

FORT KNOX INSTALLATION COMPATIBLE USE ZONE STUDY



June 2018



**Environmental Noise Branch
Army Public Health Center**

Fort Knox

ICUZ

INSTALLATION COMPATIBLE USE ZONE

STUDY

June 2018



Prepared by:
Environmental Noise Branch
Environmental Health Sciences Division
Army Public Health Center (APHC)

8252 Blackhawk Road
Aberdeen Proving Ground
Maryland, 21010

EXECUTIVE SUMMARY

OVERVIEW

One of the goals of the Department of the Army is to plan, initiate, and carry out actions and programs designed to minimize adverse impacts upon the quality of the human environment without impairing the Army's mission. The Installation Compatible Use Zone (ICUZ) Program implements Army policy for such planning. The ICUZ program promotes land use that is compatible with the military noise environment. The ICUZ study quantifies the noise environment from military training sources and recommends the most appropriate uses of noise-impacted areas. This study replaces the September 2009 Installation Operational Noise Management Plan and provides information that reflects the most accurate account of activities as of 2018.

Army Regulation (AR) 200-1 lists housing, schools, and medical facilities as examples of noise-sensitive land uses. Regulation guidelines state for land use planning purposes, noise-sensitive land uses are acceptable within the Noise Zone I, generally not compatible in Noise Zone II, and incompatible in Noise Zone III. AR 200-1 offers land use recommendations, which if adopted both on and off the installation, would facilitate future development that is unaffected by military noise. These guidelines are applied throughout the ICUZ document as individual training operations are analyzed.

The principle noise sources at Fort Knox include weapons and demolition training and aircraft operations. The City of Radcliff, adjacent to the southwest boundary is the largest population center in the local area, although several other smaller municipalities including Lebanon Junction (southeast) and Shepherdsville (northeast), tend to receive the largest noise impacts annually. These cities, along with unincorporated county areas geographically south and east of the Fort have the highest population exposure to training noise from day-to-day operations. However, single events show certain training operations are audible and may be loud in many areas outside the Fort.

CONCLUSIONS

SMALL ARMS WEAPONS OPERATIONS

Small Arms Ranges

Fort Knox has a large number of small arms ranges which are used frequently throughout the year. Multiple ranges concurrently firing can be a common daily occurrence on the installation. The Noise Zones from small arms firing are primarily contained to the range and impact areas in the eastern half of the installation. Zone III is entirely contained within the installation boundary. Zone II extends beyond the boundary in four separate areas to the north, northeast, and south-southeast. The area southeast contains a small portion of the City of Lebanon Junction. Individual homes in county lands are also scattered through these areas, although development in general is limited.

On post the Noise Zones extend into the northeast end of the cantonment. The land uses within these Noise Zones are mostly compatible. Zone III contains motor pool facilities and parking lots. A small portion of Zone II does contain some enlisted barracks.

Non-Fixed Firing Ranges

Training activities which require the firing of small arms blank ammunition occur in multiple training sites and collective training facilities throughout the Fort. A large majority of the training areas can also support these operations. In most cases, weapons fire takes place far enough from the boundary that noise impacts would be considered minimal.

LARGE CALIBER WEAPONS AND EXPLOSIVES OPERATIONS

Land Use Compatibility

The cumulative large caliber and demolition operations Noise Zones show impacts to sensitive land uses are limited to the areas beyond the southeast boundary. The Noise Zones extending off post, particularly Zones II and III are concentrated just outside the Yano Multi-Purpose Range Complex (MPRC). There are no noise-sensitive land uses contained within Zone III. Zone II contains residential land uses scattered throughout Hardin and Bullitt Counties, albeit in low density. Further development of these areas is expected to be limited, as planning measures are currently in place restricting large scale development. The Land use Planning Zone (LUPZ) extends further east, encompassing a portion of Lebanon Junction and considerably more noise-sensitive land uses. On post, the Noise Zones do not extend into the cantonment area or affect any sensitive land use.

Single Event Levels

Peak levels correlate with the receiver's perception of noise and can be a good predictor of complaints. Peak levels are included in this study as a supplement to land use compatibility Noise Zones. Individuals in an area experiencing peak sound levels between 115 and 130 dB may describe events as noticeable and distinct. Peak sound levels above 130 dB are generally objectionable, and are often described as very loud and startling. Peak levels can vary significantly for the same activity based upon weather conditions. Peak sound levels in this study were modeled with two meteorological conditions (unfavorable and neutral weather) applied.

Under unfavorable weather, peak sound levels between 115 and 130 dB extend beyond the Fort boundary to the south, southwest, north, and east. The largest noise exposure to single events occurs southwest in the City of Radcliff and east within Lebanon Junction; although, small clusters of residential development and individual homes are present throughout. Peak sound levels above 130 dB extend beyond the boundary in several areas north-northeast and south. Homes adjacent to the installation's southern boundary are located within the 130 dB contour.

On post, the 115-130 dB Peak contour encompasses the majority of the cantonment, with the exception of the northwest corner. Sensitive land uses include family and soldier housing, several schools and the Ireland Army Health Clinic (IRAHC). Peak sound levels above 130 dB extend

into the northern tip of the cantonment area as a result from activities at the Heins range. There are no noise-sensitive land uses contained within the 130 dB contour.

The absence of the downwind propagation effect greatly reduces noise impacts under neutral weather conditions. Noise levels between 115 and 130 dB still extend beyond the boundary north-northeast, southwest and south-southeast; however, to a much lesser degree. In fact, impacts to noise-sensitive land use shifts from areas southwest to the areas southeast, including the western edge of Lebanon Junction and portions of Bullitt and Hardin counties. Peak sound levels above 130 dB extend beyond the installation boundary in one small area south of the Yano MPRC. There are currently no sensitive land uses within this area

On post, sound levels between 115 and 130 dB extend into the northeast portion of the cantonment, but remain north of the barracks area. There are no noise-sensitive land uses in the contour. The 130 dB contours on post are contained to range, training site and maneuver areas, and do not extend into the cantonment area.

MICLIC Single Event Levels

In addition to day-to-day operations, single event peak sound levels were modeled for live Mine Clearing Line Charge (MICLIC) operations. These operations are relatively infrequent compared to other demolition activities; however, the large net explosive weight of the MICLIC make it one of the loudest single training events on Fort Knox. Depending on mission and unit, three different range areas (St. Vith, McFarland-Oliver and Steeles) are used to detonate MICLICs.

Noise impacts beyond the boundary are highly dependent upon weather conditions and the range used for detonation. This is particularly true in the unfavorable weather scenario, where the 115-130 dB noise contour shifts focus from areas south when firing at St. Vith and Steeles ranges to areas north when detonating from McFarland-Oliver range. In all cases, peak sound levels above 130 dB remain contained to the installation boundary, with the exception of a small enclave of Radcliff which is entirely comprised of Saunders Spring Park.

On post, MICLIC operations under unfavorable weather produce peak sound levels between 115-130 dB which blanket the cantonment area regardless of detonation point. Sounds levels above 130 dB do not enter the cantonment area or affect any sensitive land use.

AVIATION OPERATIONS

The cumulative Noise Zones at Godman Army Airfield (GAAF) show minimal impacts beyond the installation boundary, with the exception of the City of Muldraugh, an incorporated city which is completely surrounded by Fort Knox and lies just north of the airfield. Due to its location and proximity to GAAF, a large portion of Muldraugh is contained within the LUPZ. Zones II and III remain contained to the installation boundary and do not extend into Muldraugh.

On post, the LUPZ encompasses portions of the cantonment area west and south of the airfield, including several large family housing communities west of Highway 31W and several schools. Zone II extends south of the airfield along the flight track as far as the Bullion Depository, including portions of several family housing communities. Zone III remains contained to the runway.

Unmanned Aerial System (UAS) operations at Fort Knox are predominately limited to the RQ-11 Raven and RQ-20 Puma reconnaissance, surveillance and intelligence aircraft. Launch, recovery, and flight operations all take place within the restricted R3704 airspace, both on and off the installation boundary. In general, noise impacts from UAS aircraft are considered minimal, based on the size, operating altitudes and training locations used on Fort Knox.

All aircraft operating outside of Fort Knox restricted airspace either in or out of designated flight corridors or within military operations areas have the potential to cause annoyance and complaints. Pilots utilizing Fort Knox airspace are instructed to adhere to designated noise abatement procedures to help mitigate the effects of aircraft noise at the Fort and beyond, including minimum flight altitudes and avoidance areas.

RECOMMENDATIONS

The ICUZ is a proactive planning tool, which can help guide future development in surrounding communities. At a minimum, local municipal governments are encouraged to support public disclosure of all Noise Zones and supplemental metrics which convey how military training operations affect the noise environment.

The ICUZ study describes the noise characteristics of a specific operational environment, and as such, will change if a significant operational change is made. Therefore, if Fort Knox's mission, training, or training facilities undergo changes, the ICUZ should be reviewed to determine if the current noise assessment is sufficient. At a minimum, it is recommended that every five years the ICUZ and/or Noise Zones be updated to incorporate pertinent changes to the noise environment.

