AIRCRAFT OPERATIONS

3.1 INTRODUCTION

To describe the relationship between aircraft operations and land use at and around the airfield, it is necessary to fully evaluate the exact nature of flying activities. The April 2009 inventory of Travis AFB aircraft operations included where aircraft fly, how high they fly, how many times they fly over a given area, and the time of day they operate.

Subsection 3.2 discusses aircraft operations at Travis AFB. Subsection 3.3 discusses runway and flight track utilization for all operations by aircraft type. Subsection 3.4 describes aircraft maintenance activity. Subsection 3.5 discusses aircraft flight profiles, and Subsection 3.6 presents climatological data.

3.2 AIRCRAFT OPERATIONS

It is estimated that approximately 42,000 annual aircraft operations occur at Travis AFB. An aircraft operation is defined as one takeoff/departure, one approach/landing, or half a closed pattern. A closed pattern consists of two portions, a takeoff/departure and an approach/landing, *i.e.*, two operations. A sortie is a single military aircraft flight from the initial takeoff through the termination landing. The minimum number of aircraft operations for one sortie is two operations, one takeoff/departure and one approach/landing

Table 3.1 summarizes the projected average busy day aircraft operations for Travis AFB based on information provided by Base staff, flying organizations, and air traffic control personnel. Aircraft types operating at the Base consist primarily of military aircraft and contract commercial aircraft. In addition to the aircraft based at Travis AFB, numerous types of transient military and contract commercial aircraft conduct operations at the Base. Twelve transient military and civilian aircraft were selected to represent the numerous types of aircraft that operate at Travis AFB for noise modeling purposes, with selection preference based on the uniqueness of a particular aircraft or those with the greatest number of operations. Operations for the transient military and civilian aircraft types were combined with the selected aircraft based on similar characteristics (*e.g.*, number and type of engines, size of aircraft, airspeed, *etc.*). Table 3.1 reflects a total of approximately 209 average busy day aircraft operations based on collected operations data. About 8 percent of the total daily operations occur during the evening (7:00 p.m.-10:00 p.m.) while 41 percent occur at night (10:00 p.m.-7:00 a.m.).

Table 3.1 Average Busy Day Aircraft Operations for 2009

Category/ Aircraft Type	Daily Arrival/ Departure Operations	Daily Closed Pattern Operations	Total Daily Operations
Travis AFB Aircraft			
C-5	3.11	23.00	26.11
C-17	27.18	7.93	35.11
KC-10	14.00	90.00	104.00
E-6B	2.00	2.80	4.80
Subtotal	**46.29**	**123.73**	**170.02**
Transient Aircraft			
B-747	1.88	0.00	1.88
C-130H	1.76	13.02	14.78
C-17	1.49	1.94	3.73
KC-135R	1.77	12.28	14.05
C-40	0.19	0.00	0.19
KC-10	2.39	0.00	2.39
DC-8	0.37	0.00	0.37
C-5	0.15	0.00	0.15
C-20	0.17	0.00	0.17
T-38	0.32	0.95	1.27
F-15	0.22	0.00	0.22
F-16	0.22	0.00	0.22
Subtotal	10.93	28.19	39.12
Total	**57.22**	**151.92**	**209.14**

Note: An operation is one takeoff/departure or one arrival/landing. A closed pattern consists of two operations, one takeoff and one landing.

Although the number of military and civil aircraft operations at an installation usually varies from day to day, NOISEMAP requires input of the specific numbers of daily flight and aircraft maintenance engine runup operations. The Air Force does not follow the FAA's use of the "average annual day" in which annual operations are averaged over an entire 365-day year. Neither does the Air Force use the "worst-case day" since it typically does not represent the typical noise exposure. Instead, the Air Force uses the "average busy day" concept in which annual operations for an aircraft type are averaged over the number of flying days per year by that aircraft type. Non-flying days (*e.g.*, weekends or holidays) are not used in computing the "average busy day" operations. Flying activity occurs at Travis AFB 365 days per year for transient aircraft and ranges between 260 and 365 days per year for based C-5, C-17, KC-10, and E-6B aircraft.

3.3 RUNWAY AND FLIGHT TRACK UTILIZATION

Runways 03L/21R (11,001 feet long and 150 feet wide) and 03R/21L (10,992 feet long and 150 feet wide), as well as LZ 03/21 (3,500 feet long and 90 feet wide), are oriented 033°–213°. The airfield elevation is 62 feet above mean sea level.

Several civil airports within an approximate 20-mile radius of Travis AFB influence aircraft arrival and departure flight tracks at the Base. The Nut Tree Airport, which is about eight miles northwest of Travis AFB, is the airport closest to Travis AFB. The next closest airport to the Base is the Rio Vista airport, which is located approximately 14 miles east of Travis AFB.

To reduce aircraft noise in the areas surrounding Travis AFB, the following noise abatement procedures have been established:

- Departure turns are made after the departure end of the runway or as directed by air traffic control; and,
- Pilots flying visual approaches will avoid flying over populated areas below approximately 3,100 feet above ground level (AGL).

Aircraft operating at Travis AFB use the following flight patterns:

- Straight-out departure;
- Straight-in approach;
- Precision and non-precision instrument approaches; Overhead and rectangular closed patterns to the southeast side of the runways at 2,000 feet AGL and 1,500 feet AGL, respectively; and
- Spiral down approaches to a landing on the LZ or runways.

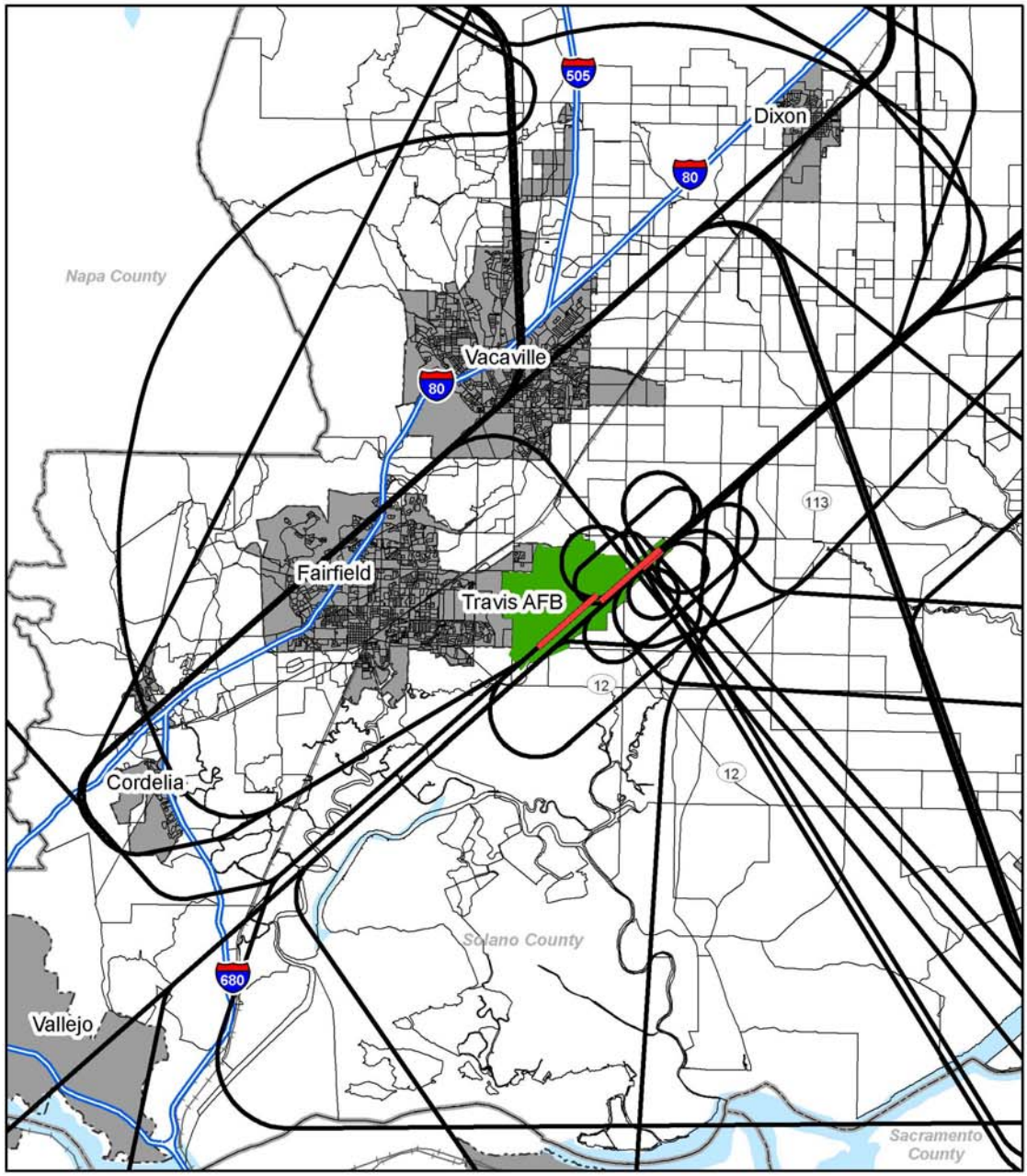
Flight patterns specific to Travis AFB result from several considerations, including:

- Takeoff patterns routed to avoid noise-sensitive areas as much as possible;
- Criteria governing the speed, rate of climb, and turning radius for each type of aircraft;
- Efforts to control and schedule missions to keep noise levels low, especially at night; and
- Coordination with the FAA to minimize conflict with civil aircraft operations.

Planning for areas surrounding an airfield considers three primary aircraft operational/ land use determinants: (1) aircraft accident potential to land users; (2) aircraft noise; and (3) hazards to operations from land uses (*e.g.*, height of structures). Each of these concerns is addressed in conjunction with mission requirements and safe aircraft operations to determine the optimum flight track for each aircraft type. The flight tracks depicted in Figures 3.1 through 3.3 are the result of such planning and depict the representative flight tracks used for noise modeling. The flight track locations represent the various types of arrivals, departures, and closed patterns accomplished at Travis AFB. The location for each track is representative for the specific track and may vary due to air traffic control, weather, and other reasons (*e.g.*, one pilot may fly the track on one side of the depicted track, while another pilot may fly the track slightly to the other side). Runways 03L and 03R and LZ 03 are used about 20 percent of the time while Runways 21L and 21R and LZ 21 are used about 80 percent of the time.

3.4 AIRCRAFT MAINTENANCE RUNUP OPERATIONS

To the maximum extent possible, aircraft maintenance engine runup locations have been established in areas to minimize noise for people on Base, as well as for those in surrounding communities. Aircraft maintenance engine runup operations are accomplished by based flying units and their associated maintenance functions.



Travis Air Force Base 2009 AICUZ

Legend

- Flight Track
- Runway
- Interstate
- Travis AFB
- County Boundary
- Urban Area

N

0 2 4 Miles

Arrival Flight Tracks

Figure 3.1

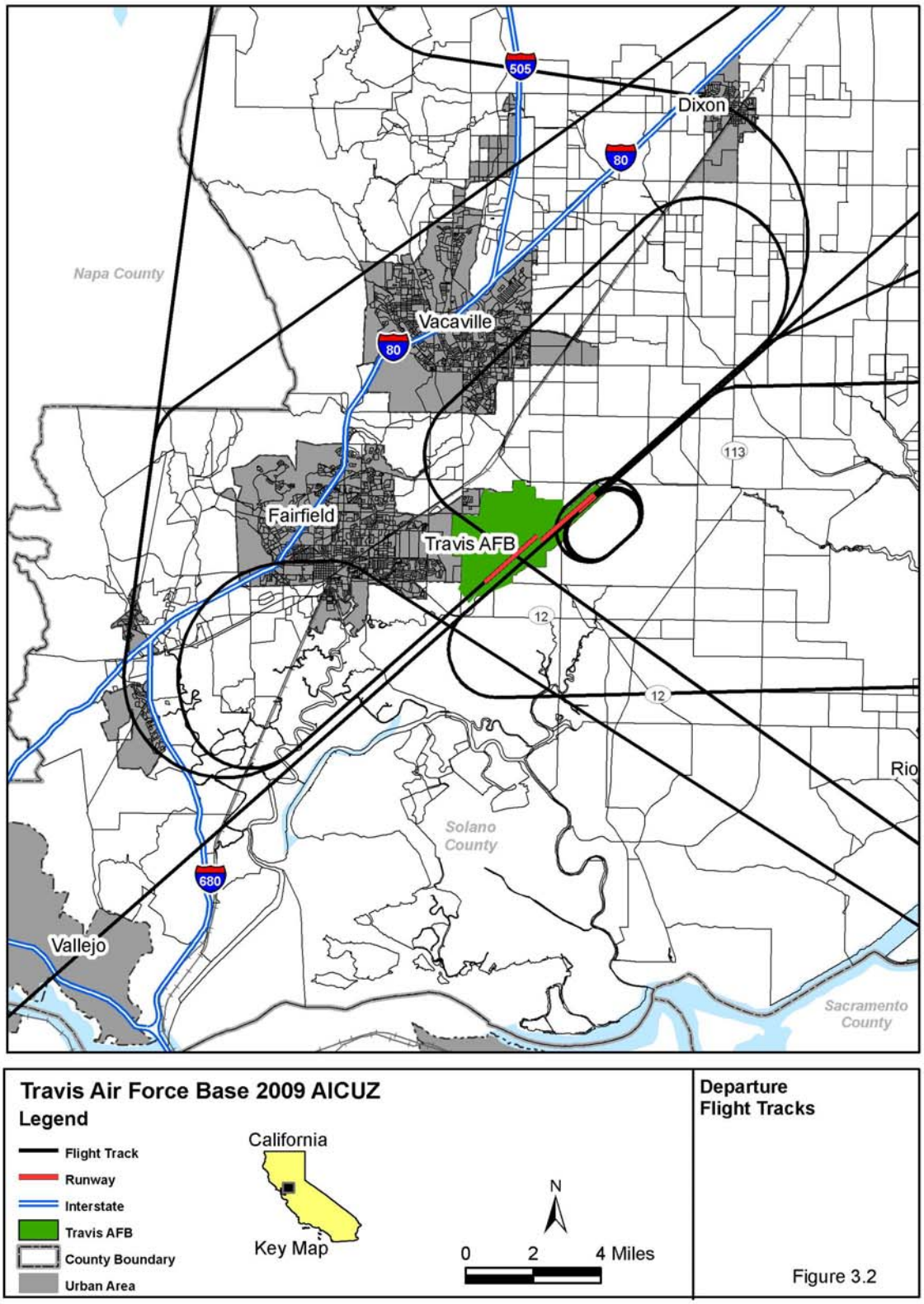
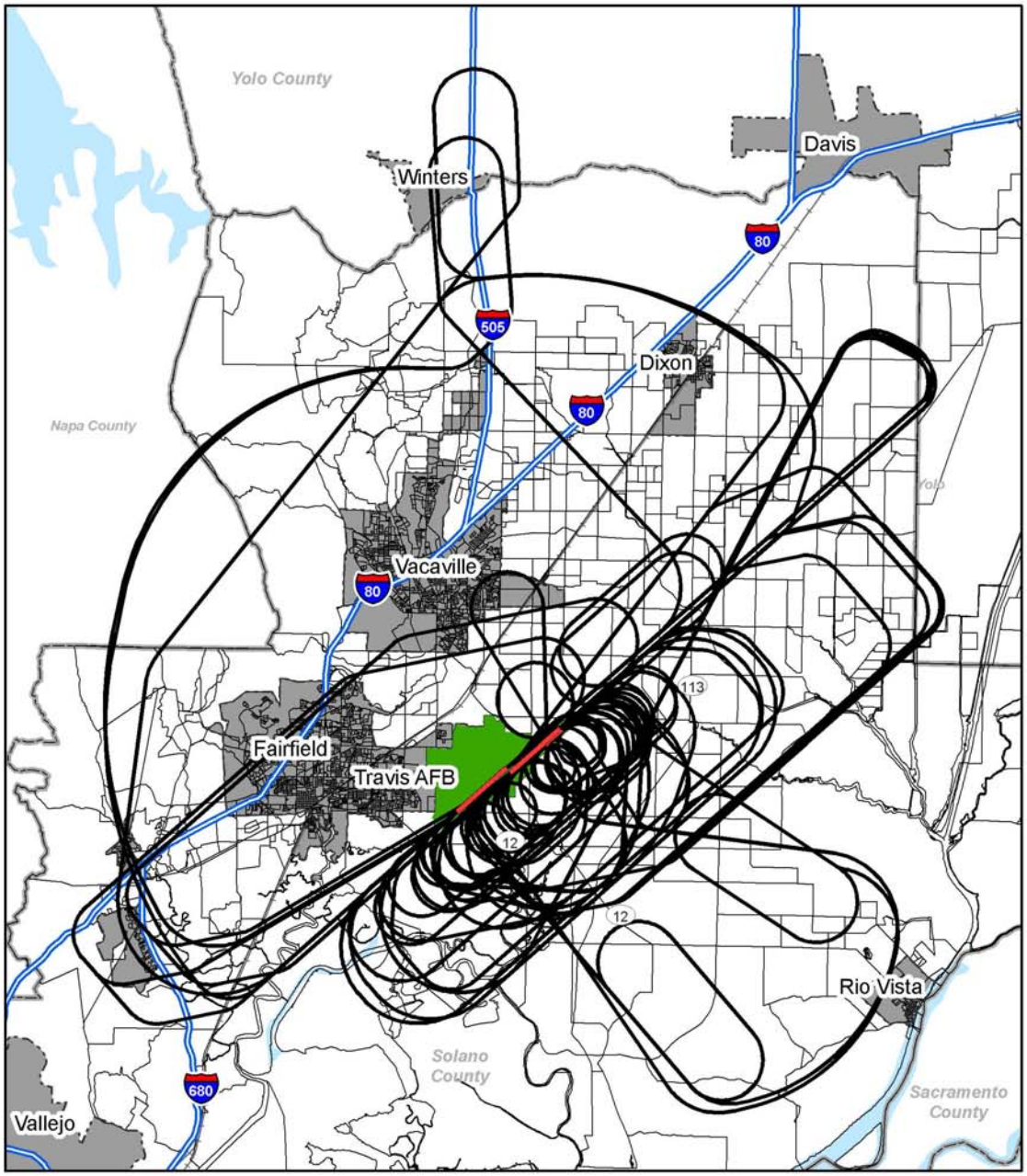

505
Dixon
80
Napa County
Vacaville
80
113
Fairfield
Travis AFB
12
12
Rio
Solano
County
680
Vallejo
Sacramento
County
Travis Air Force Base 2009 AICUZ
Legend
Flight Track
Runway
Interstate
Travis AFB
County Boundary
Urban Area
California
Key Map
N
0
2
4 Miles
Departure
Flight Tracks

Figure 3.2



Travis Air Force Base 2009 AICUZ

Legend

- Flight Track
- Runway
- Interstate
- Travis AFB
- County Boundary
- Urban Area

California

Key Map

N

0 2.5 5 Miles

Closed Pattern Flight Tracks

Figure 3.3

Average busy day aircraft maintenance runup operations were calculated similarly to flight operations described in Subsection 3.1. Weekly, monthly, or annual estimates of runups provided by Travis AFB aircraft maintenance personnel were divided by the typical number of days runups are performed over the respective period. Approximately 22 percent of the aircraft maintenance runups at Travis AFB occur during the evening (7:00 p.m.-10:00 p.m.) while 35 percent occur at night (10:00 p.m.-7:00 a.m.).

3.5 AIRCRAFT FLIGHT PROFILES

For purposes of this AICUZ Study, aircraft "flight profiles" denote the aircraft power settings, altitudes above runway level, and airspeeds along each flight track. Aircraft flight profiles for 60 AMW, 349 AMW, and Navy E-6B aircraft were obtained from Travis AFB personnel. Generic flight profiles from the BASEOPS database were used to model operations for the other military aircraft types. Noise data from the NOISEFILE database were used to model operations for all aircraft types.

3.6 CLIMATOLOGICAL DATA

Weather conditions, measured by temperature and relative humidity, are an important factor in the propagation of noise. The average temperature and humidity for each month of the year are input into BASEOPS, which then calculates the sound absorption coefficient for each month. Ranking the twelve monthly sound absorption coefficients from smallest to largest, BASEOPS chooses the sixth smallest sound absorption coefficient to represent the typical weather conditions at the Base. The month with the sixth smallest sound absorption coefficient for Travis AFB is the month with an average monthly temperature of 58 degrees Fahrenheit and 46 percent relative humidity.

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SECTION 4
EFFECTS OF AIRCRAFT OPERATIONS

4.1 INTRODUCTION

This section has two purposes. First to describe the imaginary surfaces associated with obstructions to air navigation, noise exposure, CZs, and APZs; second to present applicable land use compatibility guidelines and the Air Force's participation in the land use planning process.

4.2 RUNWAY AND LANDING ZONE AIRSPACE IMAGINARY SURFACES

Obstructions to air navigation are considered to be:

- Natural objects or man-made structures that protrude above the planes or imaginary surfaces, and/or;
- Man-made objects that extend more than 500 feet AGL at the site of the structure.

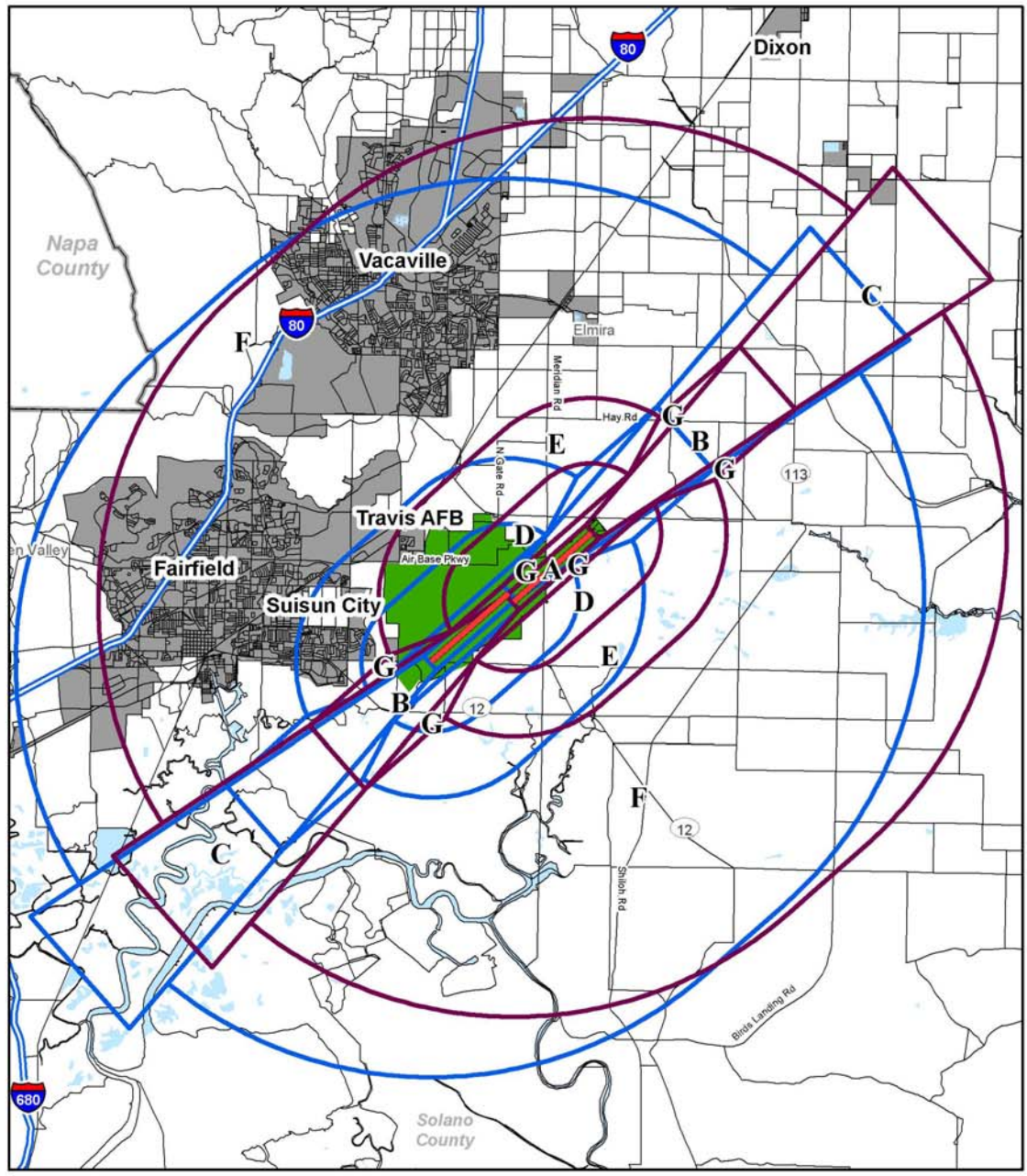
4.2.1 Explanation of Terms

The following elevation, runway length, and dimensional criteria apply:

- Controlling Elevation - whenever surfaces or planes within the obstruction criteria overlap, the controlling (or governing) elevation becomes that of the lowest surface or plane.
- Runway Length - Travis AFB has two runways and an LZ. Runway 03L/21R is 11,001 feet long and 150 feet wide, while runway 03R/21L is 10,992 feet long and 150 feet wide. Both are Class B runways designed and built for sustained heavy aircraft landings and takeoffs. Landing Zone 03/21 is 3,500 feet long and 90 feet wide and is designed for sustained C-17 assault landings and takeoffs.
- Established Airfield Elevation - the established elevation for the Travis AFB airfield is 62 feet above mean sea level.
- Dimensions - all dimensions are measured horizontally unless otherwise noted.

4.2.2 Runway Airspace Imaginary Surfaces

The area surrounding a runway that must be kept clear of objects that might damage an aircraft is bounded by imaginary surfaces that are defined in Unified Facilities Criteria (UFC) 3-260-01, *Airfield and Heliport Planning and Design.* An existing object (including a mobile object) is, and a future object would be, an obstruction to air navigation if it is higher than any of the heights or surfaces listed in UFC 3-260-01, which is based on the military airport imaginary surfaces in Federal Aviation Regulation (FAR) Part 77, *Objects Affecting Navigable Airspace*, Subpart C. Figure 4.1 depicts the runway airspace imaginary surfaces for the Travis AFB Class B runways 03L/21R and 03R/21L. The following paragraphs contain definitions of the runway airspace imaginary surfaces for Air Force Class B runways:



Travis Air Force Base 2009 AICUZ

Legend

A Primary Surface
B Approach - Departure Clearance Surface (50:1 Slope Ratio)
C Approach - Departure Clearance Surface (Horizontal)
D Inner Horizontal Surface (45.72 meters [150'] Elevation)
E Conical Surface (20:1 Slope Ratio)
F Outer Horizontal Surface (152.40 meters [500'] Elevation)
G Transitional Surface (7:1 Slope Ratio)

Runway 03R/21L
Runway 03L/21R
Runway
Travis AFB
City Limits

N

0 2.5 5 Miles

Class B Air Force Airspace Imaginary Surfaces

Figure 4.1

- Primary Surface - An imaginary surface symmetrically centered on the runway, extending 200 feet beyond each runway end that defines the limits of the obstruction clearance requirements in the vicinity of the landing area. The width of the primary surface is 2,000 feet, or 1,000 feet on each side of the runway centerline.
- Clear Zone Surface - An obstruction-free surface (except for features essential for aircraft operations) on the ground symmetrically centered on the extended runway centerline beginning at the end of the runway and extending outward 3,000 feet. The CZ width is 3,000 feet (1,500 feet to either side of runway centerline).
- Accident Potential Zone Surfaces - APZ I begins at the outer end of the CZ and is 5,000 feet long and 3,000 feet wide. APZ II begins at the outer end of APZ I and is 7,000 feet long and 3,000 feet wide.
- Approach-Departure Clearance Surface - This imaginary surface is symmetrically centered on the extended runway centerline, beginning as an inclined plane (glide angle) 200 feet beyond each end of the primary surface, and extending for 50,000 feet. The slope of the approach-departure clearance surface is 50:1 until it reaches an elevation of 500 feet above the established airfield elevation. It then continues horizontally at this elevation to a point 50,000 feet from the starting point. The width of this surface at the runway end is 2,000 feet, flaring uniformly to a width of 16,000 feet at the end point.
- Inner Horizontal Surface - This imaginary surface is an oval plane at a height of 150 feet above the established airfield elevation. The inner boundary intersects with the approach-departure clearance surface and the transitional surface. The outer boundary is formed by scribing arcs with a radius 7,500 feet from the centerline of each runway end and interconnecting these arcs with tangents.
- Conical Surface - This is an inclined imaginary surface extending outward and upward from the outer periphery of the inner horizontal surface for a horizontal distance of 7,000 feet to a height of 500 feet above the established airfield elevation. The slope of the conical surface is 20:1. The conical surface connects the inner and outer horizontal surfaces.
- Outer Horizontal Surface - This imaginary surface is located 500 feet above the established airfield elevation and extends outward from the outer periphery of the conical surface for a horizontal distance of 30,000 feet.
- Transitional Surface - This imaginary surface extends outward and upward at right angles to the runway centerline and extended runway centerline at a slope of 7:1. The transitional surface connects the primary and the approach-departure clearance surfaces to the inner horizontal, the conical, and the outer horizontal surfaces.

4.3 RESTRICTED AND/OR PROHIBITED LAND USES

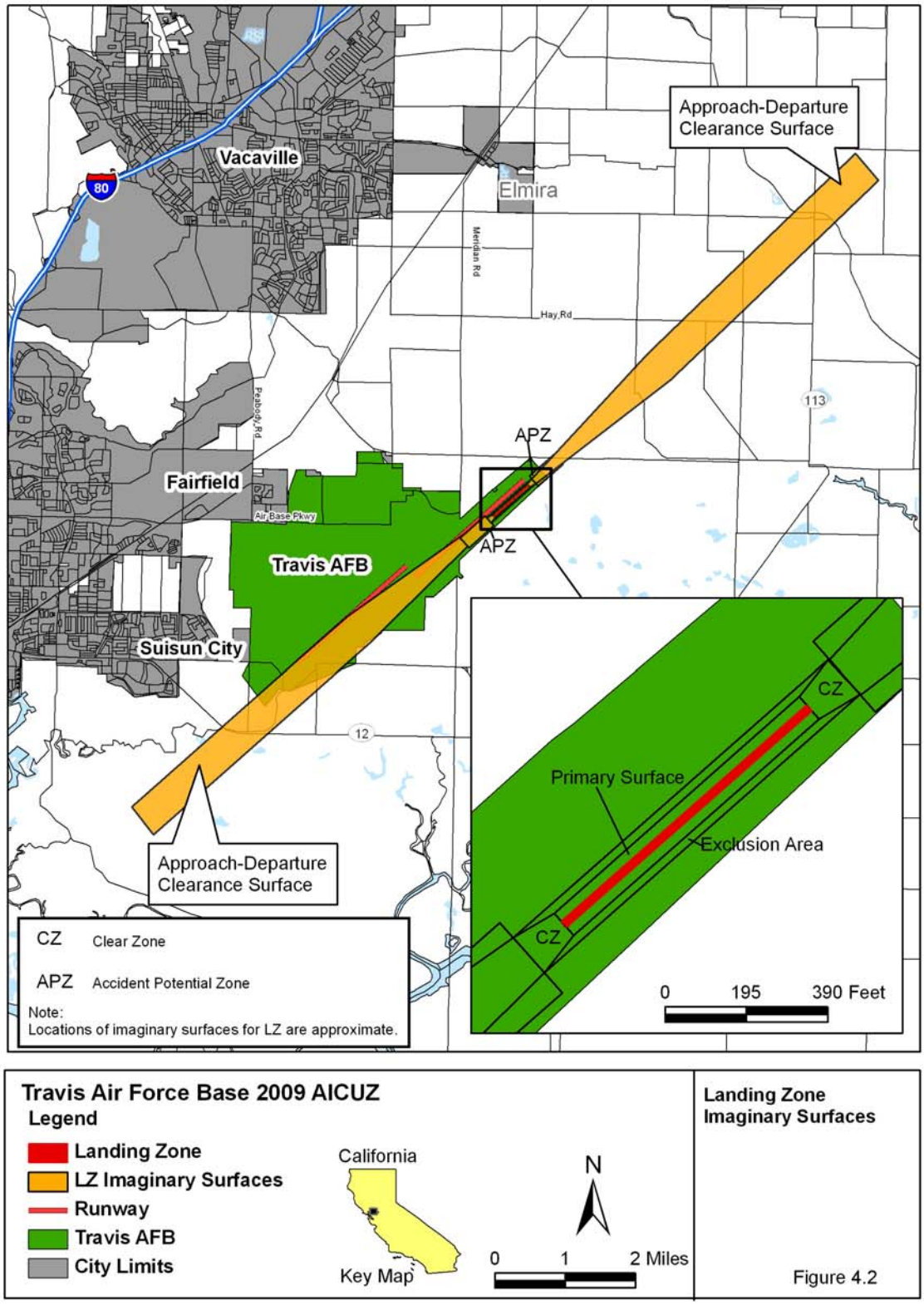
The land areas outlined by these criteria should be regulated to prevent uses that might otherwise be hazardous to aircraft operations. The following uses should be restricted and/or prohibited:

- Releases into the air of any substance that would impair visibility or otherwise interfere with the operation of aircraft (*e.g.*, steam, dust, or smoke);
- Light emissions, either direct or indirect (reflective), that would interfere with pilot vision;
- Electrical emissions that would interfere with aircraft communications systems or navigational equipment;
- Uses that would attract birds or waterfowl, including but not limited to, operation of sanitary landfills, waste transfer facilities, maintenance of feeding stations, sand and gravel dredging operations, storm water retention ponds, created wetland areas, or the growing of certain vegetation; and
- Structures within 10 feet of aircraft approach-departure and/or transitional surfaces.

4.4 LANDING ZONE AIRSPACE IMAGINARY SURFACES

Figure 4.2 depicts the imaginary surfaces established for LZs at Air Force airfields. Refer to UFC 3-260-01 for a more complete description of the airspace imaginary surfaces associated with Air Force LZs. The dimensions for some surfaces differ for C-17 and C-130 aircraft. C-17 LZ criteria are used in this study. The following paragraphs contain definitions of the imaginary surfaces for LZs.

- Primary Surface - An imaginary surface symmetrically centered on the runway, extending 1,000 feet beyond each runway end. The width of the primary surface is 150 feet, or 75 feet on each side of the runway centerline.
- Exclusion Area Surface - The 1,000-foot exclusion area is centered on the longitudinal axis of the runway (500 feet to each side of the runway centerline) for LZs in built up and occupied areas. The exclusion area extends the length of the LZ plus the CZ on each end. The width of the exclusion area in unoccupied areas is 700 feet (350 feet to each side of the runway centerline).
- Clear Zone Surface - The CZ is centered on the end of the runway and extends outward 500 feet from the end of the runway. It is 270 feet wide at the end of the runway and flares to 500 feet in width at the outer end.
- Accident Potential Zone Surface - The APZ begins at the outer end of the CZ, extends outward 2,500 feet, and is 1,000 feet wide in occupied and built-up areas (500 feet in unoccupied area).
- Approach-Departure Clearance Surface - This imaginary surface is symmetrically centered on the extended runway centerline, beginning as an inclined plane (glide angle) 500 feet beyond each end of the primary surface, and extending for a minimum 10,500 feet. The desired slope length is 32,000 feet. The slope of the approach-departure clearance surface is 20:1 throughout the entire length. The width of this surface at the inner end (CZ end) is 500 feet, flaring uniformly to a width of 2,500 feet at the 10,500 foot point. The width is a constant 2,500 feet from the 10,500 foot point to the 32,000 foot point.


Approach-Departure Clearance Surface
Vacaville
80
Elmira
Meridian Rd
Hay Rd
Peabody Rd
113
APZ
Fairfield
Air Base Pkwy
APZ
Travis AFB
Suisun City
12
CZ
Primary Surface
Exclusion Area
CZ
0 195 390 Feet
Approach-Departure Clearance Surface
CZ Clear Zone
APZ Accident Potential Zone
Note:
Locations of imaginary surfaces for LZ are approximate.
Travis Air Force Base 2009 AICUZ
Legend
Landing Zone
LZ Imaginary Surfaces
Runway
Travis AFB
City Limits
California
Key Map
N
0 1 2 Miles
Landing Zone Imaginary Surfaces
Figure 4.2

4.5 NOISE EXPOSURE

NOISEMAP Version 7.32 was used to calculate and plot the DNL noise contours based on the average busy day aircraft operations data described in Subsections 3.1 through 3.6. Figure 4.3 shows the 2009 noise contours. Figures in Section 4 show the DNL noise contours plotted in 5 dB increments, ranging from DNL 60 dB to DNL at or above 80 dB. Subsection 1.3 explains the rationale for showing noise contours beginning at DNL 60 dB.