SECTION

1	INTRODUCTION	1-1
1.1	GENERAL	1-1
1.2	PURPOSE AND NEED	1-1
1.3	PROCESS AND PROCEDURE	1-2
1.3.1	REGULATORY REQUIREMENTS	1-2
1.3.2	NOISE EXPOSURE MODELS	1-2
1.4	NOISE BASICS	1-3
1.4.1	NOISE METRICS	1-3
1.4.2	SOUND PROPAGATION	1-4
1.5	NOISE MANAGEMENT PROGRAM	1-6
1.5.1	NOISE COMPLAINT MANAGEMENT	1-7
2	FORT KNOX	2-1
2.1	LOCATION	2-1
2.2	HISTORY	2-1
2.3	MISSION, UNITS AND ORGANIZATIONS	2-3
2.4	TRAINING FACILITIES AND RANGES	2-3
2.5	LOCAL COMMUNITIES	2-8
2.6	FORT KNOX COMMUNITY	2-10
2.7	ECONOMIC IMPACT	2-10
3	NOISE ASSESSMENT GUIDELINES	3-1
4	RANGE NOISE ASSESSMENT	4-1
4.1	SMALL ARMS NOISE	4-1
4.1.1	SMALL ARMS NOISE ZONES	4-1
4.1.2	NON-FIXED FIRING POINT AREAS	4-5
4.2	LARGE CALIBER AND DEMOLITION NOISE	4-6
4.2.1	LARGE CALIBER AND DEMOLITION NOISE ZONES	4-7
4.2.2	LARGE CALIBER AND DEMOLITION SINGLE EVENT PEAK LEVELS	4-10
4.3	FUTURE LARGE CALIBER AND DEMOLITION NOISE	4-19
4.3.1	FUTURE LARGE CALIBER AND DEMOLITION NOISE ZONES	4-19
4.4	SIMULATOR NOISE	4-22
5	AIRCRAFT NOISE ASSESSMENT	5-1
5.1	GENERAL	5-1

5.2	GODMAN ARMY AIRFIELD	5-1
5.2.1	GODMAN ARMY AIRFIELD NOISE ZONES.....	5-3
5.3	ANNOYANCE POTENTIAL FROM SINGULAR OVERFLIGHT.....	5-5
5.3.1	UNMANNED AERIAL SYSTEM AIRCRAFT	5-10
5.3.2	AIRCRAFT NOISE ABATEMENT	5-10
6	NOISE RELATED LAND USE PLANNING AND POLICY	6-1
6.1	INTRODUCTION	6-1
6.2	ACHIEVING LAND USE COMPATIBILITY.....	6-1
6.3	REGIONAL LAND USE PLANNING	6-1
6.4	JOINT LAND USE STUDY (JLUS).....	6-1
6.5	ARMY COMPATIBLE USE BUFFER (ACUB) PROGRAM.....	6-3
6.6	LAND USE PLANNING OPTIONS.....	6-4
6.7	LOCAL NOISE RELATED LAND USE POLICY	6-5
7	SUMMARY	7-1
7.1	SMALL ARMS WEAPONS	7-1
7.2	LARGE CALIBER WEAPONS AND EXPLOSIVES	7-1
7.3	AVIATION ACTIVITY	7-3
7.4	RECOMMENDATIONS.....	7-3
A	GLOSSARY OF TERMS	A-1
B	LAND USE GUIDELINES	B-1
C	DATA USED TO GENERATE NOISE ZONES	C-1
D	REFERENCES	D-1

FIGURES

Figure 1-1.	Example of a Temperature Inversion.....	1-5
Figure 2-1.	Fort Knox General Location	2-2
Figure 2-2.	Range, Training Facility, Impact and Maneuver Area Locations.....	2-7
Figure 2-3.	Population Density (2013) Surrounding Fort Knox.....	2-9
Figure 4-1.	Small Arms Noise Zones	4-2
Figure 4-2.	Small Arms Zone II Off Post	4-4
Figure 4-3.	Large Caliber and Demolition Operations CDNL Noise Zones	4-8
Figure 4-4.	Large Caliber and Demolition CDNL Noise Zones II and III Off Post.....	4-9
Figure 4-5.	Large Caliber and Demolition Operations Unfavorable Weather Conditions PK15(met) Sound Levels.....	4-12
Figure 4-6.	Large Caliber and Demolition Operations Neutral Weather Conditions PK50(met) Sound Levels.....	4-13

Figure 4-7. Peak MICLIC Sound Levels- Unfavorable and Neutral Weather Conditions at Steele's Range.....	4-15
Figure 4-8. Peak MICLIC Sound Levels- Unfavorable and Neutral Weather Conditions at St. Vith Range	4-17
Figure 4-9. Peak MICLIC Sound Levels- Unfavorable and Neutral Weather Conditions at McFarland-Oliver Range	4-18
Figure 4-10. Future Large Caliber and Demolition CDNL Noise Zones with DAGIR Operations	4-20
Figure 5-1. Regulated Airspace and Aviation Operation Areas on Fort Knox.....	5-2
Figure 5-2. Godman AAF ADNL Noise Zones.....	5-4
Figure 5-3. UH-60 Singular Overflight Annoyance Potential Illustration	5-9
Figure 6-1. JLUS 2008 Primary Study Areas	6-3

TABLES

Table 1-1. University of Utah Criteria for "Good" and "Bad" Firing Conditions	1-6
Table 2-1. Small Arms Live-Fire Ranges	2-4
Table 2-2. Demolition and Large Caliber Live-Fire Ranges	2-5
Table 2-3. Collective Training Facilities	2-6
Table 2-4. Population Surrounding Fort Knox	2-8
Table 2-5. Fort Knox Daytime Population	2-10
Table 3-1. Noise Limits for Noise Zones.....	3-1
Table 3-2. Complaint Risk Guidelines.....	3-1
Table 4-1. Small Arms Noise Zones Acreage	4-1
Table 4-2. Population Exposure in Small Arms Noise Zones	4-3
Table 4-3. Predicted Peak Levels for 5.56 mm Blank Round	4-5
Table 4-4. Predicted Peak for 7.62 mm Blank Round	4-5
Table 4-5. Predicted Peak for .50 Caliber Blank Round.....	4-6
Table 4-6. Large Caliber and Demolition Noise Zones Acreage.....	4-7
Table 4-7. Population Exposure Off Post in CDNL Noise Zones	4-7
Table 4-8. Existing vs. Future Large Caliber and Demolition Noise Zone Acreages	4-21
Table 4-9. Population Exposure Off Post in Existing vs. Future CDNL Noise Zones.....	4-21
Table 4-10. Predicted Peak Noise Levels for Typical Army Simulators.....	4-22
Table 5-1. GAAF Aircraft Noise Zones Acreage	5-3
Table 5-2. Population Exposure On and Off Post in ADNL Noise Zones	5-3
Table 5-3. Maximum A-Weighted Sound Levels for Rotary-Wing and Tiltrotor Aircraft	5-5
Table 5-4. Maximum A-Weighted Sound Levels for Fixed-Wing Aircraft	5-6
Table 5-5. Percentage of Population Highly Annoyed from Aircraft Noise	5-6
Table 5-6. Rotary-Wing Overflight Annoyance Potential ¹	5-7
Table 5-7. Fixed-Wing Overflight Annoyance Potential ¹	5-8
Table 5-8. MV-22 Tiltrotor Aircraft Overflight Annoyance Potential ¹	5-9

ACRONYMS AND ABBREVIATIONS

AAD	Average Annual Day
ACUB	Army Compatible Use Buffer
ADD	Area Development District
ADNL	A-Weighted Day-Night Average Sound Level
AGL	Above Ground Level
AR	Army Regulation
ARNG	Army National Guard
AT&A	Air Traffic and Airspace
CAB	Combat Aviation Brigade
CDC	Child Development Center
CDNL	C-Weighted Day-Night Average Sound Level
CPQC	Combat Pistol Qualification Course
CY	Calendar Year
BRAC	Base Realignment and Closure
dB	Decibel(s)
dBA	Decibels, A-Weighted
dBc	Decibels, C-Weighted
dBp	Decibels, Unweighted Peak
DAGIR	Digital Air to Ground Integration Range
DEM	Digital Elevation Model
DNL	Day-Night Average Sound Level
DoD	Department of Defense
DODI	Department of Defense Instruction
DPTMS	Directorate of Plans, Training, Mobilization and Security
DZ	Drop Zone
ERG	Explosives Research Group
FAA	Federal Aviation Administration
FICUN	Federal Interagency Committee on Urban Noise
FOB	Forward Operating Base
FY	Fiscal Year
GAAF	Godman Army Airfield
GIS	Geographic Information Systems
HE	High Explosive
ICUZ	Installation Compatible Use Zone
IED	Improvised Explosive Device
IRAHC	Ireland Army Health Clinic
JLUS	Joint Land Use Study
KIPDA	Kentuckiana Regional Planning Development Agency
KD	Known Distance
LEQ	Equivalent Sound Level
Lmax	Maximum Sound Level
LTAAD	Lincoln Trail Area Development District
LUPZ	Land Use Planning Zone

LZ	Landing Zone
MEDDAC	Medical Department Activity
MICLIC	Mine Clearing Line Charge
MOA	Military Operations Area
MOUT	Military Operations in Urban Terrain
MPRC	Multi-Purpose Range Complex
MPTR	Multi-Purpose Training Range
MSL	Mean Sea Level
MTF	Maintenance Test Flight
NLR	Noise Level Reduction
OEA	Office of Economic Adjustment
PAO	Public Affairs Office
QTR	Qualification Training Range
RC	Reserve Component (US Army)
ROZ	Restricted Operating Zone
SARNAM	Small Arms Range Noise Assessment Model
SEL	Sound Exposure Level
STRAC	Standards in Training Commission
SUA	Special Use Airspace
TA	Training Area
TRADOC	U.S. Army Training and Doctrine Command
UAS	Unmanned Aerial System
USAF	U.S. Air Force
USAPHC	U.S. Army Public Health Command
USGS	U.S. Geological Survey

1 INTRODUCTION

1.1 GENERAL

The Installation Compatible Use Zone (ICUZ) study provides a strategy for noise management in the areas surrounding Fort Knox. Elements of the ICUZ program include education about noise and Army noise metrics, complaint management, noise impact analysis and when necessary, noise abatement procedures.

The study is provided to assist both installation personnel and local community officials. Specifically, the ICUZ provides a methodology for analyzing noise exposure associated with military operations and provides land use guidelines for achieving compatibility between the noise generated by the Army and the surrounding communities.

As local communities prepare and modify comprehensive development plans, it is recommended that the conclusions from this study be considered in the planning process with a goal to encourage compatible land use.

1.2 PURPOSE AND NEED

The Army has an obligation to U.S. citizens to recommend land use around its installations which will: (a) protect citizens from noise and other hazards; and (b) protect the public's investment in these training facilities. To meet these obligations, the Army will recommend land uses that are compatible with military operations while allowing maximum beneficial use of adjacent properties. The U.S. Department of Defense (DoD) and component Services have published guidelines that reflect these land use recommendations.