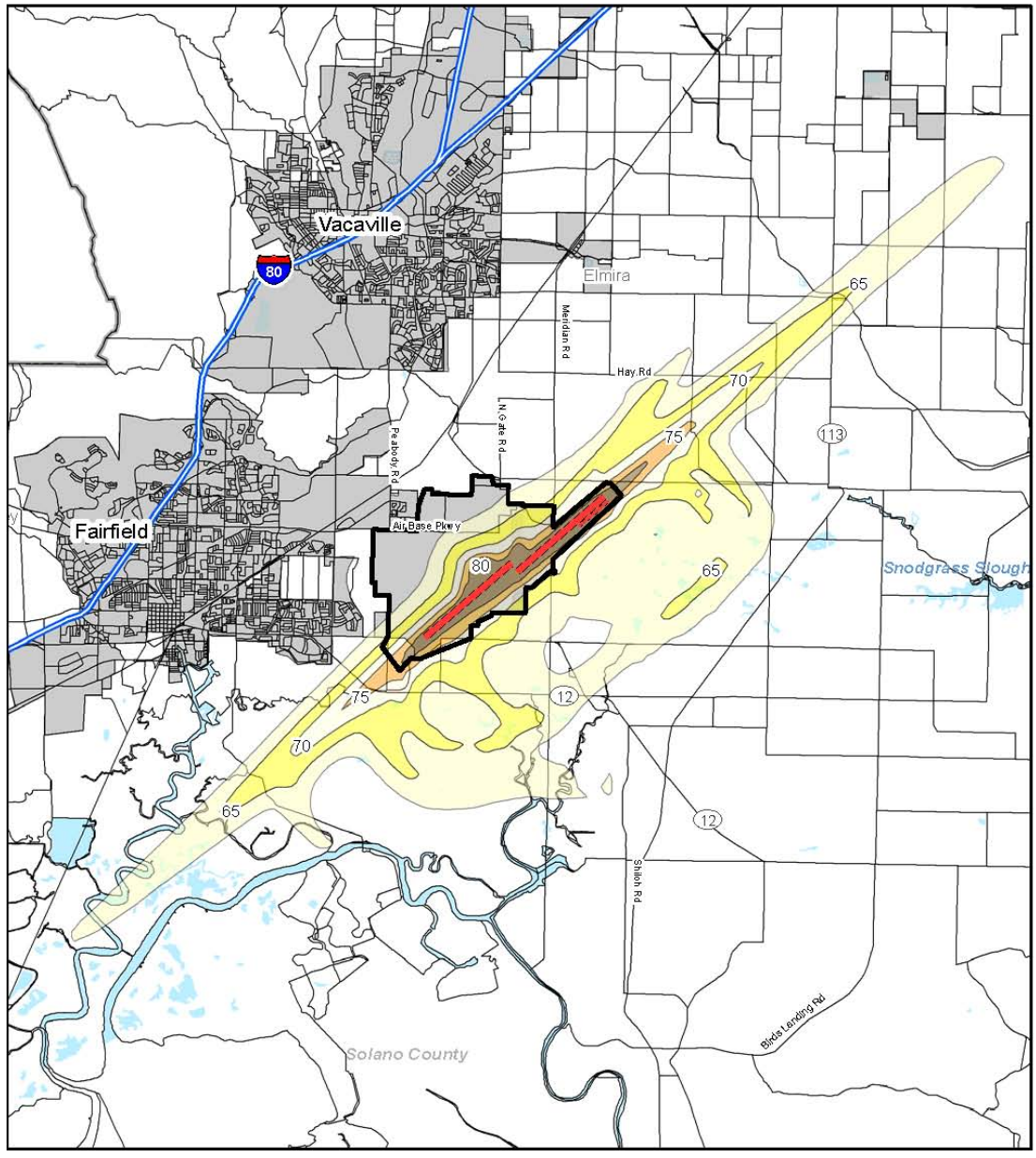
Different sounds have different frequency content. When describing sound and its effect on a human population, A-weighted (dB) sound levels are typically used to account for the response of the human ear. The term "A-weighted" refers to a filtering of the sound signal to emphasize frequencies in the middle of the audible spectrum and to de-emphasize low and high frequencies in a manner corresponding to the way the human ear perceives sound. This filtering network has been established by the American National Standards Institute. The A-weighted noise level has been found to correlate well with people's judgments of the noisiness of different sounds, and has been in use for many years as a measure of community noise. Note that DNL and CNEL represent noise levels averaged over a 24-hour period, not a single event noise.

Table 4.1 shows the off-DoD property noise exposure within the DNL 65 dB and greater noise exposure area for aircraft operations at Travis AFB in terms of acreage and estimated affected population. The population data used in preparing this estimate was obtained from the U.S. Census Bureau 2000 census. To estimate affected population, it was assumed that population was equally distributed within a census tract area. Using this assumption, the total acreage and population in each census tract surrounding Travis AFB was collected and assessed. Using the noise contour information, the number of acres of land in each NZ (*i.e.*, DNL 65-69 dB, 70-74 dB, 75-79 dB, and 80 dB and greater) was divided by the number of acres of land in each census tract to determine what portion of the census tract was contained within each NZ. To determine population, the population total in each block-group was then multiplied by this ratio to estimate affected population.

Table 4.1 Area and Population Within DNL 65 dB and Greater Noise Exposure Area (Off-DoD Property)

DNL Noise Zone	Acres	Population
65–69 dB	5,999	23
70–74 dB	1,926	7
75–79 dB	571	3
80+ dB	65	0
Total	**8,561**	**33**

From Table 4.1, a total of 8,561 acres and 33 persons occur in the off-DoD property area within the DNL 65 dB and greater noise exposure area. The largest affected population is anticipated to be within the DNL 65–69 dB NZ. This area is estimated to contain 5,999 acres in off-DoD property land area (70 percent of the total) and an estimated population of 23 persons (70 percent of the total) based on the calculated population densities for the area.



Travis Air Force Base 2009 AICUZ

Legend

- DNL 80+ dB
- DNL 75-79 dB
- DNL 70-74 dB
- DNL 65-69 dB
- DNL 60-64 dB
- Interstate
- Runway
- City Limits
- Travis AFB

California

N Key Map

0 2 4 Miles

2009 AICUZ Study Noise Contours

Figure 4.3

4.6 COMPARISON WITH 1995 AICUZ STUDY NOISE CONTOURS

The 1995 AICUZ Study presented noise contours for two operating conditions. One condition represented the contours associated with the current operations (*i.e.*, 1995 AICUZ Study Noise Contours [see Figure 4.4]). The other condition (*i.e.*, 1995 AICUZ Study Planning Noise Contours [see Figure 4.5]) represented an expansion of the 1995 AICUZ Study current operations by including tactical approaches to Runways 21R, 3R, and 3L. The 1995 Planning Noise Contours were generated by expanding the 1995 current operations and aircraft types to reflect projected training and operational requirements. The 1995 Planning Noise Contours also included a possible LZ south of runway 21L.

Noise contours presented in this study differ in both shape and extent from the noise contours in the 1995 AICUZ Study. Figure 4.6 compares the 2009 AICUZ Study Noise Contours and the 1995 AICUZ Study Noise Contours. Figure 4.7 compares the 2009 AICUZ Study Noise Contours with the 1995 AICUZ Study Planning Noise Contours.

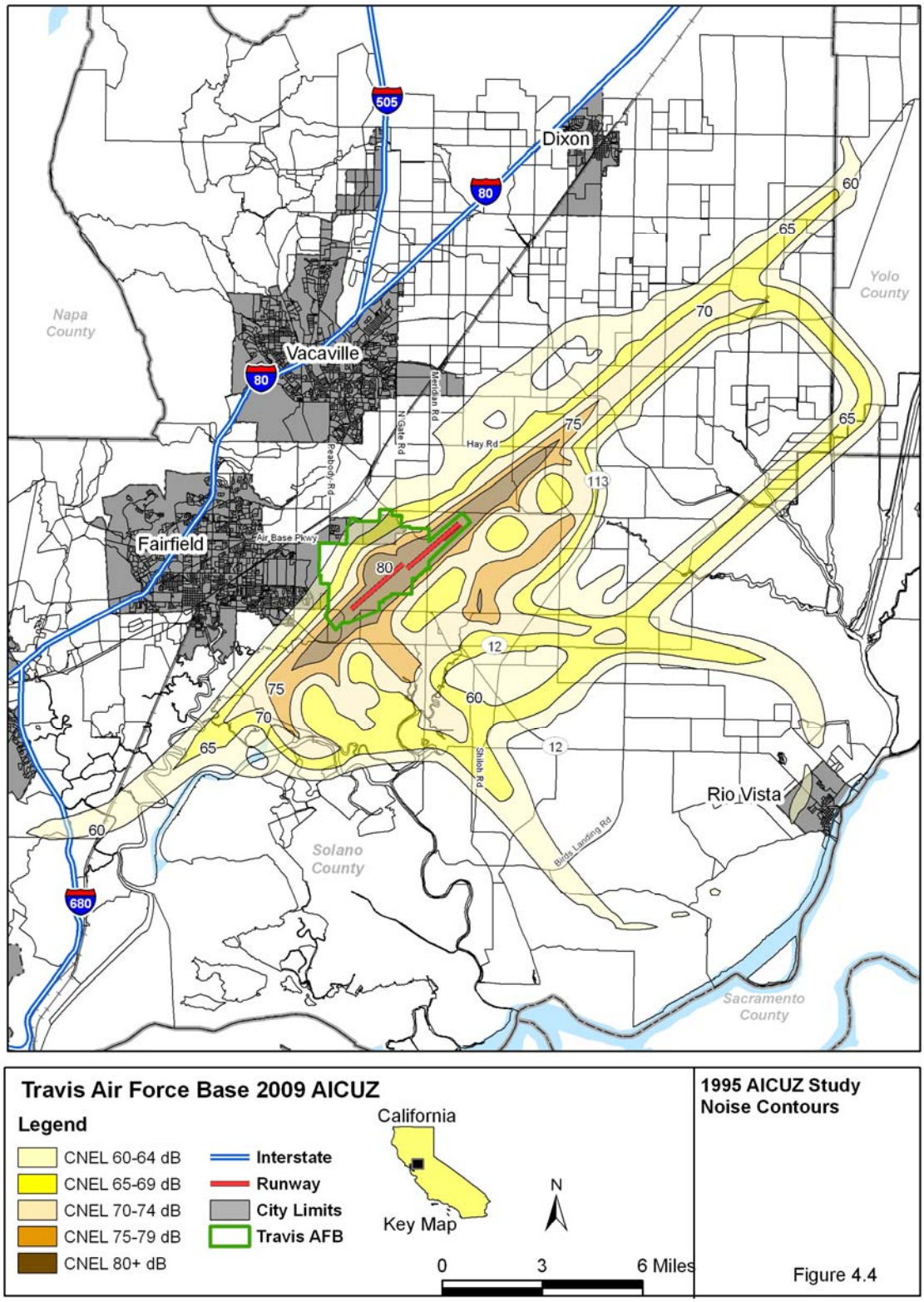
The overall off-DoD property noise exposure for this AICUZ Study is about 43,674 acres less than the 1995 AICUZ Study Noise Contours and approximately 36,743 acres less than the 1995 AICUZ Study Planning Noise Contours. Table 4.2 lists the off-installation noise exposure for the four NZs from both the 2009 and 1995 AICUZ Studies.

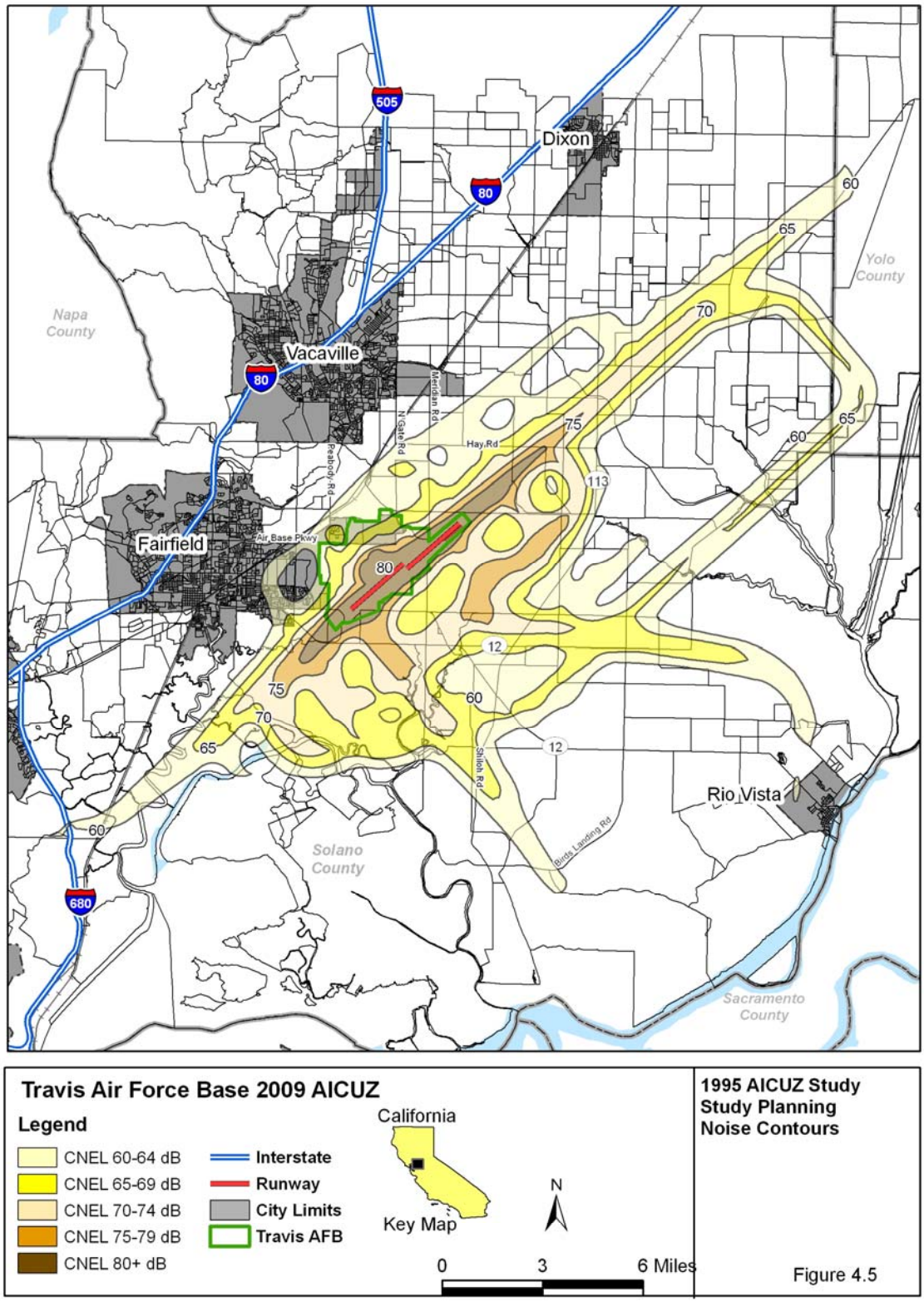
Table 4.2 Total Acres Within the 2009 AICUZ Study and 1995 AICUZ Study Noise Zones (Off-DoD Property)

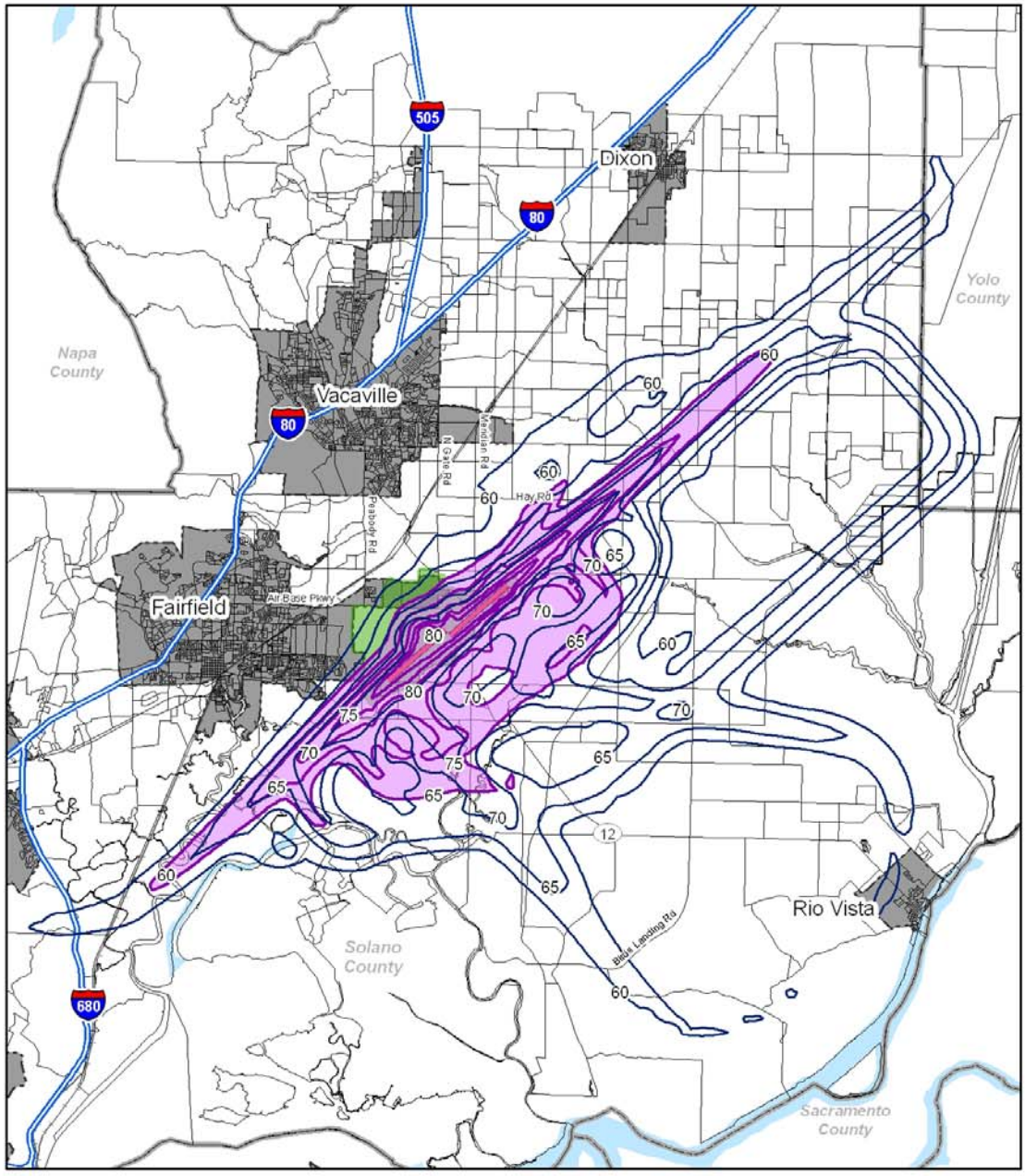
	Acres		
DNL Noise Zone	**2009 AICUZ Study Noise Contours**	**1995 AICUZ Study Noise Contours**	**1995 AICUZ Study Planning Noise Contours**
65–69 dB	5,999	27,416	24,035
70–74 dB	1,926	15,863	14,082
75–79 dB	571	6,634	5,505
80+ dB	65	2,322	1,682
Total	**8,561**	**52,235**	**45,304**

The primary reason for these reductions is the reduced number of aircraft operations currently occurring at Travis AFB. Overall, there is a decrease from 438 average busy day aircraft operations for based aircraft (i.e., C-5, C-141, and KC-10) in the 1995 Study to 209 operations for based aircraft (i.e., C-5, C-17, and KC-10) in the 2009 Study. Operations for the 26 average busy day C-5 operations associated with this 2009 AICUZ Study are about one-sixth of the 160 C-5 operations included in the 1995 Study. Likewise, the 35 average busy day operations for the C-17 aircraft in this 2009 AICUZ Study are approximately one-fifth of the 158 retired C-141 aircraft operations included in the 1995 Study.

An increase of 10 dB is generally perceived as twice as loud (see Appendix C). Noise modeling indicates the C-17 is about two-thirds quieter than a C-141. Similarly, the C-5 is more than 75 percent louder than the C-141 and more than twice as loud as a C-17. This means that the C-5 is the predominant contributor to aircraft noise at Travis AFB in both the 1995 and 2009 AICUZ Studies. The difference in noise between the C-5 and C-17 is more than 10 dB. Thus, the noise from the C-17 contributes very little to the 2009 AICUZ Study noise contours. Reducing the number of operations of the predominant noise source by 50 percent would reduce noise levels by 3 dB. Therefore, reducing the number of C-5 operations in the 2009 AICUZ Study to about one sixth of the operations in the 1995 study results in an


Travis Air Force Base 2009 AICUZ
Legend
CNEL 60-64 dB
CNEL 65-69 dB
CNEL 70-74 dB
CNEL 75-79 dB
CNEL 80+ dB
Interstate
Runway
City Limits
Travis AFB
California
Key Map
N
0
3
6 Miles
1995 AICUZ Study
Noise Contours
Figure 4.4
Dixon
Vacaville
Fairfield
Rio Vista
Napa County
Yolo County
Solano County
Sacramento County
505
80
680
Meridian Rd
N Gate Rd
Peabody Rd
Air Base Pkwy
Hay Rd
Shiloh Rd
Birds Landing Rd
60
65
70
75
80
113
12


Travis Air Force Base 2009 AICUZ
Legend
CNEL 60-64 dB
CNEL 65-69 dB
CNEL 70-74 dB
CNEL 75-79 dB
CNEL 80+ dB
Interstate
Runway
City Limits
Travis AFB
California
Key Map
N
0
3
6 Miles
1995 AICUZ Study
Study Planning
Noise Contours
Figure 4.5
Dixon
Vacaville
Fairfield
Rio Vista
Napa County
Yolo County
Solano County
Sacramento County
505
80
680
60
65
70
75
80
113
12
Hay Rd
Air Base Pkwy
Peabody Rd
N Gate Rd
Meridian Rd
Shiloh Rd
Birds Landing Rd



Travis Air Force Base 2009 AICUZ

Legend

- 1995 Noise Contour
- 2009 Noise Contour
- Interstate
- Runway
- City Limits
- Travis AFB

California

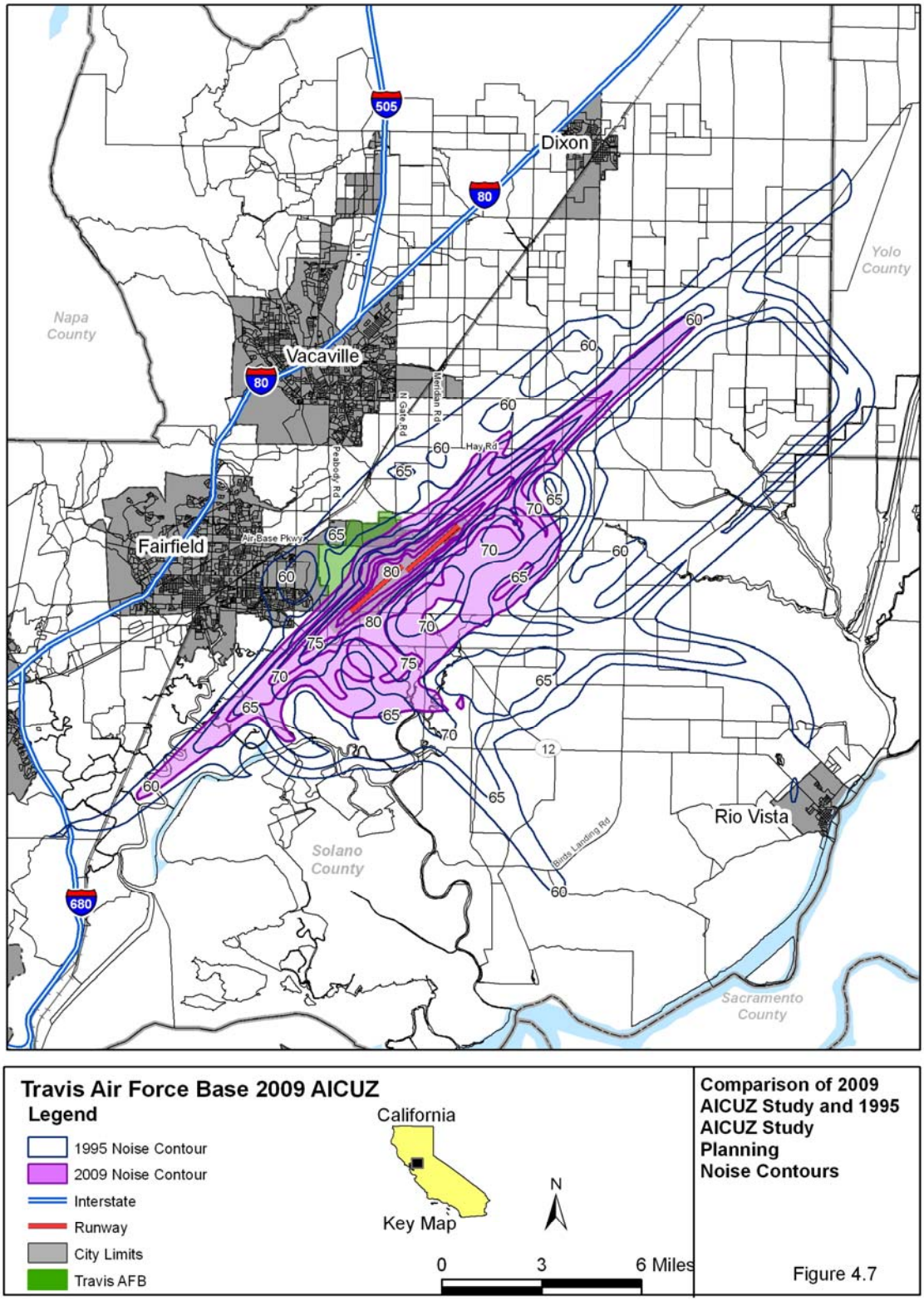
Key Map

N

0 3 6 Miles

Comparison of 2009 AICUZ Study and 1995 AICUZ Study Noise Contours

Figure 4.6


Travis Air Force Base 2009 AICUZ
Legend
1995 Noise Contour
2009 Noise Contour
Interstate
Runway
City Limits
Travis AFB
California
Key Map
N
0
3
6 Miles
Comparison of 2009 AICUZ Study and 1995 AICUZ Study Planning Noise Contours
Figure 4.7
Dixon
Vacaville
Fairfield
Rio Vista
Napa County
Yolo County
Solano County
Sacramento County
505
80
680
12
Hay Rd
Air Base Pkwy
Peabody Rd
N Gate Rd
Sheridan Rd
Birds Landing Rd

approximate 9 dB decrease in noise levels for just the C-5 aircraft. Thus, the approximate 80 percent reduction in C-5 operations is the primary reason for the decrease in noise exposure when comparing the 2009 AICUZ Study contours to the 1995 Study contours.

4.7 CLEAR ZONES AND ACCIDENT POTENTIAL ZONES FOR RUNWAYS

The purpose of this subsection is to describe the basis for CZs and APZs and apply the zones to the Travis AFB runways.

4.7.1 Basis for Clear Zones and Accident Potential Zones

Areas around airports are exposed to the possibility of aircraft accidents even with well-maintained aircraft and highly trained aircrews. Despite stringent maintenance requirements and countless hours of training, past history makes it clear that accidents may occur.

The risk of people on the ground being killed or injured by aircraft accidents is small. However, an aircraft accident is a high-consequence event and, when a crash does occur, the result is often catastrophic. Because of this, the Air Force does not attempt to base its safety standards on accident probabilities. Instead it approaches this safety issue from a land use planning perspective. Designation of safety zones around the airfield and restriction of incompatible land uses can reduce the public's exposure to safety hazards. The AICUZ Program includes three safety zones: the CZ, APZ I, and APZ II. These zones were developed from analysis of over 830 major Air Force accidents that occurred within 10 miles of an Air Force installation between 1968 and 1995. Figure B.3 in Appendix B summarizes the location of these accidents.

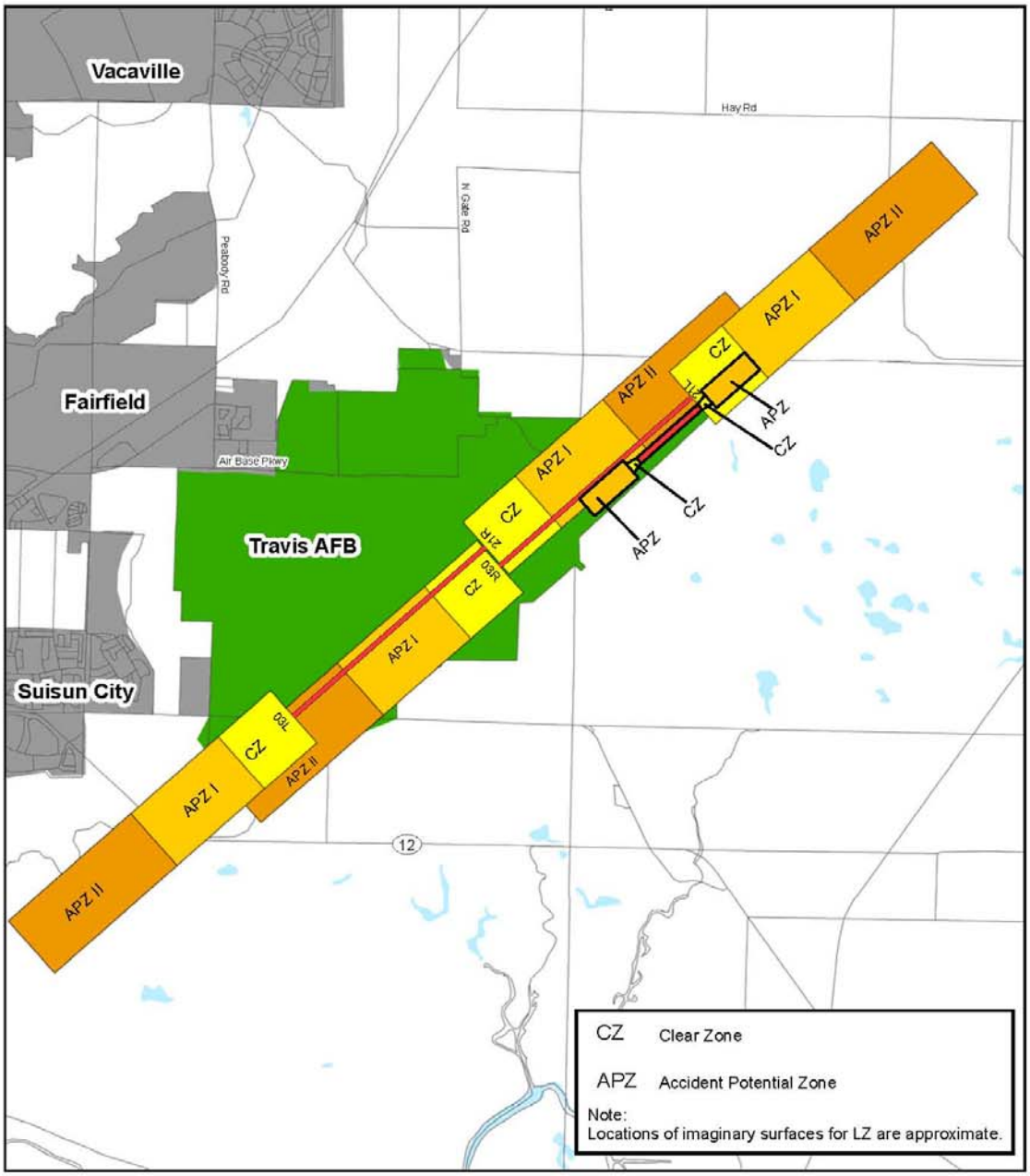
The CZ has the highest accident potential of the three zones, as 27 percent of accidents studied occurred in this area. Due to the relatively high accident potential, the Air Force adopted a policy of acquiring real estate interests in the CZ through purchase or easement when feasible.

Accident Potential Zone I is an area that possesses somewhat less accident potential than the CZ, with 10 percent of the accidents studied occurring in this zone. APZ II has less accident potential than APZ I, with 6 percent of the accidents studied occurring in this zone. While the potential for aircraft accidents in APZs I and II does not warrant land acquisition by the Air Force, land use planning and controls are strongly encouraged in these areas for the protection of the public.

4.7.2 Clear Zones and Accident Potential Zones for Travis AFB Runways

Figure 4.8 depicts the CZs and APZs for both runways at Travis AFB. The discussion in this subsection applies to both runways.

Each runway end at Travis AFB has a 3,000 foot by 3,000 foot CZ and two APZ's. Accident potential on or adjacent to the runway or within the CZ is so high that the necessary land use restrictions would prohibit reasonable economic use of land. As stated previously, it is Air Force policy to request that Congress authorize and appropriate funds for the necessary real property interests in this area to prevent incompatible land uses.



Travis Air Force Base 2009 AICUZ

Clear Zones and Accident Potential Zones

Legend

- Landing Zone (LZ)
- Runway
- City Limits
- APZ I
- APZ II
- Clear Zone
- Travis AFB

California

Key Map

N

0 0.5 1 Miles

Figure 4.8

Accident Potential Zone I is less critical than the CZ, but still possess a significant risk factor. This 3,000 foot by 5,000 foot area has land use compatibility guidelines sufficiently flexible to allow reasonable economic use of the land, such as industrial/manufacturing, transportation, communication/utilities, wholesale trade, open space, recreation, and agriculture. However, uses that concentrate people in small areas are not acceptable.

Accident Potential Zone II is less critical than APZ I, but still possesses potential for accidents. Accident Potential Zone II, also 3,000 feet wide, is 7,000 feet long extending to 15,000 feet from the runway threshold. Acceptable uses include those of APZ I, as well as low density single family residential and those personal and business services and commercial/retail trade uses of low intensity or scale of operation. High density functions such as multi-story buildings, places of assembly (*e.g.,* theaters, churches, schools, restaurants, *etc.*), and high density office uses are not considered appropriate.

High people densities should be limited to the maximum extent possible in APZ II. The optimum density recommended for residential usage (where it does not conflict with noise criteria) in APZ II is one dwelling per acre. For most nonresidential usage, buildings should be limited to one story and the lot coverage should not exceed 20 percent.

4.7.3 Land Use Compatibility Guidelines for Runways

Subsection 4.7.3.1 introduces the AICUZ concept, and Subsection 4.7.3.2 presents the land use compatibility guidelines applicable to Travis AFB.

4.7.3.1 Introduction

The DoD developed the AICUZ Program for military airfields. Using this program at its installations, the DoD works to protect aircraft operational capabilities and to assist local government officials in protecting and promoting the health, safety, and quality of life of the public. The goal is to promote compatible land use development around military airfields by providing information on aircraft noise exposure and accident potential.

AICUZ guidelines describe three basic types of constraints that affect, or result from, flight operations. The first constraint involves areas the FAA and DoD identified for height limitations (see Subsection 4.2).

The second constraint involves NZs based on the DNL metric and the DoD NOISEMAP methodology. Using the NOISEMAP program, which is similar to FAA's INM, the Air Force produces noise contours showing noise levels generated by aircraft operations. The AICUZ study contains noise contours plotted in 5 dB increments, ranging from DNL 65 dB to 80+ dB.

The third constraint involves CZs and APZs based on statistical analysis of past DoD aircraft accidents. DoD analysis has determined that areas immediately beyond the ends of runways and along approach and departure flight paths have greater potential for aircraft accidents (see Appendix B).

4.7.3.2 Land Use Compatibility Guidelines for Runways

Each AICUZ study contains land use guidelines. Table 4.3 identifies land uses and possible noise exposure and accident potential combinations for Travis AFB. These noise

guidelines are essentially the same as those published by the Federal Interagency Committee on Urban Noise in the June 1980 publication, *Guidelines for Considering Noise in Land Use Planning and Control.* The U.S. Department of Transportation publication, *Standard Land Use Coding Manual (SLUCM),* has been used to identify and code land use activities. The CZ and APZ guidelines in Table 4.3 apply to runways. The designations are a combination of criteria listed in the legend and notes at the end of the table. For example, Y^{1} means land use and related structures are compatible without restriction at a suggested maximum density of 1-2 dwelling units per acre, possibly increased under a Planned Unit Development (PUD) where lot coverage is less than 20 percent.

Table 4.3 Land Use Compatibility Guidelines

Land Use		Accident Potential Zones			Noise Zones			
SLUCM No.	Name	Clear Zone	APZ I	APZ II	65-69	70-74	75-79	80+
10	**Residential**							
11	Household units							
11.11	Single units; detached	N	N	Y^{1}	A^{11}	B^{11}	N	N
11.12	Single units; semidetached	N	N	N	A^{11}	B^{11}	N	N
11.13	Single units; attached row	N	N	N	A^{11}	B^{11}	N	N
11.21	Two units; side-by-side	N	N	N	A^{11}	B^{11}	N	N
11.22	Two units; one above the other	N	N	N	A^{11}	B^{11}	N	N
11.31	Apartments; walk up	N	N	N	A^{11}	B^{11}	N	N
11.32	Apartments; elevator	N	N	N	A^{11}	B^{11}	N	N
12	Group quarters	N	N	N	A^{11}	B^{11}	N	N
13	Residential hotels	N	N	N	A^{11}	B^{11}	N	N
14	Mobile home parks or courts	N	N	N	N	N	N	N
15	Transient lodgings	N	N	N	A^{11}	B^{11}	C^{11}	N
16	Other residential	N	N	N^{1}	A^{11}	B^{11}	N	N
20	**Manufacturing**							
21	Food & kindred products; manufacturing	N	N^{2}	Y	Y	Y^{12}	Y^{13}	Y^{14}
22	Textile mill products; manufacturing	N	N^{2}	Y	Y	Y^{12}	Y^{13}	Y^{14}
23	Apparel and other finished products made from fabrics, leather, and similar materials; manufacturing	N	N	N^{2}	Y	Y^{12}	Y^{13}	Y^{14}
24	Lumber and wood products (except furniture); manufacturing	N	Y^{2}	Y	Y	Y^{12}	Y^{13}	Y^{14}
25	Furniture and fixtures; manufacturing	N	Y^{2}	Y	Y	Y^{12}	Y^{13}	Y^{14}
26	Paper & allied products; manufacturing	N	Y^{2}	Y	Y	Y^{12}	Y^{13}	Y^{14}
27	Printing, publishing, and allied industries	N	Y^{2}	Y	Y	Y^{12}	Y^{13}	Y^{14}
28	Chemicals and allied products; manufacturing	N	N	N^{2}	Y	Y^{12}	Y^{13}	Y^{14}
29	Petroleum refining and related industries	N	N	Y	Y	Y^{12}	Y^{13}	Y^{14}

Table 4.3 Land Use Compatibility Guidelines (Continued)