Through Army Regulation (AR) 200-1, noise exposure on communities is translated into Noise Zones. Regulation guidelines state that for land use planning purposes, noise-sensitive land uses range from acceptable to not compatible within the Noise Zones. These guidelines are applied throughout the ICUZ as individual or combined training operations are analyzed. The program defines the following four Noise Zones:

- Zone III - Noise-sensitive land uses are not recommended (incompatible).
- Zone II - Although local conditions such as availability of developable land or cost may require noise-sensitive land uses in Zone II, this type of land use is generally not compatible and is strongly discouraged on the installation and in surrounding communities. All viable alternatives should be considered to limit development in Zone II to non-sensitive activities such as industry, manufacturing, transportation and agriculture.
- Zone I - Noise-sensitive land uses are acceptable within the Zone I. However, though an area may only receive Zone I levels, military operations may be loud enough to be heard - or even judged loud on occasion. Zone I is not one of the contours shown on the map; rather it is the entire area outside of the Zone II contour.

- The Land Use Planning Zone (LUPZ) is a subdivision or upper limit of Zone I. The LUPZ represents an area starting at the lower limit of Zone II and extends outward to a distance significant enough to allow for a 5 decibel (dB) reduction in sound level for large caliber and aircraft noise (There is no LUPZ for small arms activity Noise Zones). Within this area, noise-sensitive land uses are generally acceptable. However, communities and individuals often have different views regarding what level of noise is acceptable or desirable. To address this, some local governments have implemented land use planning measures out beyond the Zone II limits. Additionally, implementing planning controls within the LUPZ can develop a buffer to avert future noise conflicts.

The need for noise compatibility assessments in the Army is a greater challenge today than at any point in the past. Rapid population growth has brought land development directly adjacent to many Army installations, which were at one point relatively remote locations. This development, often referred to as encroachment, has brought military installations and civilian communities in much closer proximity, leading to issues of incompatibility.

To prevent incompatibilities between military operations and civilian land use from reaching a significant level, the Army must take reasonable steps to protect the community from training noise, and it must work with the local governments and land owners to make sure that adjoining lands are developed in ways compatible with the noise environment. Of particular concern are areas within the aforementioned Noise Zones, as well as areas that may occasionally be subjected to noise levels that the local community may find objectionable.

1.3 PROCESS AND PROCEDURE

1.3.1 REGULATORY REQUIREMENTS

This assessment has been conducted in accordance with the DoD Instruction Directive 4715.13 *Subject: DoD Noise Program* (DoD 2005) and Army Regulation (AR) 200-1, *Environmental Protection and Enhancement*, Chapter 14, *Operational Noise* (U.S. Army 2007).

1.3.2 NOISE EXPOSURE MODELS

Operations data includes the types of weapons and ammunitions fired, number of rounds fired, time of day in which rounds are fired, and the location of firing areas and targets. The data were input into computer software models which calculate noise exposure levels associated with the multiple types of military operations ongoing at Fort Knox. A summary of the computer models is provided below:

- The computer model used to create the noise contours for small arms (.50 caliber and below) ranges is the Small Arms Range Noise Assessment Model (SARNAM). SARNAM incorporates information on weapons noise source models, directivity, sound propagation, and the effects of noise mitigation and safety structures when necessary. The SARNAM calculation algorithms assume weather conditions or wind direction that favors sound propagation. Small caliber weapons noise is addressed utilizing peak levels and therefore has no assessment period.

- The BNOISE2 modeling program calculates noise levels generated by firing large arms (20mm and greater) and high-explosive charges. The sounds from large arms, demolitions, and other impulsive sounds generally create the largest complaint issues because the sound can travel far, is difficult to mitigate and can be accompanied by vibration that may increase the public's annoyance. Noise Zones for large caliber weapons are addressed using the C-weighted Day-Night average sound Level (CDNL) with an assessment period of 250 days. This is the Army standard assessment period for all Active Army training installations and ranges per AR 200-1 guidance.
- 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, maintenance, and ground run-up operations.

1.4 NOISE BASICS

Sound is defined as a physical disturbance in a medium (i.e. gas, liquid, or solid) that is capable of being detected by the human ear. Sound waves in air are caused by variations in pressure above and below an even (static) value in atmospheric pressure. These changes in atmospheric pressure as they relate to human hearing can have great variance, for example a whisper at two meters would be as low as 0.0006 Pascals, whereas an M16 rifle fired near the shooter's ear would be 1,000 Pascals.

Due to this large range of sound pressures and that the human ear responds more closely to a logarithmic scale (rather than a linear), the decibel (dB) system was developed to quantify sound energy (loudness) into a meaningful and manageable scale. On this scale, the range of average human hearing runs from approximately zero (threshold of hearing) to 140. Using the example above, the whisper at two meters would register 30 dB and the M16 rifle shot near the shooter's ear would be 154 dB.

1.4.1 NOISE METRICS

When measuring sound, the levels are often filtered (i.e. frequency weighted) to accommodate how the human ear functions. This process is known as "A-weighting" and can be assumed for all sound levels in this report unless otherwise specified. Military impulsive sounds (e.g., explosions, artillery blasts) can be felt as well as heard and utilize "C-Weighting" where the low-frequency components of these sounds are not de-emphasized to the same extent as A-weighting. Explanations of the noise metrics that are used in this assessment are listed below.

- **Day-Night Average Sound Level (DNL).** DNL is a noise metric describing the average noise level over the course of a 24-hour period. A 10 dB adjustment is applied to operations that happen during night time hours (10 p.m. through 7 a.m.) because noise tends to be more intrusive at night than during the day. DNL accounts for the total or cumulative noise level at a given location over a specified assessment (time) period. In the case of large caliber and aircraft noise, the assessment period is an annual average.

- **Maximum Sound Level (Lmax).** The highest sound level measured during a single event in which the sound level changes value with time (e.g., an aircraft overflight) is called the maximum sound level, or Lmax. The maximum sound level is important in judging the interference caused by a noise event with conversation, television or radio listening, sleeping, or other common activities.
- **Peak (dBP).** Peak is a single-event sound level without frequency weighting. There is no time component or assessment period with Peak such as with DNL. The peak level is the same day or night. It is also the same whether one round is fired or a thousand rounds fired at a given range. It is a singular measure of the peak sound produced at that instance.
- **PK15(met).** PK15(met) is a computer modeled single-event peak level that is exceeded only 15 percent of the time by the loudest munitions type detonation. This metric accounts for variations caused by weather conditions and favors noise propagation. The PK15(met) metric does not communicate any information about how often the loudest munitions type is detonated.
- **PK50(met).** PK50(met) is similar to the PK15(met) except that it represents the peak noise level that is exceeded 50 percent of the time. This metric also accounts for weather but assumes conditions which are not favorable for noise propagation, rather average or neutral weather conditions with regards to noise.

1.4.2 SOUND PROPAGATION

The principle influence on sound propagation is weather. Wind and temperature significantly influence how far sound travels from a source and how loud it will be at the receiver's location. As sound travels through air, a receiver downwind of the source will be subjected to higher sound levels than a receiver upwind; in effect the wind is actually helping move the sound to the downwind receiver, while upwind the sound must "swim against the current."

Combine wind direction with temperature variation (as a rule, sound usually travels further in cold temperatures) and one may observe the phenomena of *atmospheric refraction*. This is the process by which atmospheric conditions actually bend and/or focus sound waves toward some areas and away from others.

When a temperature inversion is present, military operations may sound much louder than normal, or be heard at greater distances. The inversion layer acts as a boundary for the sound, trapping it close to the ground. This can create areas of high intensity sound far from the sound's source. As a result, on most days it may be possible to detonate 10 pounds of explosives without disturbing a community (neutral weather conditions), while on another day with a temperature inversion, the detonation of 1 pound at the same location may be disruptive (unfavorable weather conditions).

Figure 1-1 illustrates how temperature inversions bend (refraction) the sound created by a typical explosion. The sound waves from the explosion initially travel upward, but the inversion reflects the sound back downward toward the ground, generating high noise levels many miles away. Under normal conditions, the noise levels at that distance would otherwise be much lower.

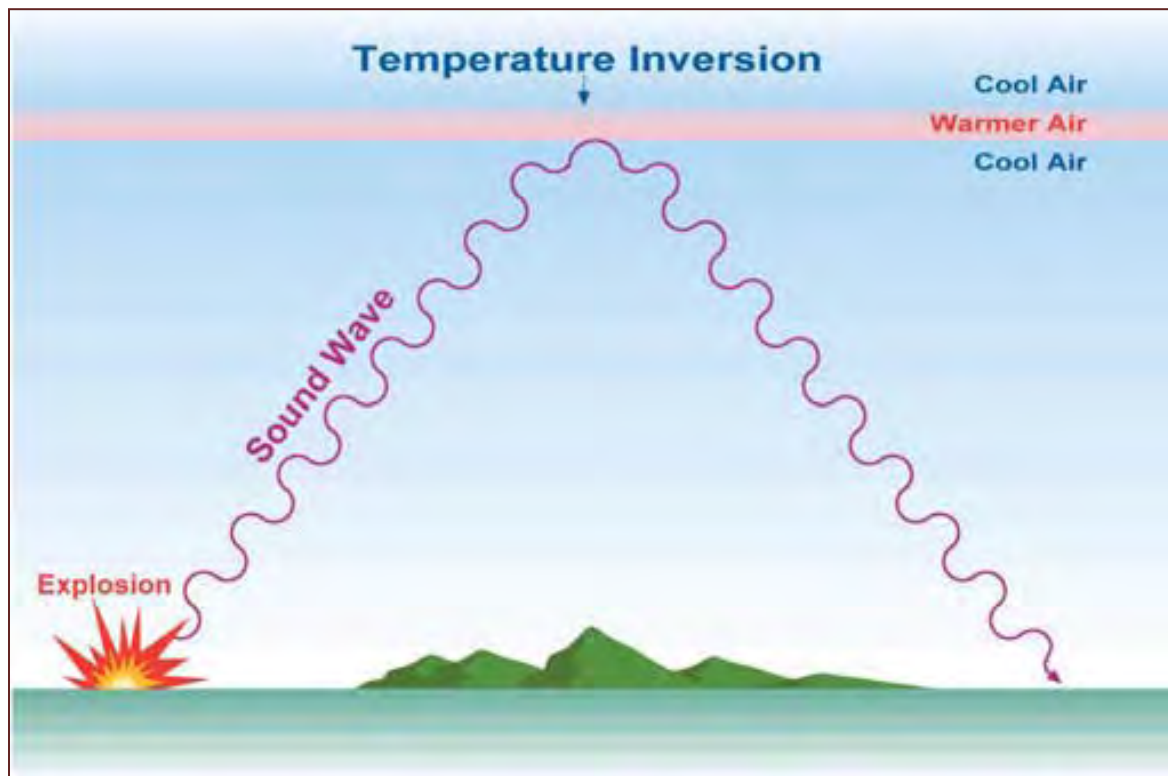


Figure 1-1. Example of a Temperature Inversion

Based on these phenomenon it is easy to see how predicting sound travel can be very difficult, but the Explosives Research Group (ERG) and the University of Utah developed guidelines to help determine what would be “good” or “bad” firing times. These guidelines are summarized in Table 1.1.

Another factor in sound propagation can be the natural topography of the land in and around the firing ranges and impact areas, as well as outside the installation. Naturally occurring terrain features have an effect on blast noise sound waves (air-blast) through both reflection and diffraction. To account for terrain effects, the BNOISE2 model uses algorithms in the calculation engine along with U.S. Geological Survey Digital Elevation Model (DEM) data. It should be noted that the mitigation effects of topography on blast noise are highly dependent upon the terrain features location and size.

Table 1-1. University of Utah Criteria for "Good" and "Bad" Firing Conditions

“Good” Firing Conditions	“Bad” Firing Conditions
<p>Clear skies with billowy cloud formations, especially during warm periods of the year.</p> <p>A rising barometer immediately following a storm.</p>	<p>Days of steady winds (5-10 mph) with gusts of greater velocities (above 20 mph) in the direction of nearby residences.</p> <p>Clear days on which “layering” of smoke or fog are observed.</p> <p>Cold, hazy, or foggy mornings.</p> <p>Days following a day when large extremes of temperature (about 36°F) between day and night are observed.</p> <p>Generally high barometer readings with low temperatures.</p>

Source: University of Utah, 1958

1.5 NOISE MANAGEMENT PROGRAM

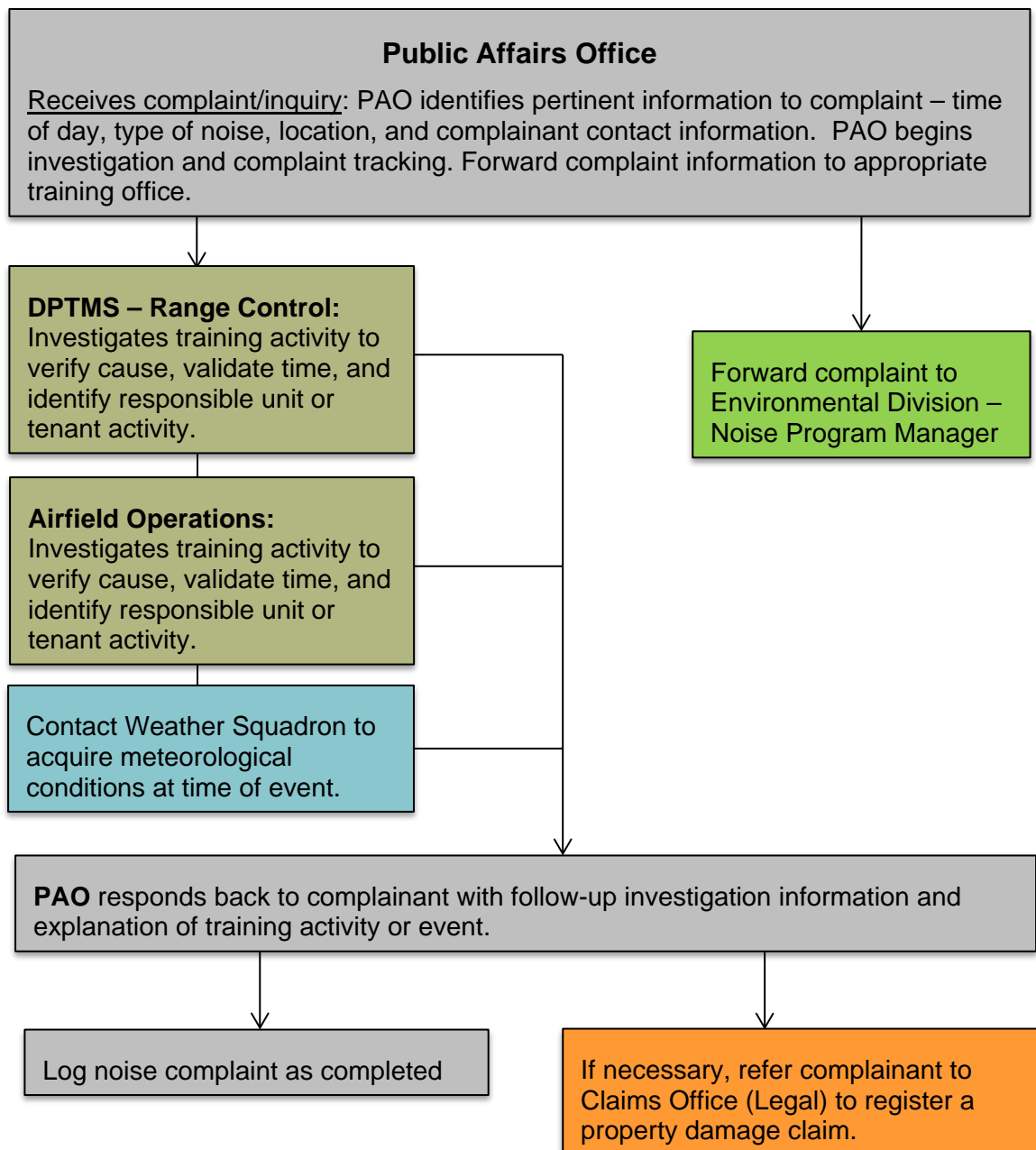
In accordance with AR 200-1, Army installations are responsible for maintaining a Noise Management Program. The program includes two main components:

- (1) *Evaluate and document the impact of noise produced by ongoing and proposed actions/activities.*
- (2) *Monitor, record, archive and address operational noise complaints.*

The ICUZ study is generally the center of the noise management program. The ICUZ is designed to provide needed information so installations can work with communities to solve noise incompatibility issues. The ICUZ study along with an effective noise complaint procedure is designed to help Fort Knox to address complaints, advise local planning commissions, and be instrumental in developing action plans which may limit future encroachment threats. The Directorate of Public Works, Environmental Division is the lead office for administering the noise management program at Fort Knox.

1.5.1 NOISE COMPLAINT MANAGEMENT

The goal of a complaint procedure is to reduce the potential for noise complaints by keeping the public informed about what is happening and to satisfy the complainants so that noise complaints do not escalate. A proactive noise complaint program will help prevent the degradation of the mission due to controversy over noise impacts, while at the same time protecting the health and safety of the local community, both civilian and military, on and off the installation. At Fort Knox, the Public Affairs Office (PAO) is the designated point of contact and primary office responsible for addressing noise complaints and/or inquiries. The diagram below illustrates the basic complaint process:



2 FORT KNOX

2.1 LOCATION

Fort Knox is located in north central Kentucky, within the counties of Meade, Hardin and Bullitt, approximately 30 miles southwest of Louisville. Municipalities in the immediate vicinity include Radcliff, Shepherdsville, Vine Grove, Lebanon Junction and West Point. Elizabethtown is located approximately 18 miles south of the installation. The Ohio River runs along the northern limits of Fort Knox, forming the border between Kentucky and Indiana. Figure 2-1 depicts the general location of Fort Knox.

2.2 HISTORY

In 1903, the land that now comprises Fort Knox was leased from private landowners. In January 1918, 10,000 acres of the current installation was used for training by troops from Camp Zachary Taylor. Approximately 40,000 acres, including the town of Stithton, were purchased in June of 1918 to establish an artillery-training center for use in World War I. This was the beginning of Camp Knox, which was named for Major General Henry Knox who served as Chief of Field Artillery from 1775 to 1782 and later served as Chief of Staff of the Army and the first Secretary of War. In 1922, the camp was closed as a permanent installation; however, from 1922 until 1932, artillery and infantry units stationed at other posts annually used Camp Knox as a training area (TA).

In 1932 the camp was selected for mechanized cavalry training and in turn became a permanent post, aptly designated Fort Knox. The U.S. Bullion Depository was completed in 1936 and remains on post today controlled by the U.S. Treasury Department. In 1940, the Armored Force was created and headquartered at Fort Knox. During the World War II era Fort Knox facilities saw a rapid expansion as the number of buildings on-post more than quadrupled. In 1946, the centralized responsibility for armor training and doctrine was assigned to the Armor School. In 1957 additional acreage was acquired to satisfy the need for larger caliber weapons bringing Fort Knox to its present size of 109,000 acres (U.S. Army 2009).

In 2005, after sixty-five years of hosting the Armor Center and School, Fort Knox's mission shifted from Armor training to human resources due to Base Realignment and Closure (BRAC). BRAC actions were completed in 2010, relocating the Armor Center and School to Fort Benning. Fort Knox acquired the Army's Human Resources Command, Cadet Command and Recruiting Command, which together form the Human Resource Center of Excellence.