Land Use		Accident Potential Zones			Noise Zones			
SLUCM No.	Name	Clear Zone	APZ I	APZ II	65-69	70-74	75-79	80+
30	**Manufacturing**							
31	Rubber and misc. plastic products, manufacturing	N	N[2]	N[2]	Y	Y[12]	Y[13]	Y[14]
32	Stone, clay and glass products manufacturing	N	N[2]	Y	Y	Y[12]	Y[13]	Y[14]
33	Primary metal industries	N	N[2]	Y	Y	Y[12]	Y[13]	Y[14]
34	Fabricated metal products; manufacturing	N	N[2]	Y	Y	Y[12]	Y[13]	Y[14]
35	Professional, scientific, and controlling instruments; photographic and optical goods; watches and clocks manufacturing	N	N	N[2]	Y	A	B	N
39	Miscellaneous manufacturing	N	Y[2]	Y[2]	Y	Y[12]	Y[13]	Y[14]
40	**Transportation, Communications and Utilities**							
41	Railroad, rapid rail transit and street railroad transportation	N[3]	Y[4]	Y	Y	Y[12]	Y[13]	Y[14]
42	Motor vehicle transportation	N[3]	Y	Y	Y	Y[12]	Y[13]	Y[14]
43	Aircraft transportation	N[3]	Y[4]	Y	Y	Y[12]	Y[13]	Y[14]
44	Marine craft transportation	N[3]	Y[4]	Y	Y	Y[12]	Y[13]	Y[14]
45	Highway & street right-of-way	N[3]	Y	Y	Y	Y[12]	Y[13]	Y[14]
46	Automobile parking	N[3]	Y[4]	Y	Y	Y[12]	Y[13]	Y[14]
47	Communications	N[3]	Y[4]	Y	Y	A[15]	B[15]	N
48	Utilities	N[3]	Y[4]	Y	Y	Y	Y[12]	Y[13]
49	Other transportation communications and utilities	N[3]	Y[4]	Y	Y	A[15]	B[15]	N
50	**Trade**							
51	Wholesale trade	N	Y[2]	Y	Y	Y[12]	Y[13]	Y[14]
52	Retail trade-building materials, hardware and farm equipment	N	Y[2]	Y	Y	Y[12]	Y[13]	Y[14]
53	Retail trade-general merchandise	N	N[2]	Y[2]	Y	A	B	N
54	Retail trade-food	N	N[2]	Y[2]	Y	A	B	N
55	Retail trade-automotive, marine craft, aircraft and accessories	N	Y[2]	Y[2]	Y	A	B	N
56	Retail trade-apparel and accessories	N	N[2]	Y[2]	Y	A	B	N
57	Retail trade-furniture, home furnishings and equipment	N	N[2]	Y[2]	Y	A	B	N
58	Retail trade-eating and drinking establishments	N	N	N[2]	Y	A	B	N
59	Other retail trade	N	N[2]	Y[2]	Y	A	B	N

Table 4.3 Land Use Compatibility Guidelines (Continued)

Land Use		Accident Potential Zones			Noise Zones			
SLUCM No.	Name	Clear Zone	APZ I	APZ II	65-69	70-74	75-79	80+
60	**Services**							
61	Finance, insurance and real estate services	N	N	Y[6]	Y	A	B	N
62	Personal services	N	N	Y[6]	Y	A	B	N
62.4	Cemeteries	N	Y[7]	Y[7]	Y	Y[12]	Y[13]	Y[14,21]
63	Business services	N	Y[8]	Y[8]	Y	A	B	N
64	Repair services	N	Y[2]	Y	Y	Y[12]	Y[13]	Y[14]
65	Professional services	N	N	Y[6]	Y	A	B	N
65.1	Hospitals, nursing homes	N	N	N	A*	B*	N	N
65.1	Other medical facilities	N	N	N	Y	A	B	N
66	Contract construction services	N	Y[6]	Y	Y	A	B	N
67	Governmental services	N	N	Y[6]	Y*	A*	B*	N
68	Educational services	N	N	N	A*	B*	N	N
69	Miscellaneous services	N	N[2]	Y[2]	Y	A	B	N
70	**Cultural, Entertainment and Recreational**							
71	Cultural activities (including churches)	N	N	N[2]	A*	B*	N	N
71.2	Nature exhibits	N	Y[2]	Y	Y*	N	N	N
72	Public assembly	N	N	N	Y	N	N	N
72.1	Auditoriums, concert halls	N	N	N	A	B	N	N
72.11	Outdoor music shell, amphitheaters	N	N	N	N	N	N	N
72.2	Outdoor sports arenas, spectator sports	N	N	N	Y[17]	Y[17]	N	N
73	Amusements	N	N	Y[8]	Y	Y	N	N
74	Recreational activities (including golf courses, riding stables, water recreation)	N	Y[8,9,10]	Y	Y*	A*	B*	N
75	Resorts and group camps	N	N	N	Y*	Y*	N	N
76	Parks	N	Y[8]	Y[8]	Y*	Y*	N	N
79	Other cultural, entertainment and recreation	N	Y[9]	Y[9]	Y*	Y*	N	N
80	**Resources Production and Extraction**							
81	Agriculture (except livestock)	Y[16]	Y	Y	Y[18]	Y[19]	Y[20]	Y[20,21]
81.5 to 81.7	Livestock farming and animal breeding	N	Y	Y	Y[18]	Y[19]	Y[20]	Y[20,21]
82	Agricultural related activities	N	Y[5]	Y	Y[18]	Y[19]	N	N
83	Forestry activities and related services	N[5]	Y	Y	Y[18]	Y[19]	Y[20]	Y[20,21]
84	Fishing activities and related services	N[5]	Y[5]	Y	Y	Y	Y	Y
85	Mining activities and related services	N	Y[5]	Y	Y	Y	Y	Y
89	Other resources production and extraction	N	Y[5]	Y	Y	Y	Y	Y

LEGEND

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

Y - (Yes) - Land use and related structures are compatible without restriction.

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

Y^x - (yes with restrictions) - Land use and related structures generally compatible; see notes 1-21.

N^x - (no with exceptions) - See notes 1-21.

NLR - (Noise Level Reduction) - NLR (outdoor to indoor) to be achieved through incorporation of noise attenuation measures into the design and construction of the structures.

A, B, or C - Land use and related structures generally compatible; measures to achieve NLR of A (DNL 25 dB), B (DNL 30 dB), or C (DNL 35 dB) need to be incorporated into the design and construction of structures.

A^*, B^*, and C^* - Land use generally compatible with NLR. However, measures to achieve an overall NLR do not necessarily solve noise difficulties and additional evaluation is warranted. See appropriate footnotes.

***** - The designation of these uses as "compatible" in this zone reflects individual federal agency and program consideration of general cost and feasibility factors, as well as past community experiences and program objectives. Localities, when evaluating the application of these guidelines to specific situations, may have different concerns or goals to consider.

NOTES

1. *Suggested maximum density of 1-2 dwelling units per acre possibly increased under a PUD where maximum lot coverage is less than 20 percent.*
2. *Within each land use category, uses exist where further definition may be needed due to the variation of densities in people and structures. Shopping malls and shopping centers are considered incompatible in any accident potential zone (CZ, APZ I, or APZ II).*
3. *The placing of structures, buildings, or above ground utility lines in the clear zone is subject to severe restrictions. In a majority of the clear zones, these items are prohibited. See AFI 32-7063 and UFC 3-260-01 for specific guidance.*
4. *No passenger terminals and no major above ground transmission lines in APZ I.*
5. *Factors to be considered: labor intensity, structural coverage, explosive characteristics, and air pollution.*
6. *Low-intensity office uses only. Meeting places, auditoriums, etc., are not recommended.*
7. *Excludes chapels.*
8. *Facilities must be low intensity.*
9. *Clubhouse not recommended.*
10. *Areas for gatherings of people are not recommended.*

11A. *Although local conditions may require residential use, it is discouraged in DNL 65-69 dB and strongly discouraged in DNL 70-74 dB. An evaluation should be conducted prior to approvals, indicating a demonstrated community need for residential use would not be met if development were prohibited in these zones, and there are no viable alternative locations.*

11B. *Where the community determines the residential uses must be allowed, measures to achieve outdoor to indoor NLR for DNL 65-69 dB and DNL 70-74 dB should be incorporated into building codes and considered in individual approvals.*

11C. *NLR criteria will not eliminate outdoor noise problems. However, building location and site planning, and design and use of berms and barriers can help mitigate outdoor exposure, particularly from near ground level sources. Measures that reduce outdoor noise should be used whenever practical in preference to measures which only protect interior spaces.*

12. *Measures to achieve the same NLR as required for facilities in the DNL 65-69 dB range 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.*
13. *Measures to achieve the same NLR as required for facilities in the DNL 70-74 dB range 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.*
14. *Measures to achieve the same NLR as required for facilities in the DNL 75-79 dB range 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.*
15. *If noise sensitive, use indicated NLR; if not, the use is compatible.*
16. *No buildings.*
17. *Land use is compatible provided special sound reinforcement systems are installed.*
18. *Residential buildings require the same NLR required for facilities in the DNL 65-69 dB range.*
19. *Residential buildings require the same NLR required for facilities in the DNL 70-74 dB range.*
20. *Residential buildings are not permitted.*
21. *Land use is not recommended. If the community decides the use is necessary, personnel should wear hearing protection devices.*

4.8 CLEAR ZONE, ACCIDENT POTENTIAL ZONE, AND LAND USE COMPATIBILITY GUIDELINES FOR LANDING ZONES

UFC 3-260-01 contains the CZ, APZ, and land use compatibility guidelines for LZs. Figure 4.8 depicts the CZs and APZs for LZ 03/21 at Travis AFB. Each end of LZ 03/21 at Travis AFB has one CZ and one APZ. The LZ APZ possesses a significant potential for accidents. Therefore, land use in the APZ is a concern. UFC 3-260-01 lists the following limitations for LZ APZs in addition to the first four items in Subsection 4.3.

- No explosive storage facilities or activities.
- No troop concentrations, such as housing areas, dining or medical facilities, and recreational fields that include spectators.

Only features required to operate the LZ such as taxiways and aprons, navigational aids, aircraft and support equipment, and cargo loading and unloading areas and equipment are permissible in the exclusion area. Security forces, roads, parking lots, storage areas, etc., are not permitted in the exclusion area.

4.9 PARTICIPATION IN THE PLANNING PROCESS

The Air Force provides results of the AICUZ Study to local communities to assist them in preparing their local land use plans. This subsection discusses how the Base participates in the community planning process. Subsection 6.3 addresses the role played by the local community in enhancing compatible land use.

Airspace obstructions, construction in the APZs, residential development, and the construction of other noise-sensitive uses near the Base are of great concern to Travis AFB. The Air Force is very interested in minimizing increases in incompatible usage and in encouraging voluntary conversion of non-compatible usage to compatible usage. Applying the categories for compatible land use described in Table 4.3, the Base evaluates the impact aircraft operations have on surrounding properties and the effect new development or changes in land use might have on operational capabilities of Travis AFB.

The point of contact for AICUZ matters at Travis AFB is Public Affairs (707-424-2011). In addition to working with local governing entities and planning professionals, the Travis AFB Public Affairs Office works to address complaints and concerns expressed by off-airfield neighbors.

Travis AFB conducts active outreach to the community by meeting with various community groups and speaking with individuals as needed. The Travis AFB Civil Engineer and Public Affairs Offices work together providing public meetings and informational workshops to disseminate information about Base operations, forecasts, plans, and mitigation strategies.

SECTION 5
LAND USE ANALYSIS

5.1 INTRODUCTION

Land use planning and control is a dynamic, rather than a static process. Specific characteristics of land use determinants will always reflect, to some degree, changing conditions of the economic, social, and physical environment of a community, as well as changing public concern. The planning process accommodates this fluidity in which decisions are normally not based on boundary lines, but rather on more generalized area designations.

Travis AFB was originally established in a relatively undeveloped area in Solano County, California. Land use in the immediate vicinity of Travis AFB is predominantly agricultural with interspersed rural residences, except to the west, where urban development (mixed commercial and residential) is adjacent to the Base. There are areas of residential, industrial, commercial, and public uses extending from Cannon Drive to Peabody Road north of Air Base Parkway in the City of Fairfield. Similar land uses occur in unincorporated Solano County to the north of the city limits and east of Peabody Road. To the west of Peabody Road, industrial development is occurring within the City of Fairfield, with major urbanized portions of the City of Fairfield extending to a point approximately one half mile west of the Base. Residential development in Suisun City is located near the southwest corner of Travis AFB along Walters Road, but is separated from the Base by safety clearance zones easements where no development is allowed. The Suisun City Lambrecht Sports Complex and Public Works Yard are located at the southwest corner of the Travis AFB boundary.

Geographic information systems and detailed digital orthophotography enable the Air Force to more accurately analyze its flight tracks and noise contours for land use planning purposes. These methods reveal the extent of Travis AFB's region of influence with respect to Solano County and the surrounding communities.

For the purpose of this AICUZ study, the existing and future land uses depicted on the figures within this section have been generalized into one of the following six categories:

Residential: Residential dwellings, such as single-family and multi-family residences and mobile homes, developed at a density greater than one dwelling unit per acre.

Commercial: Offices, retail stores, restaurants, and other commercial establishments.

Industrial: Manufacturing, warehousing, and other similar uses.

Public/Quasi-Public: Publicly-owned lands and/or land to which the public has access, including military reservations and training grounds, public buildings, schools, churches, cemeteries, and hospitals.

Recreational: Land areas designated for recreational activity, including parks, wilderness areas and reservations, conservation areas, and areas designated for sporting events, hiking, camping, etc.

Open/Agricultural/Low Density: Undeveloped land, farms, pasture land, and residential development with a density of one dwelling unit per acre or less.

5.2 EXISTING LAND USE

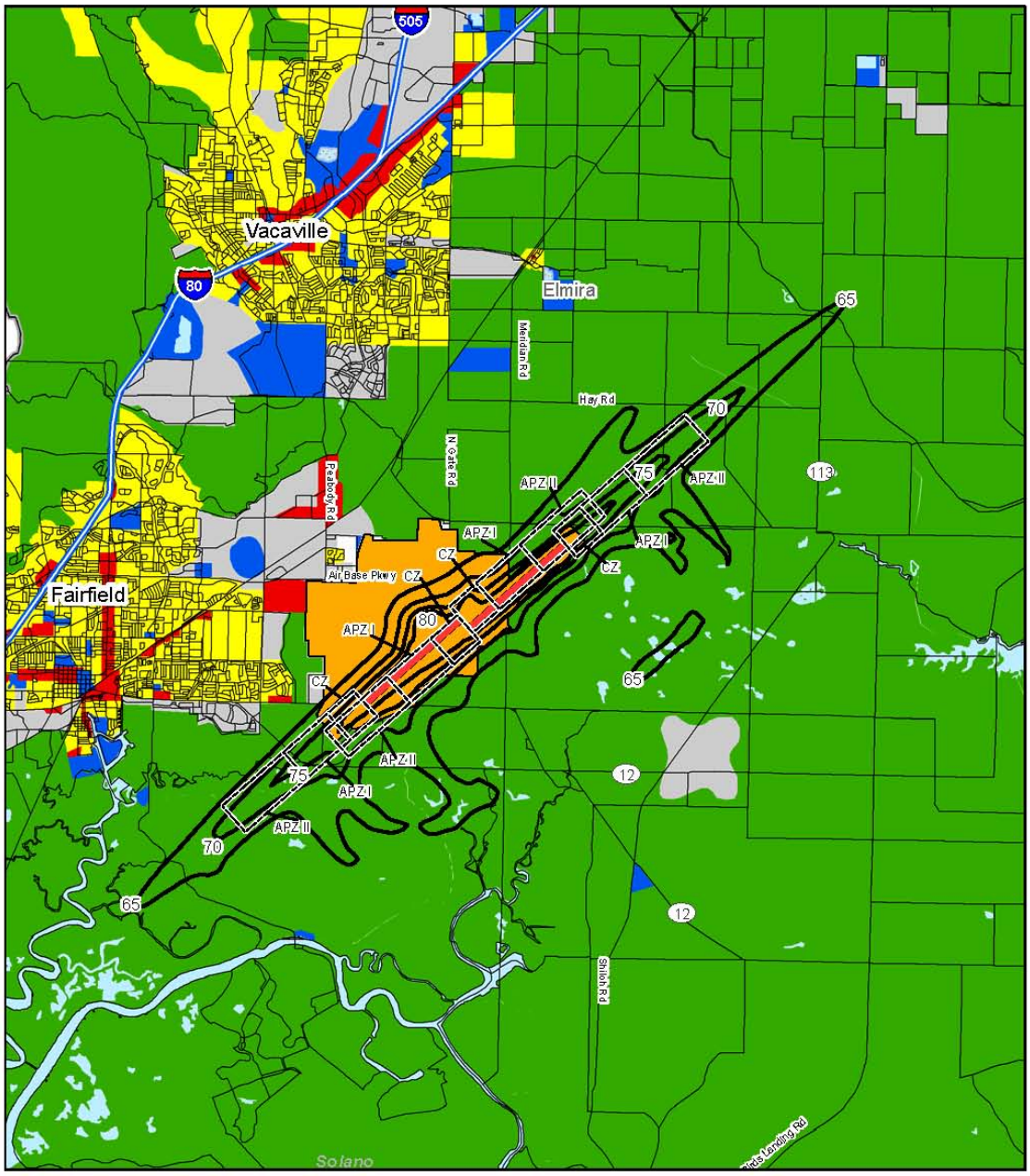
The existing land use pattern in the vicinity of Travis AFB is shown in Figure 5.1. The land adjacent to the Base is primarily used for agriculture or open grazing and includes unincorporated areas of Solano County. The cities of Fairfield, Suisun City and Vacaville lie to the north and west of the Base. Based on the location and orientation of Travis AFB's runways, aircraft operations primarily occur over non-military land to the north, south and east of the Base. This area includes unincorporated areas of Solano County.

During the 1990s, the area experienced a boom in residential growth followed by an increase in commercial development necessary to serve new residents. In the 1990's the area experienced a slowing in the rate of development, but since 2000, the area has experienced a slow, but steady growth rate. The majority of land surrounding Travis AFB can be characterized as low to moderate density rural development, with some areas of rural residential and undeveloped land east of the Base. In accordance with the Air Force's guidance on land use compatibility, residential development with a density of less than one dwelling unit per acre has been classified as open/agricultural/low density on Figure 5.1.

The Cities of Fairfield and Suisun City surround Travis AFB to the west, with the City of Vacaville to the north. The Suisun City Lambrecht Sports Complex lies adjacent to the Base on the southwest. This sports complex has baseball/softball diamonds, soccer fields and picnic areas. Although the sports complex occurs adjacent to the Base, this land is not incompatible land when considering the guidelines in Table 4.3. Much of the area directly surrounding Travis AFB is in the unincorporated area of Solano County. Much of the development near the Base is along two main arteries, Peabody Road and Air Base Parkway which both provide direct access to the Base. Interstate 80 is located approximately six miles west of Travis AFB and is vital to transportation in the region. Residential neighborhoods and public uses have been developed adjacent to the highways and are served by networks of primary and secondary streets.

The adopted Land Use Elements of the General Plans for Fairfield and Suisun City include proposed land uses within their respective city limits, and in proposed adjacent growth areas outside their city limits. These growth areas overlap the Solano County land use designations, but the Solano County designations control land use in these areas until annexed by the respective municipality.

The Travis AFB Land Use Compatibility Plan, adopted by the Solano County Airport Land Use Commission (ALUC) in June 2002, provides direction for future use of lands in the vicinity of the Base. Land use issues of interest to the ALUC include those involving noise and overflight compatibility, obstruction clearances, and safety of persons on the ground. The noise contours in the Travis AFB Land Use Compatibility Plan are based on a "potential future noise" scenario. A determination of consistency with the Travis AFB Land Use Compatibility Plan is required of all new development proposals within the ALUC planning boundary, which includes all lands that could be negatively impacted by aircraft operations from the Base. Standards for the ALUC determination of consistency are similar to the land use compatibility standards of the Travis AFB AICUZ program. If the ALUC finds that a proposed development is not consistent with the Travis AFB Land Use Compatibility Plan, the responsible local agency may amend the proposal to be consistent, or it could override the ALUC determination with a two-thirds vote of its governing body.