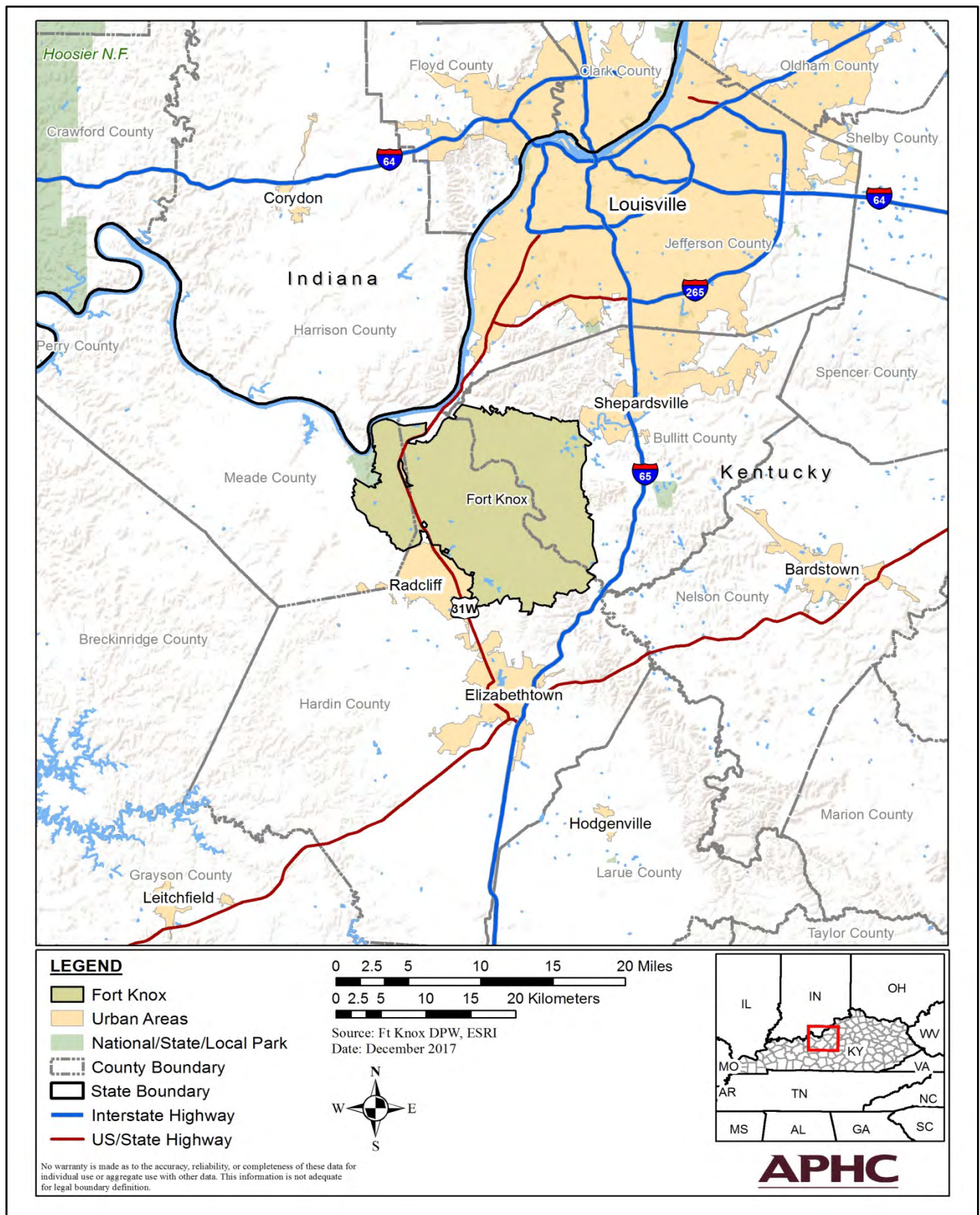


Figure 2-1. Fort Knox General Location

2.3 MISSION, UNITS AND ORGANIZATIONS

As the home of the Army's Human Resource Center of Excellence, the three major missions at Fort Knox are dedicated to leader development, enlistment and commissioning of soldiers and the management of soldiers careers through retirement and beyond (Fort Knox 2017). Major units and organizations on Fort Knox are as follows:

- U.S. Army Cadet Command
- U.S. Army Recruiting Command
- U.S. Army Human Resources Command
- 1st U.S. Army Division East
- 1st Sustainment Command (Theater)
- Fort Knox Garrison Command
- Army Medical Command - Ireland Army Health Clinic (IRAHC)
- U.S. Army Marketing and Engagement Brigade
- 4th Cavalry Brigade
- 19th Engineer Battalion
- Mission and Installation Contracting Command

In addition to active duty units, Fort Knox serves as home to the following Army Reserve units and organizations:

- 84th Training Command
- U.S. Army Reserve Aviation Command
- 100th Division
- 8/229th Aviation Battalion
- U.S. Army Reserve Careers Division
- 83rd Army Reserve Readiness Training Center

2.4 TRAINING FACILITIES AND RANGES

Fort Knox encompasses approximately 109,000 total acres of land with 101,353 acres of range, training and maneuver areas, 6,856 acres of cantonment, and 746 acres of recreational area. The TAs are capable of supporting the heaviest equipment in the Army's inventory and executing multiple large scale exercises simultaneously. The range complex provides realistic combat and maneuver training utilizing training sites, live-fire small and large caliber weapons and demolition ranges, collective training facilities, bivouac sites, Forward Operating Bases (FOB) and other special use facilities. Coordination of range use is provided by the Training Division of the Directorate of Plans, Training, Mobilization and Security (DPTMS).

The live-fire training ranges and facilities are located east of the cantonment area, occupying the central portion and eastern half of the installation. The dudded impact area is located in the southeastern portion of the installation in conjunction with several bombing and aerial gunnery ranges.

Tables 2-1 through 2-3 list the available live-fire small and large caliber weapons ranges, demolition ranges, and collective training facilities at Fort Knox. Figure 2-2 illustrates the range, training site, impact and training maneuver area locations.

Table 2-1. Small Arms Live-Fire Ranges

Range	Description
Fraser CPQC Range	Combat Pistol/MP Firearms Qualification Course
Lee Pistol Range	Combat Pistol Range
Tollgate Pistol Range	Combat Pistol/MP Firearms Qualification Course
Morgan AFF Range	Automated Field Fire (AFF) Range
Reiley AFF Range	Automated Field Fire (AFF) Range
Wood Range #1	Automated Record Fire (ARF) Range
Wood Range #2	Automated Record Fire (ARF) Range
Pells ARF Range	Automated Record Fire (ARF) Range
Lee Rifle Range	Basic 10M-25M Firing Range (Zero)
Hooker Mountain 1	Basic 10M-25M Firing Range (Zero)
Hooker Mountain 2	Basic 10M-25M Firing Range (Zero)
Hooker Mountain 3	Basic 10M-25M Firing Range (Zero)
Hooker Mountain 4	Basic 10M-25M Firing Range (Zero)
Hooker Mountain 5	Basic 10M-25M Firing Range (Zero)
Finnegan Range	Basic 10M-25M Firing Range (Zero)
Handiboe Range	Basic 10M-25M Firing Range (Zero)
Clark Range	Basic 10M-25M Firing Range (Zero)
Rice Range	Basic 10M-25M Firing Range (Zero)
Easy Gap Range #1	Basic 10M-25M Firing Range (Zero)
Canby Hill Range	Basic 10M-25M Firing Range (Zero)
Schroeder Range	Field Fire Range Non-automated
Ashley Combat Movement Course	Fire and Movement Range
McKie Range	Fire and Movement Range
George-Blair MRF Range	Modified Record Fire Range
Brown Pistol Range	Non-Standard Small Arms Range
Crane Range	Machine Gun Field Fire Range
Crane Range #2	Non-Standard Small Arms Range
Longstreet Range #1	Machine Gun Field Fire Range
Longstreet Range #2	Machine Gun Transition Range
Scott Mountain Range	Known Distance (KD) Range
Heins QTR	Automated Qualification Training Range
French Range	Skeet Range
Choate Defense Fire Range	Squad Defense Range
Danner Range	Light Anti-Armor (Subcaliber)
Benavidez Range	Infiltration Course
Wilcox Convoy Operations Site	Convoy Live-Fire Range
Easy Gap Range #2	Mine Warfare Area

Table 2-2. Demolition and Large Caliber Live-Fire Ranges

Range	Description
Hackett Range	40mm Grenade Qualification Range
FBI Range	40mm Grenade Qualification Range
Flat Lick Bombing Range	Aerial Bombing Range
Snellen Aerial Gunnery Range	Aerial Gunnery Range
Rolling Fork Aerial Gunnery Range	Aerial Gunnery Range
Arnold Bottoms Aerial Gunnery Range	Aerial Gunnery Range
Flat Lick Aerial Gunnery Range	Aerial Gunnery Range
Hays Flats Aerial Gunnery Range	Aerial Gunnery Range
Miller Range	Grenade Launcher Range
Mill Creek M203 Range	Grenade Launcher Range
Christensen Hand Accuracy Course	Hand Grenade
Christensen Hand Grenade Range	Hand Grenade
Christensen Hand Qualification Range	Hand Grenade
Porter River Road Quarry Demolition	Light Demolition Range
Mill Creek Demolitions Range	Light Demolition Range
House Range	Light Demolition Range
Crumb Range	Light Demolition Range
Rodgers Hollow Demolitions Range	Heavy Demolition Range
Raridan Hollow Demolitions Range	Heavy Demolition Range
Mendick Range	Tank/Fighting Vehicle Scaled Gunnery Range
Wilson Range	Tank/Fighting Vehicle Scaled Gunnery Range
McFarland-Oliver Tank Range	Tank/Fighting Vehicle Stationary Gunnery Range
Donnelly Range	Tank/Fighting Vehicle Stationary Gunnery Range
Boydston Range	Tank/Fighting Vehicle Stationary Gunnery Range
Steeles Tank Range	Tank/Fighting Vehicle Stationary Gunnery Range
Brumfield Range	Field Artillery Indirect Range
Ames (Firing Point)	Multiple Launch Rocket System Range
Yano MPRC	Multi-Purpose Range Complex
Baum Tank Range	Multi-Purpose Training Range
Cedar Creek IPBC	Multi-Purpose Training Range
St. Vith MPTR	Multi-Purpose Training Range
Wilcox DMPTR	Digital Multi-Purpose Training Range
Kennedy ISBC	Stationary Gunnery Range
Garvin Range	Anti-Armor Tracking
TOW Familiarization Fire Range	Anti-Armor Tracking
TOW Dragon	Anti-Armor Tracking
Mill Creek Claymore	Mine Warfare Area

Table 2-3. Collective Training Facilities

Facility	Description
Zussman MOUT	Military Operations in Urban Terrain (MOUT)
Anaconda Village	Military Operations in Urban Terrain (MOUT)
Red Wing Village	Military Operations in Urban Terrain (MOUT)
Burcham UAC Range	Urban Assault Course
Salt River South	Non-Standard Small Arms / IED Lane
Salt River North	Non-Standard Small Arms / IED Lane
Andrews Shoothouse	Live-Fire Exercise Shoothouse

Fort Knox has one major airfield; the Godman Army Airfield (GAAF), located in the northwest corner of the cantonment area, just inside highway 31West. The airfield is utilized by a mix of rotary-wing and fixed-wing aircraft from Active Army, Air National Guard, Army National Guard and the U.S. Marine Corps units. The local airspace is managed by the Fort Knox Air Traffic and Airspace (AT&A) Officer.

Fort Knox contains six authorized Drop Zones (DZs):

- ROSZOV DZ
- Zoomer DZ
- Matero Circular DZ
- Tracy Circular DZ
- Atcher DZ
- Medley DZ

The drop zones are utilized for both parachute personnel and equipment drops, including static-line and High Altitude Low Opening operations.

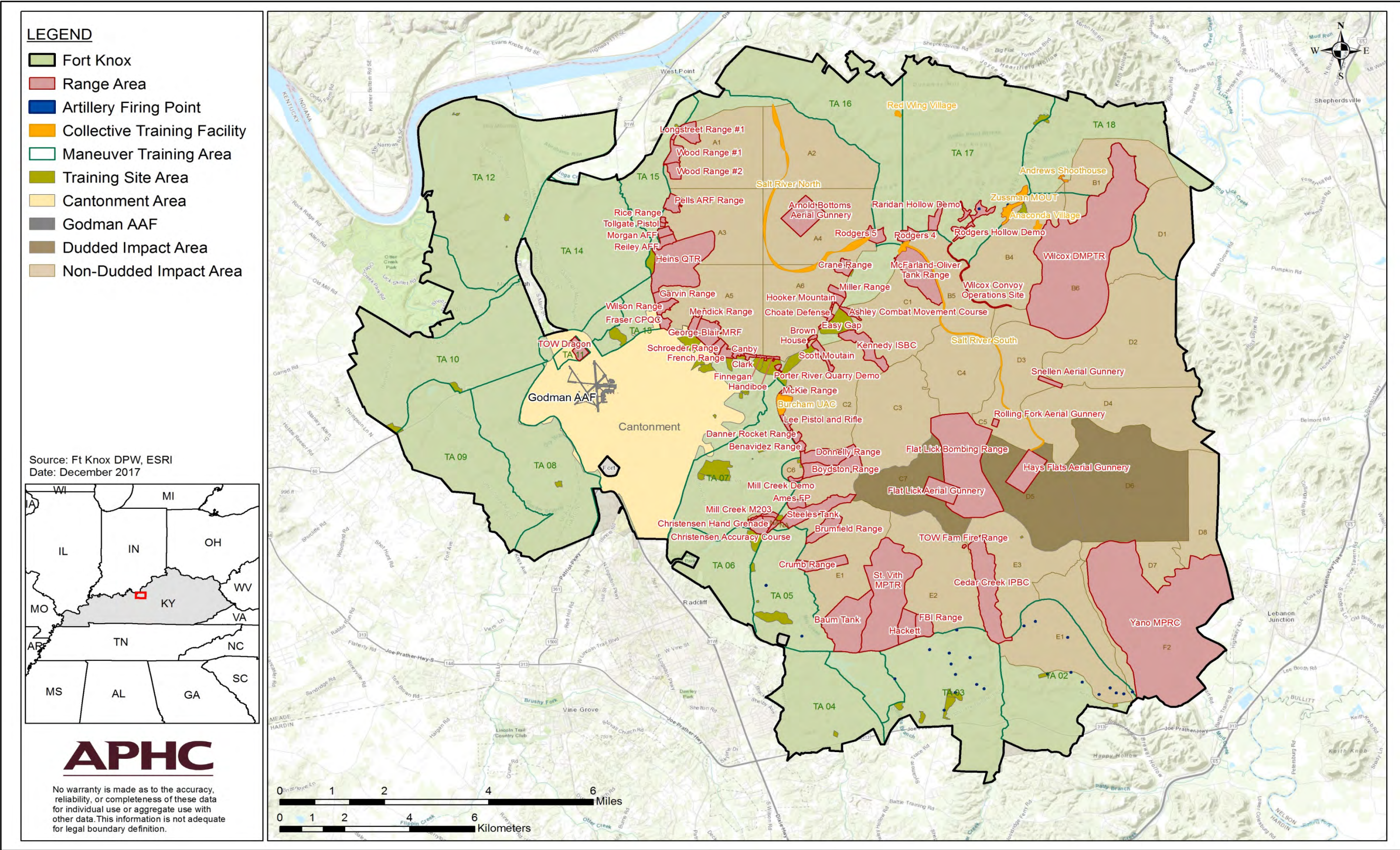


Figure 2-2. Range, Training Facility, Impact and Maneuver Area Locations

2.5 LOCAL COMMUNITIES

The largest urban centers surrounding Fort Knox include the incorporated cities of Radcliff, just outside the cantonment along the southwest boundary in Hardin County, and Shepherdsville to the northeast in Bullitt County. The smaller communities of West Point and Lebanon Junction are adjacent to the north and southeast boundary respectively. Elizabethtown, the Hardin County seat, is located approximately eighteen miles from the Fort Knox cantonment (eight miles from the Fort's southern boundary). County lands outside these urban areas are predominately rural in nature, consisting of forest and agriculture lands. Larger scale development is primarily contained to the Interstate 65 and US 31 corridors running east and west of the Fort; however, individual and some small clusters of residential homes are dispersed throughout the private lands in the areas just beyond the boundary.

Although population growth has slowed considerably from the previous decade (2000-2010), as seen in Table 2-4, positive growth since 2010 has continued to be the trend in the majority of the areas outside of Fort Knox. Bullitt County, along with the City of Shepherdsville, have seen the largest growth 6.5% and 7.6% respectively. Hardin County to the south has had more modest growth in this period (1.6%), however the cities of Radcliff (3.7%) and Elizabethtown (4.8%) have continued to outpace the State average (2.2%). By contrast, Meade County experienced negative growth in this same time period.

Table 2-4. Population Surrounding Fort Knox

	2000	2010	2016 (Est)
Radcliff	21,961	21,688	22,491
Shepherdsville	8,334	11,222	12,082
Elizabethtown	22,542	28,531	29,906
Meade County	26,349	28,602	28,126
Bullitt County	61,236	74,319	79,151
Hardin County	94,174	105,543	107,316
Kentucky	4,041,769	4,339,367	4,436,974

Source: U.S. Census Bureau (www.census.gov)

Figure 2-3 illustrates the population distribution in the local region surrounding Fort Knox. The highest population densities occur northeast in Shepherdsville and south-southwest from Radcliff to Elizabethtown.