Travis Air Force Base 2009 AICUZ

Legend

- Public/ Quasi-Public
- Residential
- Commercial
- Industrial
- Open/ Agriculture/ Low Density
- CZ/ APZ Boundary
- Noise Contour
- Runway
- Travis AFB
- County Boundary
- Interstate

N

0 0.5 1 2 Miles

Generalized Existing Land Use

Figure 5.1

There are six city-centered growth areas in Solano County, one of which is the Fairfield-Suisun Urban Area. It is estimated that nearly all population growth will occur in and around these six urban areas. The urban growth line defines the extent of urbanization around each city in the county and represents estimated urban expansion within the next 15 to 20 years. The ALUC designation for areas surrounding Travis AFB on the north, east, and south is agriculture or extensive agriculture, and these areas are currently zoned for agricultural use. The land south of Highway 12 is proposed as Marsh Protection District. The remaining area west of the Base (west of Peabody Road) is within the urban growth line, and the proposed uses reflect the Fairfield Land Use Element, with residential, commercial, and industrial growth.

The City of Fairfield updated its Land Use Element as part of a comprehensive update to the county's General Plan. The update also included the Travis Protection Element. The revised plan adopts a more stringent noise standard requiring that no new or additional residential zoning be adopted within the CNEL 60 dBA noise contours. Under the 2002 revisions, a significant portion of land located east of North Gate Road, as well as land adjacent to the Base west of North Gate Road, and land southeast of the Base, has a "Travis Reserve" land use designation. Land in the Travis Reserve is set aside for future expansion of Travis AFB only as long as the military mission of the Base remains. No residential uses will be permitted in the Travis Reserve and the City of Fairfield supports its continued use for agriculture and grazing. Approximately 800 acres west of North Gate Road and north of the proposed Travis Reserve is designated for a technology park. The unincorporated area on the east side of Peabody Road near the northwest corner of the Base between the city limits and the former Sacramento Northern Railroad is designated as a combination office commercial, community commercial, and medium- and high-density residential. Other areas west of the Base would remain predominantly non-residential with commercial, light industrial, and mixed-use light industrial/commercial. The only residential use in the vicinity of the Base would remain the area east of Peabody Road between Dobe Lane and Whitney Drive, while the public land use designation would remain for the Vanden High School and Golden West Intermediate School sites.

The Suisun City Land Use Element (*i.e.*, Chapter 4 of the Suisun City General Plan), establishes a proposed land use pattern to the southwest of Travis AFB that is predominantly residential, extending along Walters Road from Tabor Avenue to Scandia Road. At the northern end of this area is the Peterson Ranch, approved by Suisun City for residential development, with smaller areas near the intersection of Scandia and Walters Roads designated for commercial development. The area south of Scandia Road to Highway 12 is designated as "Agriculture Open Space Reserve." All undeveloped lands south of Highway 12 are within the Suisun Marsh Protection District. The land use controls within the Suisun Marsh Protection District effectively prevent any further urban development south of Highway 12

Table 5.1 summarizes the existing acreage by land use category that lies within the DNL 65 dB and greater noise exposure area. It is important to note that these acreages represent only the area occurring outside the boundaries of Travis AFB. However, it is also important to note that no residential, commercial, industrial, or other major uses occur in this area.

Table 5.1 Generalized Existing Land Use Within DNL 65 dB and Greater Noise Exposure Area (Off-DoD Property)

Category	Acreage
Residential	0
Commercial	0
Industrial	0
Public/Quasi-public	0
Recreational	0
Open/Agricultural/Low Density	8,561
Total	**8,561**

Table 5.2 summarizes the amounts of off-Base land by land use category that lie under the Travis AFB CZs and APZs. There are no residential areas that occur within the Travis AFB CZs and APZs. The noise contours and APZs occur in the unincorporated, Recreational/Open/Agricultural/ Low Density land in Solano County, and areas designated for the Travis Reserve.

Table 5.2 Generalized Existing Land Use Within the Travis AFB Clear Zones and Accident Potential Zones (Off-DoD Property)

Category	Acreage
Residential	0
Commercial	0
Industrial	0
Public/Quasi-public	0
Recreational/Open/Agricultural/Low Density	2,145
Total	**2,145**

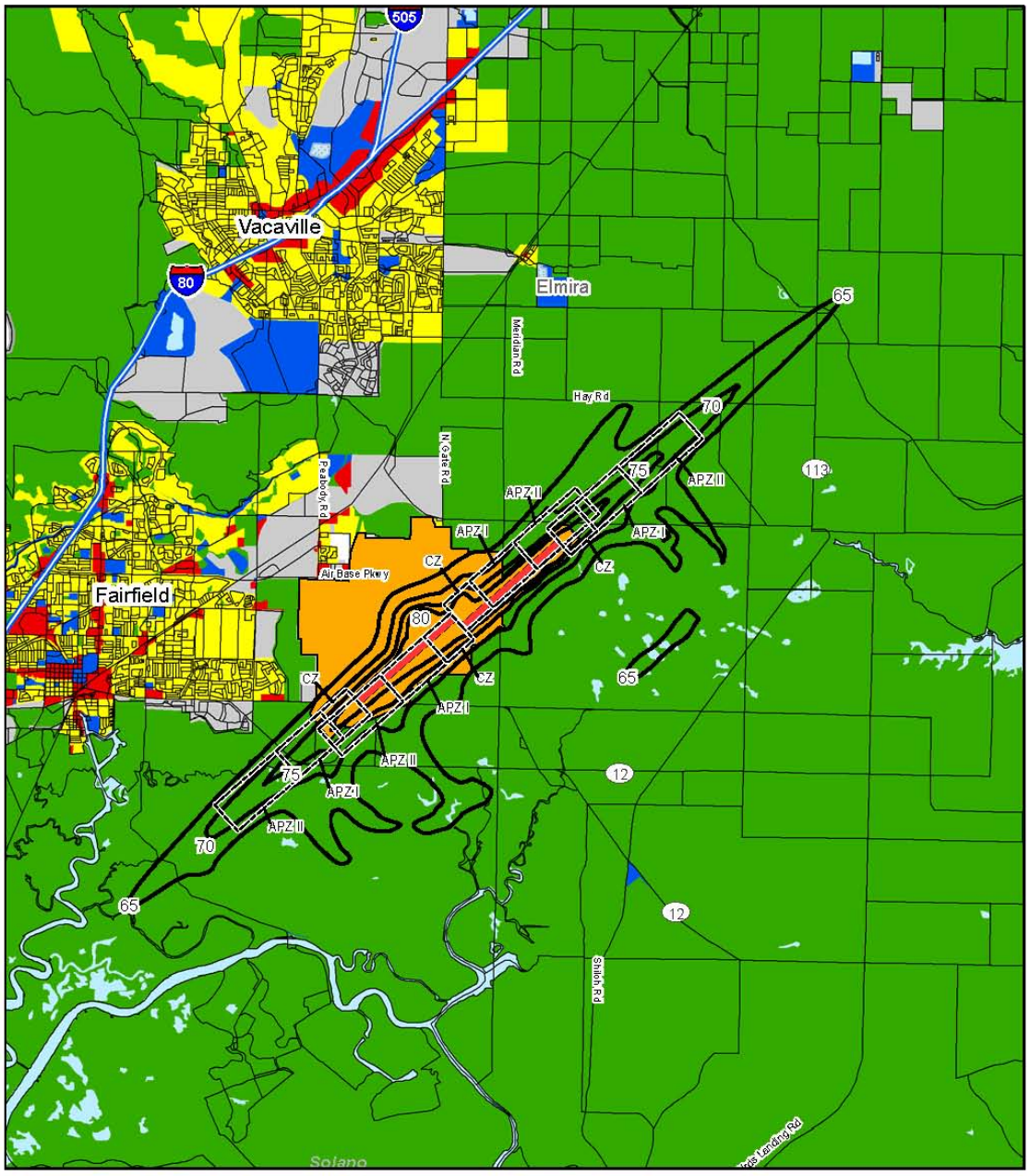
5.3 CURRENT ZONING

This section reflects current zoning based on the Travis AFB Land Use Compatibility Plan. The existing land use described in Subsection 5.2 reflects current land use. Existing land use (see Subsection 5.2) may not align with zoning due to variances that have been granted or land uses that were allowed to continue because they were in existence prior to the establishment of current zoning. Table 5.3 summarizes the amounts of off-Base land by zoning category that lie outside the Travis AFB CZs and APZs. Figure 5.2 overlays the 2009 noise contours and CZs and APZs on a map displaying the current generalized zoning in the vicinity of Travis AFB. As described in Section 5.2, the region of influence includes Travis AFBs Reserve, and unincorporated, Recreational/Open/Agricultural/ Low Density land in Solano County.

Table 5.3 Generalized Zoning Within DNL 65 dB and Greater Noise Exposure Area (Off-DoD Property Outside CZs and APZs)

Category	Acreage
Residential	0
Commercial	0
Industrial	0
Public/Quasi-public	0
Recreational/Open/Agricultural/Low Density	5,684
Total	**5,684**

Source: Solano County General Plan



Travis Air Force Base 2009 AICUZ

Legend

- Public/ Quasi-Public
- Residential
- Commercial
- Industrial
- Open/ Agriculture/ Low Density
- CZ/ APZ Boundary
- Noise Contour
- Runway
- Travis AFB
- County Boundary
- Interstate

N

0 0.5 1 2

Miles

Generalized Zoning

Figure 5.2

A similar analysis was performed to determine the acreage of each generalized zoning category within the Travis AFB CZs and APZs and is shown on Table 5.4.

Table 5.4 Generalized Zoning Within the Travis AFB Clear Zones and Accident Potential Zones (Off-DoD Property)

Category	Acreage
Residential	0
Commercial	0
Industrial	0
Public/Quasi-public	0
Recreational/Open/Agricultural/Low Density	2,145
Total	**2,145**

Source: Solano County General Plan

5.4 INCOMPATIBLE LAND USES

Table 4.3 contains the guidelines used to determine land use compatibility for existing land use within the Travis AFB area of influence. For a land use area to be considered compatible, it must meet the criteria for its category for both noise and accident potential as shown in Table 4.3. No incompatible land uses occur within the runway CZs and APZs when comparing the guidelines in Table 4.3 with existing land use data in Figure 5.1. Likewise, there are no incompatible land uses associated with the LZ 03/21 CZs or APZs when considering the criteria in Subsection 4.8. Additionally, there are no incompatible land uses resulting from aircraft noise when considering the guidelines in Table 4.3.

5.5 PLANNING CONSIDERATIONS

AICUZ noise contours describe the noise characteristics of a specific operational environment, and as such, will change if a significant operational change is made. An AICUZ Study should be evaluated for an update if the noise exposure map changes by DNL 2 dB or more in noise sensitive areas from the noise contour map in the last publicly released AICUZ Study. Accordingly, this AICUZ Study updates the 1995 AICUZ Study and provides flight track, accident potential, CZ, and NZ information in this report which reflects the most accurate picture of the aircraft activities at Travis AFB as of April 2009.

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SECTION 6
IMPLEMENTATION

6.1 INTRODUCTION

Implementation of the AICUZ Program must be a joint effort between the Air Force and adjacent communities. The role of the Air Force is to minimize the Travis AFB aircraft operations' impact on the local communities. The role of the communities is to ensure that development in the surrounding areas is compatible with accepted planning and development principles and practices.

6.2 AIR FORCE RESPONSIBILITIES

In general, the Air Force perceives its AICUZ responsibilities as encompassing the areas of flying safety, noise abatement, and participation in the land use planning process.

Well-maintained aircraft and well-trained aircrews do a great deal to assure the avoidance of aircraft accidents. Despite the best aircrew training and aircraft maintenance intentions, however, history clearly shows that accidents do occur. It is imperative that flights be routed over sparsely populated areas as regularly as possible to reduce the exposure of lives and property to a potential accident.

Commanders are required by Air Force policy to periodically review existing traffic patterns, instrument approaches, weather *minima*, and operating practices, and evaluate these factors in relationship to populated areas and other local situations. This requirement is a direct result and expression of Air Force policy that all AICUZ plans must include an analysis of flying and flying-related activities designed to reduce and control the effects of such operations on surrounding land areas. Noise is generated from aircraft both in the air and on the ground. In an effort to reduce the noise effects of Travis AFB operations on surrounding communities, the installation routes flight tracks to avoid populated areas.

Preparation and presentation of this Travis AFB AICUZ Study is one phase of continuing Air Force participation in the local planning process. It is recognized that as the local community updates its land use plans, the Air Force must be ready to provide additional input when needed.

It is also recognized that the AICUZ Program is an ongoing activity even after compatible development plans are adopted and implemented. Travis AFB personnel are prepared to participate in the continuing discussion of zoning and other land use matters as they may affect, or may be affected by, the Base. Travis AFB personnel are also available to provide information, criteria, and guidelines to state, regional, and local planning bodies, civic associations, and similar groups.

Participation in land use planning can take many forms. The simplest of these forms is straightforward, consistent two-way discussion and information sharing with both professionals and neighbors. Copies of the AICUZ Study, including maps, will be provided to regional planning departments and zoning administrators. Through this communication process, the Base reviews applications for development or changed use of properties within

the noise impact and safety areas, as well as other nearby parcels. The Base coordinates closely with surrounding communities and counties on zoning and land use issues.

6.3 LOCAL COMMUNITY RESPONSIBILITIES

Residents in the area neighboring Travis AFB and Base personnel have a long history of working together for mutual benefit of the area around Travis AFB. Local jurisdictions have taken a proactive approach in incorporating land use regulations into local plans and ordinances which take into account Travis AFB flying operations when considering development proposals. Adoption of the following recommendations will strengthen this relationship, increase the health and safety of the public, and help protect the integrity of the Base's flying mission:

- Continue to incorporate policies and guidelines of the AICUZ Program into the comprehensive plans of Solano County and local communities. Use overlay maps of the AICUZ noise contours and Air Force Land Use Compatibility Guidelines to evaluate existing and future land use proposals.
- Modify existing zoning ordinances and subdivision regulations to support the compatible land uses outlined in this AICUZ Study and require real estate disclosure of noise impact to all prospective property buyers of properties exposed to noise affecting the property.
- Modify building codes to ensure new construction within the AICUZ area has the recommended NLRs incorporated into its design and construction.
- Implement height and obstruction ordinances that reflect current Air Force and FAR Part 77 requirements. Ensure proponents for wind generating facilities/turbines file FAA Form 7460-1, Notice of Proposed Construction, for FAA and Air Force review, as there are potential operational impacts that include reduced radar effectiveness, height obstructions, and increasing the minimum aircraft descent altitude.
- Continue supporting working groups, such as the Joint Land Use Study, ALUC, and City, County, and Base planners, that meet, as needed, to discuss development proposals that could potentially affect airfield operations.
- Inform Travis AFB of planning and zoning actions that have the potential to affect Base operations. Also, provide early notification to Travis AFB of any wind generating facilities/turbine farm proposals in the vicinity of the Base as they potentially could impact Travis AFB flying and navigational aids.

Appendix A

THE AICUZ CONCEPT, PROGRAM, METHODOLOGY, AND POLICIES

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THE AICUZ CONCEPT, PROGRAM, METHODOLOGY, AND POLICIES

A.1 Concept

Federal legislation, national sentiment, and other external forces, which directly affect the Air Force mission, serve greatly to increase the role of the Air Force in environmental and planning issues. Problems of airfield encroachment from incompatible land uses surrounding installations, as well as air and water pollution and socioeconomic impact, require continued and intensified Air Force involvement. The nature of these problems dictates direct Air Force participation in comprehensive community and land use planning. Effective, coordinated planning that bridges the gap between the federal government and the community requires establishment of good working relationships with local citizens, local planning officials, and state and federal officials. This depends on creating an atmosphere of mutual trust and helpfulness. The AICUZ concept has been developed in an effort to:

- protect local citizens from noise exposure and accident potential associated with flying activities; and
- prevent degradation of the capability of the Air Force to achieve its mission by promoting compatible land use planning.

The land use guidelines developed herein are a composite of a number of other land use compatibility studies that have been refined to fit the Travis AFB aviation environment.

A.2 Program

Installation commanders establish and maintain active programs to promote the maximum feasible land use compatibility between air installations and neighboring communities. The program requires that all appropriate government bodies and citizens be fully informed whenever AICUZ or other planning matters affecting the installation are under consideration. This includes positive and continuous programs designed to:

- provide information, criteria, and guidelines to federal, state, regional, and local planning bodies, civic associations, and similar groups;
- inform such groups of the requirements of the flying activity, noise exposure, aircraft accident potential, and AICUZ plans;
- describe the noise reduction measures that are being used; and
- ensure that all reasonable, economical, and practical measures are taken to reduce or control the impact of noise-producing activities. These measures include such considerations as proper location of engine test facilities, provision of sound suppressors where necessary, and adjustment of flight patterns and/or techniques to minimize the noise impact on populated areas. This must be done without jeopardizing safety or operational effectiveness.

A.3 Methodology

The AICUZ consists of land areas upon which certain land uses may obstruct the airspace or otherwise be hazardous to aircraft operations, and land areas that are exposed to the health, safety, or welfare hazards of aircraft operations. The AICUZ includes:

- Accident Potential Zones and CZs based on past Air Force aircraft accidents and installation operational data (see Appendix B);
- Noise zones produced by the computerized DNL modeling of the noise created by aircraft flight and maintenance operations (see Appendix C); and
- The area designated by the FAA and the Air Force for purposes of height limitations in the approach and departure zones of the Base (see Section 4 of the Study).

The APZ, CZ, and NZ are the basic building blocks for land use planning with AICUZ data. Compatible land uses are specified for these zones (see Table 4.3), and recommendations on building materials and standards to reduce interior noise levels inside structures are provided in Appendix C.4.

As part of the AICUZ Program, the only real property acquisition for which the Air Force has requested and received Congressional authorization, and for which the installation and major commands request appropriation, are the areas designated as the CZ. Travis AFB does not own all property in the CZs located at the runway 03L and 21L ends. Compatible land use controls for the remaining airfield area of influence should be accomplished through the community land use planning processes.

A.4 AICUZ Land Use Development Policies

The basis for any effective land use control system is the development of, and subsequent adherence to, policies which serve as the standard by which all land use planning and control actions are evaluated. Travis AFB recommends the following policies be considered for incorporation into the comprehensive plans of agencies in the vicinity of the Base's area of influence:

A.4.1 Policy 1

To promote the public health, safety, peace, comfort, convenience, and general welfare of the inhabitants in the airfield area of influence, it is necessary to:

- guide, control, and regulate future growth and development;
- promote orderly and appropriate use of land;
- protect the character and stability of existing land uses;
- prevent destruction or impairment of the airfield and the public investment therein;
- enhance the quality of living in the areas affected; and
- protect the general economic welfare by restricting incompatible land use.

A.4.2 Policy 2

In furtherance of Policy 1, it is appropriate to:

- establish guidelines of land use compatibility;
- restrict or prohibit incompatible land use;
- prevent establishment of any land use which would unreasonably endanger aircraft operations and the continued use of the airfield;
- incorporate the AICUZ concept into community land use plans, modifying them when necessary; and
- adopt appropriate ordinances to implement airfield area of influence land use plans.

A.4.3 Policy 3

Within the boundaries of the CZ, certain land uses are inherently incompatible. The following land uses are not in the public interest and must be restricted or prohibited:

- uses that release into the air any substance, such as steam, dust, or smoke which would impair visibility or otherwise interfere with the operation of aircraft;
- uses that produce light emissions, either direct or indirect (reflective), which would interfere with pilot vision;
- uses that produce electrical emissions which would interfere with aircraft communication systems or navigation equipment;
- uses that attract birds or waterfowl, such as operation of sanitary landfills, maintenance or feeding stations, or growth of certain vegetation; and
- uses that provide for structures within 10 feet of aircraft approach-departure and/or transitional surfaces.

A.4.4 Policy 4

Certain noise levels of varying duration and frequency create hazards to both physical and mental health. A limited, though definite, danger to life exists in certain areas adjacent to airfields. Where these conditions are sufficiently severe, it is not consistent with public health, safety, and welfare to allow the following land uses:

- residential;
- retail business;
- office buildings;
- public buildings (schools, churches, etc.); and
- recreation buildings and structures.

A.4.5 Policy 5

Land areas below takeoff and final approach flight paths are exposed to significant danger of aircraft accidents. The density of development and intensity of use must be limited in such areas.

A.4.6 Policy 6

Different land uses have different sensitivities to noise. Standards of land use acceptability should be adopted, based on these noise sensitivities. In addition, a system of NLR guidelines (Appendix C) for new construction should be implemented to permit certain uses where they would otherwise be prohibited.

A.4.7 Policy 7

Land use planning and zoning in the airfield area of influence cannot be based solely on aircraft-generated effects. Allocation of land used within the AICUZ should be further refined by consideration of:

- physiographic factors;
- climate and hydrology;
- vegetation;
- surface geology;
- soil characteristics;
- intrinsic land use capabilities and constraints;
- existing land use;
- land ownership patterns and values;
- economic and social demands;
- cost and availability of public utilities, transportation, and community facilities; and
- other noise sources.

A.5 Basic Land Use Compatibility

Research on aircraft accident potential, noise, and land use compatibility is ongoing at a number of federal and other agencies. These and all other compatibility guidelines must not be considered inflexible standards. They are the framework within which land use compatibility questions can be addressed and resolved. In each case, full consideration must be given to local conditions such as:

- previous community experience with aircraft accidents and noise;
- local building construction and development practices;
- existing noise environment due to other urban or transportation noise sources;
- time periods of aircraft operations and land use activities;
- specific site analysis; and
- noise buffers, including topography.

These basic guidelines cannot resolve all land use compatibility questions, but they do offer a reasonable framework within which to work.

A.6 Accident Potential

Each end of Runways 03L/21R and 03R/21L at Travis AFB has a 3,000 foot by 3,000 foot CZ and two APZs (see Section 5). Likewise, each end of LZ 03/21 has a CZ that extends outward 500 feet from the end of the runway, is centered on the end of the runway, and is 320 feet wide at the end of the runway, flaring to 500 feet in width at the outer end. Accident potential on or adjacent to the runway or within the CZ is so high that the necessary land use restrictions would prohibit reasonable economic use of land. As stated previously, it is Air Force policy to request Congress to authorize and appropriate funds for the necessary real property interests in this area to prevent incompatible land uses.

Accident Potential Zone I is less critical than the CZ, but still possesses a significant risk factor. This 3,000 foot by 5,000 foot area has land use compatibility guidelines which are sufficiently flexible to allow reasonable economic use of the land, such as industrial/manufacturing, transportation, communication/utilities, wholesale trade, open space, recreation, and agriculture. However, uses that concentrate people are not acceptable.

Accident Potential Zone II is less critical than APZ I, but still possesses potential for accidents. Accident Potential Zone II, also 3,000 feet wide, is 7,000 feet long extending to 15,000 feet from the runway threshold. Acceptable uses include those of APZ I, as well as low density single family residential and those personal and business services and commercial/retail trade uses of low intensity or scale of operation. High density functions such as multistory buildings, places of assembly (theaters, churches, schools, restaurants, *etc*.), and high density office uses are not considered appropriate.

High density populations should be limited to the maximum extent possible. The optimum density recommended for residential usage (where it does not conflict with noise criteria) in APZ II is one to two dwelling units per acre, possibly increased under a PUD where maximum lot coverage is less than 20 percent (see Table 4.3, Land Use Compatibility Guidelines), buildings should be limited to one story, and the lot coverage should not exceed 20 percent.

Land use guidelines (see Subsection 4.7.3) for Air Force Class B runway CZs and APZs (see Subsection 4.4.2) are based on a hazard index system that compares the relationship of accident occurrence for five areas:

- on or adjacent to the runway;
- within the CZ;
- in APZ I;
- in APZ II; and
- in all other areas within a 10 nautical mile radius of the runway.

Accident potential on or adjacent to the runway or within the CZ is so high that few uses are acceptable. The risk outside APZ I and APZ II, but within the 10 nautical mile radius area, is significant, but is acceptable if sound engineering and planning practices are followed.

Land use guidelines for APZs I and II have been developed. The main objective has been to restrict all people-intensive uses because there is greater risk in these areas. The basic guidelines aim at prevention of uses that:

- have high residential density characteristics;
- have high labor intensity;
- involve above-ground explosives, fire, toxic, corrosive, or other hazardous characteristics;
- promote population concentrations;
- involve utilities and services required for area-wide population, where disruption would have an adverse impact (telephone, gas, etc.);
- concentrate people who are unable to respond to emergency situations, such as children, elderly, handicapped, etc.; and
- pose hazards to aircraft operations.

There is no question that these guidelines are relative. Ideally, there should be no people-intensive uses in any APZ. The free market and private property systems prevent this where there is a demand for land development. To go beyond these guidelines, however, substantially increases risk by placing more people in areas where there may ultimately be an aircraft accident.

A.7 Noise

Nearly all studies analyzing aircraft noise and residential compatibility recommend no residential uses in NZs above DNL 75 dB. Usually, no restrictions are recommended below NZ DNL 65 dB. There is currently no consensus between DNL 65-74 dB. These areas may not qualify for federal mortgage insurance in residential categories according to U.S. Department of HUD Regulation 24 Code of Federal Regulations (CFR) 51B. In many cases, HUD approval requires noise attenuation measures, the Regional Administrator's concurrence, and an Environmental Impact Statement. The U.S. Department of Veterans Affairs also has airfield noise and accident restrictions which apply to its home loan guarantee program. Whenever possible, residential land use should be located below DNL 65 dB according to Air Force land use recommendations. Residential buildings within the DNL 65-70 dB noise contours should contain NLR in accordance with the Air Force land use compatibility guidelines in the AICUZ Study, Table 4.3.

Most industrial/manufacturing uses are compatible in the airfield area of influence. Exceptions are uses such as research or scientific activities that require lower noise levels. Noise attenuation measures are recommended for portions of buildings devoted to office use, receiving the public, or where the normal background noise level is low.

The transportation, communications, and utilities categories have a high noise level compatibility because they generally are not people-intensive. When people use land for these purposes, the use is generally very short in duration. Where buildings are required for these uses, additional evaluation is warranted.

The commercial/retail trade and personal and business services categories are compatible without restriction up to DNL 70 dB; however, they are generally incompatible above DNL 80 dB. Between DNLs 70-79 dB, NLR measures should be included in the design and construction of buildings.

The nature of most uses in the public and quasi-public services category requires a quieter environment, and attempts should be made to locate these uses below DNL 65 dB (an Air Force land use recommendation), or else provide adequate NLR.

Although recreational use has often been recommended as compatible with high noise levels, recent research has resulted in a more conservative view. Above DNL 75 dB, noise becomes a factor that limits the ability to enjoy such uses. Where the requirement to hear is a function of the use (*e.g.*, music shell, etc.), compatibility is limited. Buildings associated with golf courses and similar uses should be noise attenuated.

With the exception of forestry activities and livestock farming, uses in the resources production, extraction, and open space category are compatible almost without restrictions.

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Appendix B

CLEAR ZONES AND ACCIDENT POTENTIAL ZONES

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CLEAR ZONES AND ACCIDENT POTENTIAL ZONES

B.1 Guidelines For Accident Potential

Areas around airports are exposed to the possibility of aircraft accidents even with well-maintained aircraft and highly trained aircrews. Despite stringent maintenance requirements and countless hours of training, history makes it clear that accidents do happen.

When the AICUZ Program began, there were no current comprehensive studies on accident potential. To support the program, the Air Force completed a study of Air Force aircraft accidents that occurred between 1968 and 1972 within 10 nautical miles of airfields. The study of 369 accidents revealed that 75 percent of aircraft accidents occurred on or adjacent to the runway (1,000 feet to each side of the runway centerline) and in a corridor 3,000 feet (1,500 feet either side of the runway centerline) wide, extending from the runway threshold along the extended runway centerline for a distance of 15,000 feet. The Air Force updated these studies and this information is presented later in this section.

The runway CZ, APZ I, and APZ II were established based on crash patterns. The CZ starts at the end of the runway and extends outward 3,000 feet. It has the highest accident potential of the three zones. The Air Force adopted a policy of acquiring property rights to areas designated as CZs because of the high accident potential. APZ I extends from the CZ an additional 5,000 feet. It includes an area of reduced accident potential. APZ II extends from APZ I an additional 7,000 feet in an area of further reduced accident potential.

Research in accident potential conducted by the Air Force was the first significant effort in this subject area since 1952 when the President's Airport Commission published "The Airport and Its Neighbors," better known as the "Doolittle Report." The recommendations of this earlier report were influential in the formulation of the APZ concept.

The risk to people on the ground being killed or injured by aircraft accidents is small. However, an aircraft accident is a high consequence event, and when a crash does occur, the result is often catastrophic. Because of this, the Air Force does not attempt to base its safety standards on accident probabilities. Instead, the Air Force approaches this safety issue from a land use planning perspective.

B.2 Guidelines For Accident Potential

Military aircraft accidents differ from commercial air carrier and general aviation accidents because of the variety of aircraft used, the type of missions, and the number of training flights. In 1973, the Air Force performed a service-wide aircraft accident hazard study to identify land near airfields with significant accident potential. Accidents studied occurred within 10 nautical miles of airfields.

The study reviewed 369 major Air Force accidents during 1968-1972, and found that 61 percent of those accidents were related to landing operations, and 39 percent were takeoff related. It also found that 70 percent occurred in daylight, and that fighter and training aircraft accounted for 80 percent of the accidents.

Because the purpose of the study was to identify accident hazards, the study plotted each of the 369 accidents in relation to the airfield. This plotting found that the accidents clustered

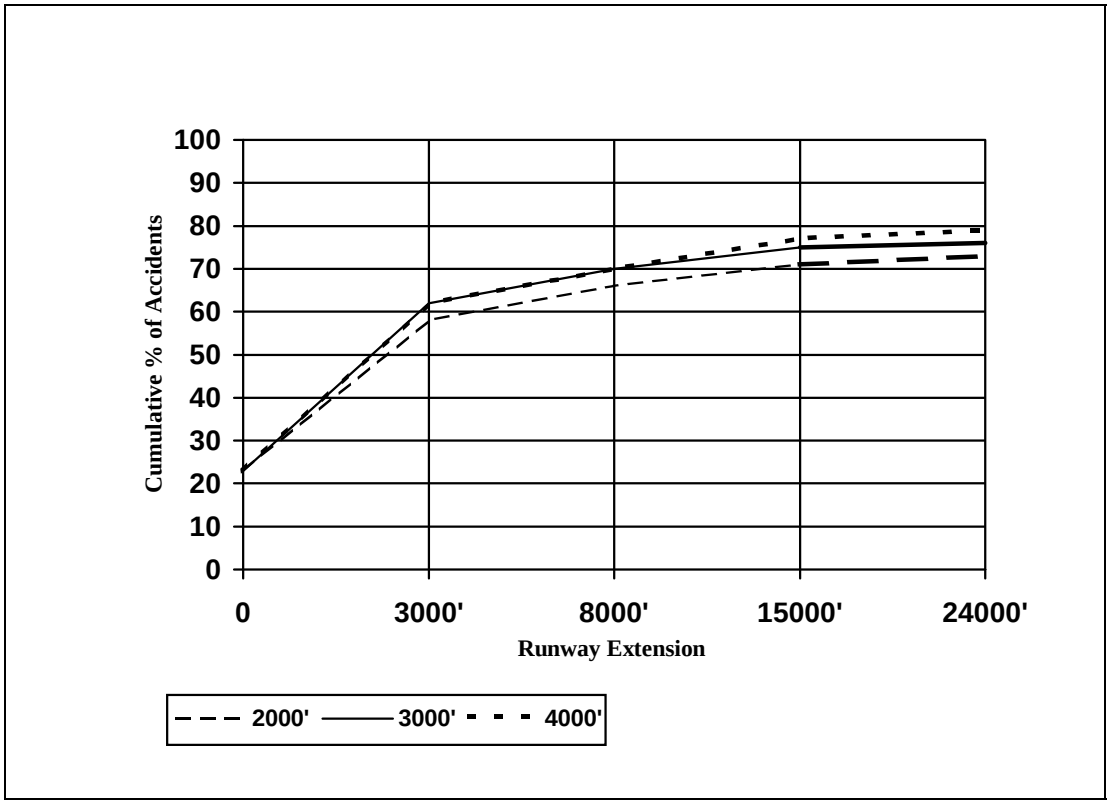
along the runway and its extended centerline. To further refine this clustering, a tabulation was prepared that described the cumulative frequency of accidents as a function of distance from the runway centerline along the extended centerline. This analysis was done for widths of 2,000, 3,000, and 4,000 total feet. Table B.1 reflects the location analysis.

Table B.1 Location Analysis

	Width of Runway Extension (feet)		
Length From Both Ends of Runway (feet)	**2000**	**3000**	**4000**
Percent of Accidents			
On or Adjacent to Runway (1,000 feet to each side of runway centerline)	23	23	23
0 to 3,000	35	39	39
3,000 to 8,000	8	8	8
8,000 to 15,000	5	5	7
Cumulative Percent of Accidents			
On or Adjacent to Runway (1,000 feet to each side of runway centerline)	23	23	23
0 to 3,000	58	62	62
3,000 to 8,000	66	70	70
8,000 to 15,000	71	75	77

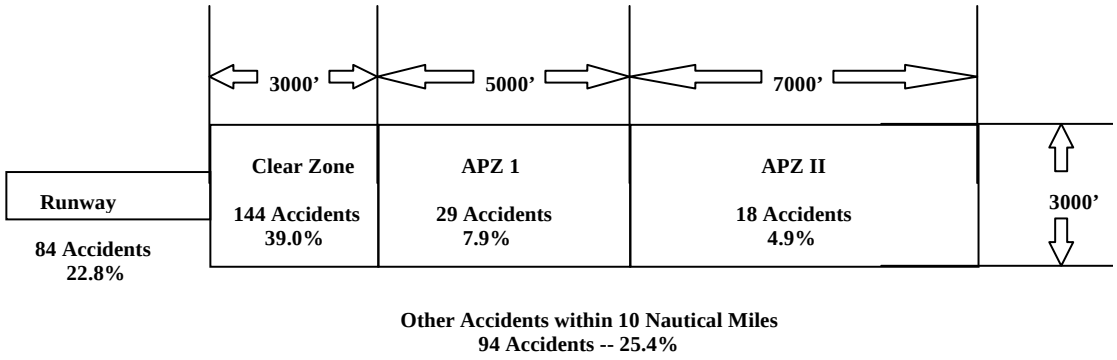
Figure B.1 indicates that the cumulative number of accidents rises rapidly from the end of the runway to 3,000 feet, rises more gradually to 8,000 feet, then continues at about the same rate of increase to 15,000 feet, where it levels off rapidly. The location analysis also indicates 3,000 feet as the optimum runway extension width and the width which includes the maximum percentage of accidents in the smallest area.

Figure B.1 Distribution of Air Force Aircraft Accidents (369 Accidents - 1968 - 1972)



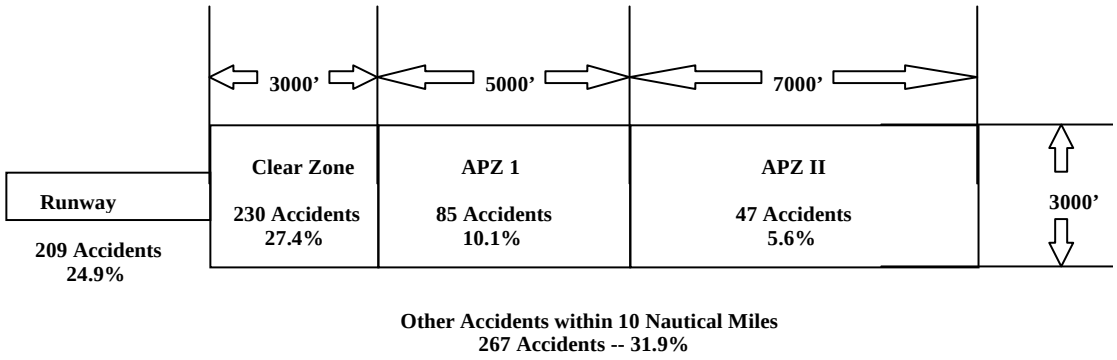
Using the optimum runway extension width, 3,000 feet, and the cumulative distribution of accidents from the end of the runway, zones were established that minimized the land area included and maximized the percentage of accidents included. The zone dimensions and accident statistics for the 1968-1972 study are shown in Figure B.2.

Figure B.2 Air Force Aircraft Accident Data (369 Accidents - 1968 - 1972)



The original study was updated to include accidents through September 1995. This updated study includes 838 accidents during the 1968-1995 period. Using the optimum runway extension width of 3,000 feet, the accident statistics of the updated study are shown in Figure B.3.

Figure B.3 Air Force Aircraft Accident Data
(838 Accidents - 1968 - 1995)



Using the designated zones and accident data, it is possible to calculate a ratio of percentage of accidents to percentage of area size. These ratios indicate the CZ, with the smallest area size and the highest number of accidents, has the highest ratio, followed by the runway and adjacent area, APZ I, and then APZ II. Table B.2 reflects this data.

Table B.2 Accident to Area Ratio

Ratio of Percentage of Accidents to Percentage of Area (Air Force Accident Data 1968 - 1995)						
	Area[1] (Acres)	Number[2] Accident	Accident Per Acre	Percent of Total Area	Percent of Total Accidents	Ratio:[3] % Accidents to % Area
Runway Area	487	209	1 Per 2.3 acres	0.183	24.9	136
Clear Zone	413	230	1 Per 1.8 acres	0.155	27.4	177
APZ I	689	85	1 Per 8.1 acres	0.258	10.1	39
APZ II	964	47	1 Per 20.5 acres	0.362	5.6	16
Other Area	264,053	267	1 Per 989 acres	99.042	31.9	0.3

1 Area includes land within 10 nautical miles of runway.

2 Total number of accidents is 838 (through 1995).

3 Percent total accidents divided by percent total area.

Additional accident data for 1986 through July 1995 has been analyzed. Specific location data for some of the 1986-1995 accidents was not available and these were not included in the analysis. Table B.3 compares the 1968-1985 data with the data through July 1995:

Table B.3 Additional Accident Data

	1968-1985		1968-1995	
ZONE	**Accidents**	**% of Total**	**Accidents**	**% of Total**
On-Runway	197	27.1	209	24.9
Clear Zone	210	28.8	230	27.4
APZ I	57	7.8	85	10.1
APZ II	36	5.0	47	5.7
Other (Within 10 nautical miles)	228	31.3	267	31.9
Total	728	100.0	838	100.0

Analysis has shown that the cumulative changes evident in accident location through July 1995 reconfirm the dimensions of the CZs and APZs.