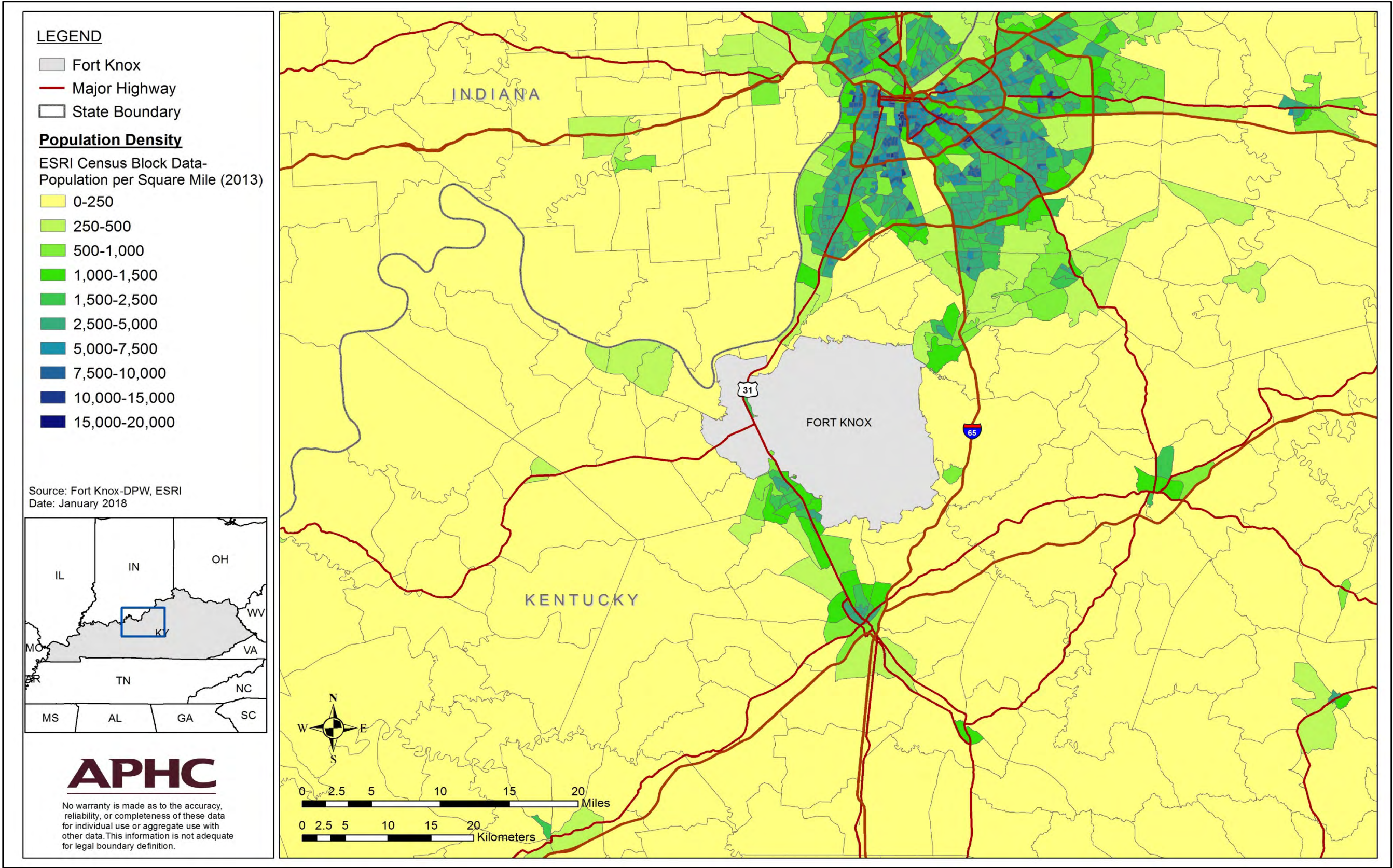


Figure 2-3. Population Density (2013) Surrounding Fort Knox

2.6 FORT KNOX COMMUNITY

The cantonment area on Fort Knox totals 6,856 acres, and contains soldier and family housing areas, office and administrative buildings, public works facilities and utilities, four separate schools, Child Development Centers (CDC), community facilities, outdoor recreation and green spaces, and GAAF, as well as a variety of other facilities typically found in any small municipality. The daily population of Fort Knox (Table 2-5) including those working and/or living on-post, equals or exceeds any other local municipality in the region. This total does not include the roughly 45,000 annual transient students and trainees at Fort Knox each year. In addition, Fort Knox also supports an estimated 57,000 active and reserve military retirees and their dependents within a forty-mile radius of the installation.

Table 2-5. Fort Knox Daytime Population

Daytime Population	Total
Active duty military	6,500
Active duty military dependents	4,500
Reserve component military	2,000
DoD civilian employees, contractors, and other personnel	10,250
Total	23,250

Source: Fort Knox Facts 2017

2.7 ECONOMIC IMPACT

Fort Knox generates substantial revenues to local economies through military and civilian wages, equipment rentals, utilities, supplies, construction contractor payments and other prime contract awards. Installation expenditures in 2017 totaled \$2.6 billion dollars, with \$750 million dollars in annual payroll (military and DoD civilian employees). As one of the region's largest employers, Fort Knox is responsible either directly or indirectly for 27,600 jobs.

In addition to annual operating costs, Fort Knox attracts visitors throughout the year for business, research, industry, and tours. Graduation and commencement ceremonies for Cadets each year bring visitors, many of whom travel from out-of-state, creating an inflow of economic activity into the state and the surrounding region each year.

3 NOISE ASSESSMENT GUIDELINES

The APHC recommends land use options based on the type of noise source. Table 3-1 lists the noise limits as shown in Army Regulation (AR) 200-1. Tables B-1 through B-3 (Appendix B) contain detailed land use recommendations for each noise source.

Table 3-1. Noise Limits for Noise Zones

Noise Zone	Noise Limits			Noise-Sensitive Land Use
	Aviation ADNL (dB)	Impulsive CDNL (dB)	Small Arms dBP	
LUPZ	60 – 65	57 – 62	n/a	Generally Compatible
I	< 65	< 62	< 87	Generally Compatible
II	65 – 75	62 – 70	87 – 104	Generally Not Compatible
III	> 75	> 70	> 104	Not Compatible

Source: AR 200-1

Notes: dB = decibel, ADNL = A-weighted Day-Night Level, CDNL = C-weighted Day-Night Level, P = Peak

There are often existing “noise-sensitive” land uses defined as non-conforming within a Noise Zone. In most cases this is not a risk to community quality of life or mission sustainment. Average noise levels may be the best tool for long-term land use planning, but they may not adequately assess the probability of community annoyance. As recommended in AR 200-1, this assessment includes supplemental metrics to identify where noise from aviation overflights, demolition activity, and large caliber weapons may periodically reach levels high enough to generate complaints. In many instances Noise Zones will indicate land use compatibility; however, noise complaints from impulsive noise, often referred to as blast noise, typically are attributable to a specific event rather than annual average noise levels. Peak levels are useful for estimating the risk of receiving a noise complaint from blast noise, as they correlate with the receiver’s perception of noise levels. Table 3-2 lists the Army’s Complaint Risk Guidelines.

Table 3-2. Complaint Risk Guidelines

Perceptibility	dBP	Risk of Receiving Noise Complaints
May be Audible	< 115	Low
Noticeable, Distinct	115 - 130	Moderate
Very Loud, May Startle	> 130	High
*Perceptibility is subjective. The classifications are based on how a typical person might describe the event.		

- People in an area experiencing peak sound pressure levels between 115 and 130 dB may describe events as noticeable and distinct. From within this area, the installation has a moderate risk of receiving noise complaints. The magnitude of the complaint risk is dependent upon frequency of occurrence in addition to factors such as time of day activity occurs, propagation conditions under which activity takes place, and noise sensitivity of individuals in these areas.
- Peak sound pressure levels above 130 dB are generally objectionable, and are often described as very loud and startling. These levels correlate with a high risk of noise complaints.
- If the operations which generate high peak sound pressure levels in the community are very infrequent, land use controls may not be warranted. However, prior public notification is important for mitigating complaint risk, and also an important role of being good neighbors.
- Peak sound pressure levels directly correlate with airborne vibration which is the dominant cause of structural response from military training. Peak sound pressure levels above 120 dB may rattle windows or loose ornaments (e.g. pictures on walls) and annoy occupants but will not cause structural damage. It is widely recognized that structural damage is improbable when peak sound pressure levels do not exceed 140 dB.

Peak levels can vary significantly for the same activity dependent on weather conditions. Thus, the supplemental Peak noise contours modeled in this ICUZ study have the following weather conditions applied:

- Unfavorable Weather Conditions: PK15(met) is the Peak sound level, factoring in statistical variations caused by weather, that are likely to be exceeded only 15 percent of the time (i.e., 85 percent certainty that sound will be within this range). This “85 percent solution” gives the installation and the community a means to consider the areas that at times may be impacted by training noise. PK15(met) levels would occur under unfavorable weather conditions that enhance sound propagation.
- Neutral Weather Conditions: PK50(met) is the Peak sound level that is likely to be exceeded 50 percent of the time (i.e., 50 percent certainty that sound will be within this range). These levels would be seen during neutral weather conditions. It should be noted that if activities take place under favorable weather conditions, such as the wind blowing away from the receiver, noise levels would be lower.

The unfavorable weather conditions PK15(met) metric is a good tool to indicate areas that may periodically be exposed to high noise levels. When land use planning programs such as real estate disclosure, a Joint Land Use Study or the Army Compatible Use Buffer are implemented, the PK15(met) complaint risk areas can and should be used to delineate areas of focus. However, since the complaint risk areas are based on single event levels and are not dependent on the number of events, planners should also consider frequency of operations when making land use decisions.

4 RANGE NOISE ASSESSMENT

4.1 SMALL ARMS NOISE

The small arms designation includes weapons of .50 caliber or less. The weapons utilized in the range complex at Fort Knox include a multitude of rifles, machine guns, pistols, and shotguns with various ammunition. Small arms noise within the ICUZ is divided into subsections based on the type of range facility:

- Small Arms Range - a defined area or range with fixed firing points and/or targets.
- Non-fixed Firing Point – range/area/facility with non-fixed firing points and/or targets.

The SARNAM model was used to calculate and plot the peak noise levels based on the loudest weapon at each small arms range from the operations data described in Appendix C. To generate noise contours using SARNAM, specific firing point and target point locations must be entered into the program. Therefore, ranges without set firing points or target point locations such as firing at collective training facilities and urban terrain facilities are addressed via predicted peak noise levels.

4.1.1 SMALL ARMS NOISE ZONES

The small arms ranges at Fort Knox are heavily utilized and are operational year round. Based on range records for fiscal years (FY) 2016 and 2017, small arms ammunition expenditures at Fort Knox average nearly nine million rounds per year. The Noise Zones for small arms firing activity are illustrated in Figure 4-1. These Noise Zones represent a maximum small arms training scenario (all ranges actively firing) for live-fire ammunition operations. As previously mentioned, there is no assessment period with the Peak noise metric. Thus, only Noise Zones II and III are depicted in the map figures (Note: Zone I includes all areas outside the Zone II noise limit of 87 dBP).

Although large in size, the Noise Zones from small arms firing are primarily contained to the range and impact areas. Zone II extends beyond the boundary in four separate areas; one area north approximately 680 meters (m), just inside Highway 31; two areas northeast approximately 243 m and 375 m and one larger area south-southeast which extends approximately 600 m. Zone III is entirely contained within the installation boundary. On post, Zone II extends into the northeast corner of the cantonment approximately 681 m. Zone III extends into the cantonment in several small areas which are directly adjacent to ranges areas. Table 4-1 lists the acreages for each Noise Zone.