B.3 Definable Debris Impact Areas

The Air Force also determined which accidents had definable debris impact areas, and in what phase of flight the accident occurred. Overall, 75 percent of the accidents had definable debris impact areas, although they varied in size by type of accident. The Air Force used weighted averages of impact areas, for accidents occurring only in the approach and departure phase, to determine the following average impact areas:

Average Impact Areas for Approach and Departure Accidents

Overall Average Impact Area	5.06 acres
Fighter, Trainer, and Misc. Aircraft	2.73 acres
Heavy Bomber and Tanker Aircraft	8.73 acres

B.4 Findings

Designation of safety zones around the airfield and restriction of incompatible land uses can reduce the public's exposure to safety hazards.

Air Force accident studies have found that aircraft accidents near Air Force installations occurred in the following patterns:

- 61% were related to landing operations.
- 39% were related to takeoff operations.
- 70% occurred in daylight.
- 80% were related to fighter and training aircraft operations.

- 25% occurred on the runway or within an area extending 1,000 feet out from each side of the runway.
- 27% occurred in an area extending from the end of the runway to 3,000 feet along the extended centerline and 3,000 feet wide, centered on the extended centerline.
- 15% occurred in an area between 3,000 and 15,000 feet along the extended runway centerline and 3,000 feet wide, centered on the extended centerline.

Air Force aircraft accident statistics found 75% of aircraft accidents resulted in definable impact areas. The size of the impact areas were:

- 5.06 acres overall average.
- 2.73 acres for fighters and trainers.
- 8.73 acres for heavy bombers and tankers.

Appendix C

NOISE AND NOISE LEVEL REDUCTION GUIDELINES

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NOISE AND NOISE LEVEL REDUCTION GUIDELINES

C.1 General

Noise, often defined as unwanted sound, is one of the most common environmental issues associated with aircraft operations. Of course, aircraft are not the only sources of noise in an urban or suburban surrounding, where noise from interstate and local roadway traffic, rail, industrial, and neighborhood sources also intrude on the everyday quality of life. Nevertheless, aircraft are readily identifiable to those affected by their noise and are typically singled out for special attention and criticism. Consequently, aircraft noise problems often dominate analyses of environmental impacts.

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

The measurement and human perception of sound involves two basic physical characteristics - intensity and frequency. Intensity is a measure of the acoustic energy of the sound vibrations and is expressed in terms of sound pressure. The higher the sound pressure, the more energy carried by the sound and the louder the perception of that sound. The second important physical characteristic is sound frequency, that is, the number of times per second the air vibrates or oscillates. Low-frequency sounds are characterized as rumbles or roars, while high-frequency sounds are typified by sirens or screeches.

The loudest sounds, which can be detected comfortably by the human ear, have intensities that are a trillion times larger than those of sounds that can be detected at the lower end of the spectrum. Because of this vast range, any attempt to represent the intensity of sound using a linear scale becomes very unwieldy. As a result, a logarithmic unit known as the decibel (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 and eventually pain at still higher levels.

Because of the logarithmic nature of the decibel unit, sound levels cannot be added or subtracted directly 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. Thus, for example:

$$60 \text{ dB} + 60 \text{ dB} = 63 \text{ dB, and}$$

$$80 \text{ dB} + 80 \text{ dB} = 83 \text{ dB.}$$

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 behaves differently than that of ordinary numbers, such an addition is often referred to as "decibel addition" or "energy addition." The latter term arises from the fact that what is really happening when decibel values are added is each decibel value is first converted to its corresponding acoustic energy, then the energies are added using the normal rules of addition, and finally the total energy is converted to its decibel equivalent.

An important facet of decibel addition arises later when the concept of time-average sound levels is introduced to explain DNL. Because of the logarithmic units, the louder levels that occur during the averaging period dominate the time-average sound levels. As a simple example, consider a sound level that is 100 dB and lasts for 30 seconds, followed by a sound level of 50 dB which also lasts for 30 seconds. The time-average sound level over the total 60-second period is 97 dB, not 75 dB.

Sound frequency is measured in terms of cycles per second (cps), or hertz (Hz), which is the preferred scientific unit for cps. The normal human ear can detect sounds that range in frequency from about 20 Hz to about 15,000 Hz. All sounds in this wide range of frequencies, however, are not heard equally well by the human ear, which is most sensitive to frequencies in the 1000 to 4000 Hz range. In measuring community noise, this frequency dependence is taken into account by adjusting the sound levels of the very high and low frequencies to approximate the human ear's lower sensitivity to those frequencies. This is called "A-weighting" and is commonly used in measurements of community environmental noise.

Sound levels measured using A-weighting are most properly called A-weighted sound levels while sound levels measured without any frequency weighting are most properly called sound levels. However, since most environmental impact analysis documents deal only with A-weighted sound levels, the adjective "A-weighted" is often omitted, and A-weighted sound levels are referred to simply as sound levels. In some instances it will be indicated that the sound levels have been A-weighted by using the abbreviation dBA or dB(A), rather than the abbreviation dB, for decibel. As long as the use of A-weighting is understood to be used, there is no difference implied by the terms "sound level" and "A-weighted sound level" or by the units dB, dBA, and dB(A).

In this document and most AICUZ documents, all sound levels are A-weighted sound levels and the adjective "A-weighted" has been omitted and dB is used for the decibel units.

Sound levels do not represent instantaneous measurements but rather averages over short periods of time. Two measurement time periods are most commonly used - one second and one-eighth of a second. Most environmental noise studies use slow response measurements, and the adjective "slow response" is usually omitted. It is easy to understand why the proper descriptor "slow response A-weighted sound level" is usually shortened to "sound level" in environmental impact analysis documents.

C.2 Noise Metrics

A "metric" is defined as something "of, involving, or used in measurement." In environmental noise analyses, a metric refers to the unit or quantity that quantitatively measures the effect of noise on the environment. Noise studies have typically involved a confusing proliferation of noise metrics as individual researchers have attempted to understand and represent the effects of noise. As a result, past literature describing environmental noise abatement has included many different metrics.

Various federal agencies involved in environmental noise mitigation agree on common metrics for environmental impact analysis documents, and both the DoD and the FAA specified those which should be used for federal aviation noise assessments. These metrics are as follows.

C.2.1 Maximum Sound Level

The highest A-weighted sound level measured during a single event in which the sound level changes value as time goes on (*e.g.*, an aircraft overflight) is called the maximum A-weighted sound level or maximum sound level, for short. It is usually abbreviated by ALM, $L_{max,}$ or L_{Amax}.

C.2.2 Sound Exposure Level

Individual time-varying noise events have two main characteristics - a sound level which changes throughout the event and a period of time during which the event is heard. Although the maximum sound level, described above, provides some measure of the intrusiveness of the event, it alone does not completely describe the total event. The period of time during which the sound is heard is also significant. The Sound Exposure Level (abbreviated SEL or L_{AE}) combines both of these characteristics into a single metric.

Sound Exposure Level is a logarithmic measure of the total acoustic energy transmitted to the listener during the event. Mathematically, it represents the sound level of the constant sound that would, in one second, generate the same acoustic energy as did the actual time-varying noise event. Since aircraft overflights usually last longer than 1 second, the SEL of an overflight is usually greater than the ALM of the overflight.

Note that SEL is a composite metric that represents both the intensity of a sound level of the constant sound and its duration. It does not directly represent the sound level heard at any given time, but rather provides a measure of the net impact of the entire acoustic event. It has been well established in the scientific community that SEL measures this impact much more reliably than just the ALM.

Because the SEL and the ALM are both A-weighted sound levels expressed in decibels, there is sometimes confusion between the two, so the specific metric used should be clearly stated.

C.2.3 Day-Night Average Sound Level

Time-average sound levels are measurements of sound levels that are averaged over a specified length of time. These levels provide a measure of the average sound energy during the measurement period.

For the evaluation of community noise effects, and particularly aircraft noise effects, the DNL (mathematically represented as L_{dn}) is used. DNL averages aircraft sound levels at a location over a complete 24-hour period, with a 10-dB adjustment added to those noise events which take place between 10:00 p.m. and 7 a.m. (local time). This 10-dB "penalty" represents the added intrusiveness of sounds which occur during normal sleeping hours, both because of the increased sensitivity to noise during those hours and because ambient sound levels during nighttime are typically about 10 dB lower than during daytime hours.

Ignoring the 10-dB nighttime adjustment for the moment, DNL may be thought of as the continuous DNL occurring over a 24-hour period smoothed out to contain the same total sound energy.

DNL provides a single measure of overall noise impact, but does not provide specific information on the number of noise events or the individual sound levels which occur during the day. For example, a DNL of 65 dB could result from a very few noisy events, or a large number of quieter events.

As noted earlier for SEL, DNL does not represent the sound level heard at any particular time. Scientific studies and social surveys which have been conducted to evaluate community annoyance to all types of environmental noise have found the DNL to be the best measure to predict annoyance. Its use is endorsed by the scientific community (See References C.1 through C.5 at the end of this section).

There is, in fact, a remarkable consistency in the results of attitudinal surveys about aircraft noise conducted in different countries to find the percentages of groups of people who express various degrees of annoyance when exposed to different levels of DNL.

Reference C.6 was published in 1978. A more recent study has reaffirmed this relationship (Reference C.7). In general, correlation coefficients of 0.85 to 0.95 are found between the percentages of groups of people highly annoyed and the level of average noise exposure. The correlation coefficients for the annoyance of individuals are relatively low, however, on the order of 0.5 or less. This is not surprising, considering the varying personal factors that influence the manner in which individuals react to noise. Nevertheless, findings substantiate that community annoyance to aircraft noise can be predicted quite reliably using DNL.

This relation between community annoyance and DNL has been confirmed, even for infrequent aircraft noise events. Reference C.8 reported the reactions of individuals in a community to daily helicopter overflights correlated quite well with the daily time-average sound levels over this range of numbers of daily noise events.

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

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

As a simple example of this characteristic, consider a case in which only one aircraft overflight occurs in daytime during 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 65.5 dB. Assume, as a second example, that ten such 30-second overflights occur in 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 75.4 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. This is the basic concept of a time-average sound metric, and specifically the DNL.

C.3 Noise Effects

C.3.1 Hearing Loss

Noise-induced hearing loss is probably the best-defined of the potential effects of human exposure to excessive noise. Federal workplace standards for protection from hearing loss allow a time-average level of 90 dB over an 8-hour work period, or 85 dB averaged over a 16-hour period. An outdoor DNL of 75 dBA is considered the threshold above which the risk of hearing loss should be evaluated. Following guidelines recommended by the Committee on Hearing, Bioacoustics, and Biomechanics of the National Research Council, the average change in the threshold of hearing for people exposed to DNL equal to or greater than 75 dBA was evaluated. Results indicated that an average of 1 dBA hearing loss could be expected for people exposed to DNL equal to or greater than 75 dBA. For the most sensitive 10 percent of the exposed population, the maximum anticipated hearing loss would be 4 dBA. These hearing loss projections must be considered conservative as the calculations are based on an average daily outdoor exposure of 16 hours (7:00 a.m. to 10:00 p.m.) over a 40-year period. Since it is unlikely that airport neighbors will remain outside their homes 16 hours per day for extended periods of time, there is little possibility of hearing loss below a DNL of 75 dB, and this level is extremely conservative.

C.3.2 Nonauditory Health Effects

Nonauditory health effects of long-term noise exposure, where noise may act as a risk factor, have never been found to occur at levels below those protective against noise-induced hearing loss, described above. Most studies attempting to clarify such health effects have found that noise exposure levels established for hearing protection will also protect against any potential nonauditory health effects, at least in workplace conditions. The best scientific summary of these findings is contained in the lead paper at the National Institute of Health Conference on Noise and Hearing Loss, held on 22-24 January 1990 in Washington, D.C.

> "The nonauditory effects of chronic noise exposure, when noise is suspected to act as one of the risk factors in the development of hypertension, cardiovascular disease, and other nervous disorders, have never been proven to occur as chronic manifestations at levels below these criteria (an average of 75 dBA for complete protection against hearing loss for an eight-hour day). At the recent (1988) International Congress on Noise as a Public Health Problem, most studies attempting to clarify such health effects did not find them at levels below the criteria protective of noise-induced hearing loss, and even above these

> criteria, results regarding such health effects were ambiguous. Consequently, one comes to the conclusion that establishing and enforcing exposure levels protecting against noise-induced hearing loss would not only solve the noise-induced hearing loss problem but also any potential nonauditory health effects in the work place." (Reference C.9; parenthetical wording added for clarification.)

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

For example, in an often-quoted paper, two University of California at Los Angeles (UCLA) researchers apparently found a relationship between aircraft noise levels under the approach path to Los Angeles International Airport and increased mortality rates among the exposed residents by using an average noise exposure level greater than 75 dB for the "noise-exposed" population (Reference C.10). Nevertheless, three other UCLA professors analyzed those same data and found no relationship between noise exposure and mortality rates (Reference C.11).

In summary, there is no scientific basis for a claim that potential health effects exist for aircraft DNL below 75 dB.

C.3.3 Annoyance

The primary effect of aircraft noise on exposed communities is one of annoyance. Noise annoyance is defined by the USEPA as any negative subjective reaction on the part of an individual or group (Reference C.3). As noted in the discussion of DNL above, community annoyance is best predicted by that metric.

It is often suggested that a lower DNL, such as 60 or 55 dB, be adopted as the threshold of community noise annoyance for airport environmental analysis documents. While there is no technical reason why a lower level cannot be measured or calculated for comparison purposes, a DNL of 65 dB:

- provides a valid basis for comparing and assessing community noise effects;
- represents a noise exposure level which is normally dominated by aircraft noise and not other community or nearby highway noise sources; and
- reflects the FAA's threshold for grant-in-aid funding of airport noise mitigation projects.
- U.S. Department of HUD also establishes a DNL standard of 65 dB for eligibility for federally guaranteed home loans.

C.3.4 Speech Interference

Speech interference associated with aircraft noise is a primary cause of annoyance to individuals on the ground. The disruption of routine activities such as radio or television

listening, telephone use, or family conversation gives rise to frustration and irritation. The quality of speech communication is also important in classrooms, offices, and industrial settings and can cause fatigue and vocal strain in those who attempt to communicate over the noise. Research has shown that "whenever intrusive noise exceeds approximately 60 dB indoors, there will be interference with speech communication" (Reference C.5). A steady A-weighted background sound level of 60 dB will produce 93 percent intelligibility; that of 70 dB will produce 66 percent intelligibility; and that of 75 dB will produce 2 percent intelligibility (Figure D-1 in Reference C.3).

C.3.5 Sleep Interference

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

A recent analysis sponsored by the Air Force summarized 21 published studies concerning the effects of noise on sleep (Reference C.14). The analysis concluded that a lack of reliable studies in homes, combined with large differences among the results from the various laboratory studies and the limited in-home studies, did not permit development of an acceptable accurate assessment procedure. The noise events used in the laboratory studies and in contrived in-home studies were presented at much higher rates of occurrence than would normally be experienced in the home. None of the laboratory studies was of sufficiently long duration to determine any effects of habituation, such as those which would occur under normal community conditions.

Nevertheless, some guidance is available in judging sleep interference. The USEPA identified an indoor DNL of 45 dB as necessary to protect against sleep interference (Reference C.3). Assuming a very conservative structural noise insulation of 20 dB for typical dwelling units, this corresponds to an outdoor DNL of 65 dB as minimizing sleep interference.

The Federal Interagency Committee on Noise (Reference C.5) reviewed the sleep disturbance issue and presented an Air Force-developed sleep disturbance dose-response prediction curve, which is based on data from Reference C.14, as an interim tool for analysis of potential sleep disturbance. This interim curve shows that for an indoor SEL of 65 dB, approximately 15 percent or less of those exposed should be awakened.

C.3.6 Noise Effects on Domestic Animals and Wildlife

Animal species differ greatly in their responses to noise. Each species has adapted, physically and behaviorally, to fill its ecological role in nature, and its hearing ability usually reflects that role. Animals rely on their 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. Secondary effects may include nonauditory effects similar to those exhibited by humans - stress, hypertension, and other nervous disorders. Tertiary effects may include interference with mating and resultant population declines.

Many scientific studies are available regarding the effects of noise on wildlife and some anecdotal reports of wildlife "flight due to noise." Few of these studies or reports include any reliable measures of the actual noise levels involved.

In the absence of definitive data on the effect of noise on animals, the Committee on Hearing, Bioacoustics, and Biomechanics proposed that protective noise criteria for animals be taken to be the same as for humans (Reference C.16).

C.3.7 Effects of Noise-Induced Vibration on Structures and Humans

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. 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 of the energy lost in the airspace. This surface then radiates sound into the dwelling interior. 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 and, infrequently, the plastered walls and ceilings. An evaluation of the peak sound pressure impinging on the structure is normally sufficient to determine the possibility of damage. In general, at sound levels above 130 dB, there is the possibility of structural damage. While certain frequencies (such as 30 Hz for window breakage) may be of more concern than other frequencies, conservatively, only sounds lasting more than 1 second above a sound level of 130 dB are potentially damaging to structural components (Reference C.17).

In terms of average acceleration of wall or ceiling vibration, the thresholds for structural damage (C.18) are:

- 0.5 meters/second/second—threshold of risk of damage to sensitive structures (e.g., ancient monuments); and
- 1.0 meter/second/second—threshold of risk of damage to normal dwellings (e.g., houses with plaster ceilings and walls).

Noise-induced structural vibration may also 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 aircraft noise, causing homeowners to fear breakage. In general, such noise-induced vibrations occur at sound levels above those considered normally compatible with residential land use. Thus, assessments of noise exposure levels for compatible land use should also be protective of noise-induced secondary vibrations.

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

- Type of excitation: steady state, intermittent, or impulsive vibration;
- Frequency of the excitation. International Organization for Standardization (ISO) 2631-2 (Reference C.18) recommends a frequency range of 1 to 80 Hz for the assessment of vibration on humans;

- Orientation of the body with respect to the vibration;
- The use of the occupied space; and
- Time of day.

C.3.8 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 structures, especially in mountainous areas, causing landslides or avalanches. There are no known instances of such effects, and it is considered improbable that such effects will result from routine, subsonic aircraft operations.

C.3.9 Noise Effects on Historical and Archaeological Sites

Because of the potential for increased fragility of structural components of historical buildings and other historical sites, aircraft noise may affect such sites more severely than newer, modern structures. Again, there are few scientific studies of such effects to provide guidance for their assessment.

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

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

C.4 Noise Level Reduction Guidelines

In April 2005, Wyle Labs published a study for the Naval Facilities Engineering Command, entitled "*Guidelines for Sound Insulation of Residences Exposed to Aircraft Operations*." (C.20) The study provides in-depth, state-of-the-art NLR guidelines. Copies of this study are available on-line at:
http://www.afcee.af.mil/shared/media/document/AFD-070914-039.pdf .

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