Table 4-1. Small Arms Noise Zones Acreage

Noise Zone	Noise Zone Acreage		
	Total	On Post (Cantonment)	Off Post
Zone II	49,074	383	1,820
Zone III	7,819	32	0

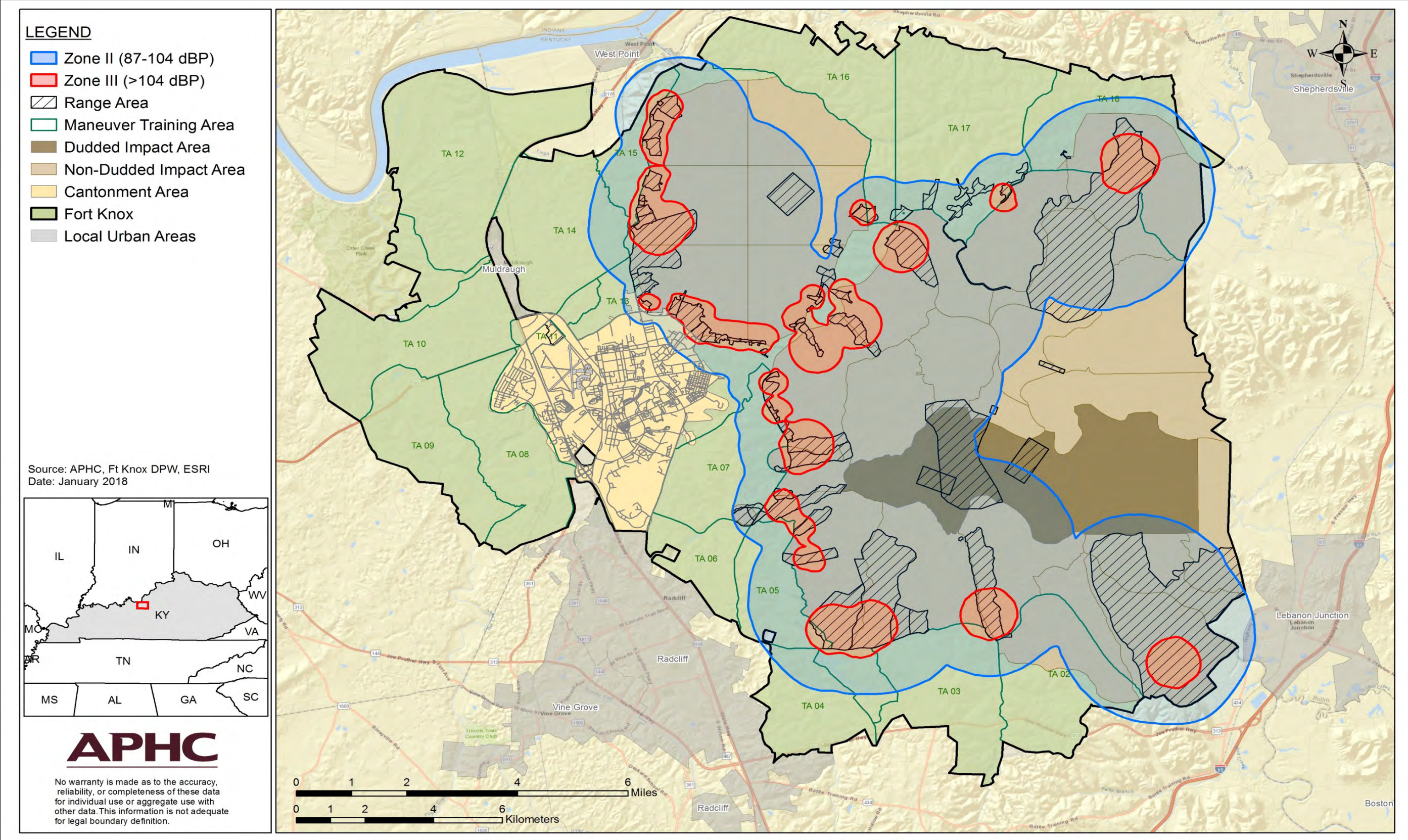


Figure 4-1. Small Arms Noise Zones

The Zone II areas off post consist primarily of mixed forest lands, wetlands, pasture and grasslands and agricultural uses. Individual homes are scattered through these areas, although development in general is limited. The largest concentration of noise-sensitive land uses occurs in the area south and east of the Yano Multi-Purpose Range Complex (MPRC), where Zone II encompasses the western edge of the City of Lebanon Junction and some unincorporated areas of Bullitt and Hardin Counties. Population density within the county areas is low. Figure 4-2 illustrates the Zone II off post in this area. Current zoning in these areas is primarily residential; however, development within the counties is discouraged and any new development is generally restricted to single-family dwellings with large (10 acre) lot sizes, keeping population density as low as possible.

Land uses within the Noise Zones on post are mostly compatible. Zone III contains motor pool facilities and parking lots. A small portion of the Zone II does contain some enlisted barracks.

Table 4-3 lists the daytime and nighttime ambient population exposure within the Noise Zones area off post and within the cantonment based on an analysis using the LandScan™ dataset. As expected, population exposure is relatively low, both on and off post, particularly during day time hours when the majority of small arms firing takes places.

Table 4-2. Population Exposure in Small Arms Noise Zones

Population	Noise Zone	
	Zone II	Zone III
Off Post		
Daytime	48	0
Nighttime	54	0
On Post (Cantonment Area)		
Daytime	32	0
Nighttime	144	0

Note: Land Analysis Ambient Population Exposure: The LandScan™ ambient population estimates used in this plan are based on the 2013 annual mid-year national population estimates from the Geographic Studies Branch, U.S. Bureau of Census.¹ The daytime and nighttime LandScan™ data were derived based on the habits and movements of people over a day. Whereas a national census only measures the population based on residences, the LandScan™ dataset measures areas where people tend to be during a typical day. Nighttime estimates are representative of residential figures.

¹ This product was made utilizing the LandScan (2012)™ High Resolution global Population Data Set copyrighted by UT-Battelle, LLC, operator of Oak Ridge National Laboratory under Contract No. DE-AC05-00OR22725 with the United States Department of Energy. The United States Government has certain rights in this Data Set.

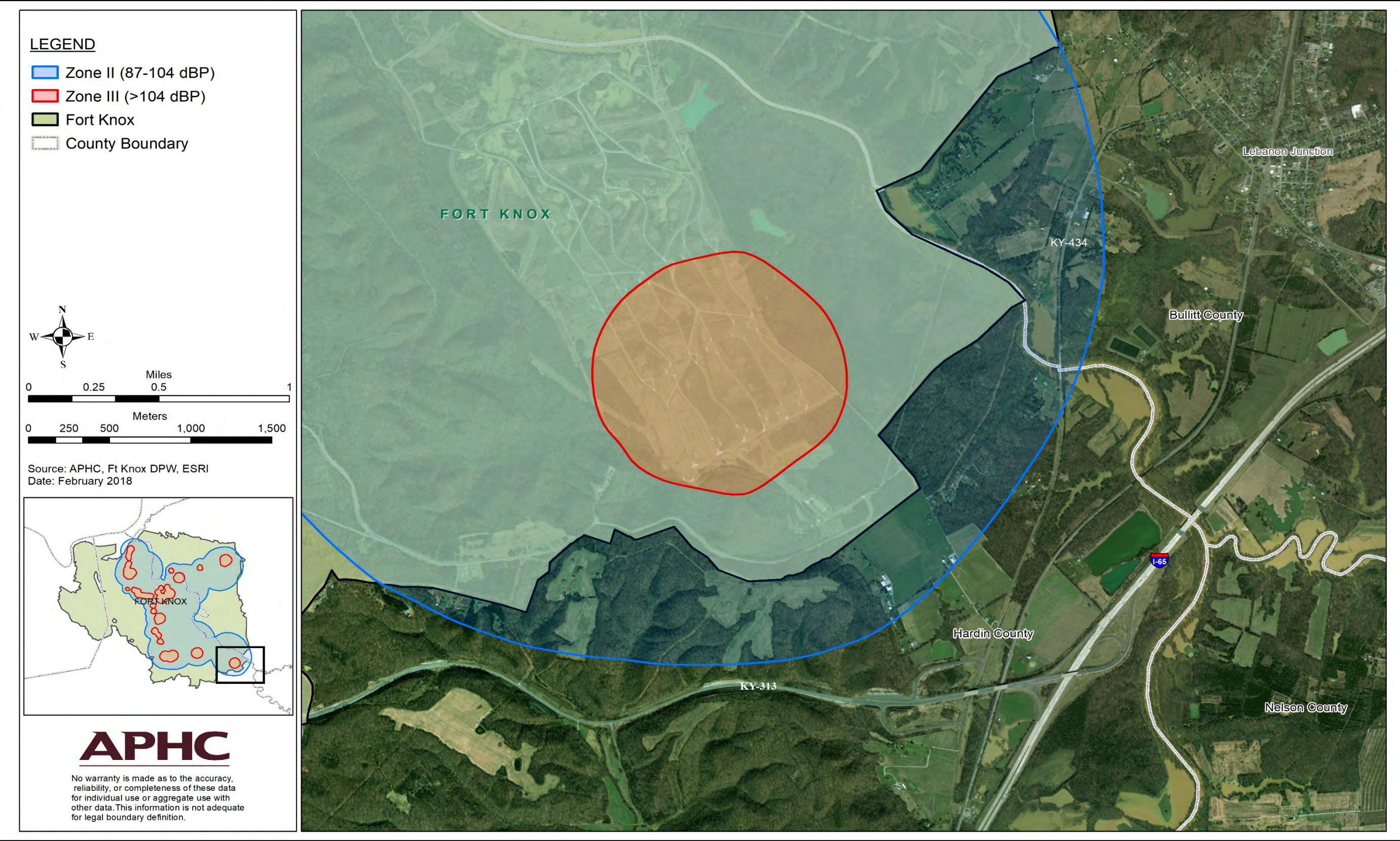


Figure 4-2. Small Arms Zone II Off Post

4.1.2 NON-FIXED FIRING POINT AREAS

Units at Fort Knox conduct training at multiple collective training and training site facilities as well as within the maneuver TAs using blank ammunition and/or simunitions. These activities produce training which replicates real-world environments and scenarios. With the absence of specific firing and target point locations, noise contours for these activities cannot be modeled. However, by looking at known predicted peak levels, we can attempt to assess noise exposure from these training activities.

Tables 4-3 through 4-5 list the predicted peak levels for commonly used rifle and machine gun blank ammunition on Fort Knox. In each column, the upper limit levels would occur under weather conditions that enhance sound propagation (unfavorable), such as the wind blowing toward the receiver. The lower limit levels occur under favorable weather conditions, such as the wind blowing away from the receiver. The azimuth angle can be defined as the direction of fire, i.e. 0 degrees is directly in front of the weapon and 180 degrees is directly behind the weapon.

When combining these variables, the highest peak levels occur when rounds are fired in the direction of the receiver (0 degree azimuth) and under unfavorable weather conditions. As an example, Table 4-3 indicates that under unfavorable weather conditions, a Zone II noise level [87 dBP] extends approximately 200 m for the 5.56 mm blank round at all three given azimuth angles.

Table 4-3. Predicted Peak Levels for 5.56 mm Blank Round

	Predicted Level, dBP Azimuth		
Distance, meters	0°	90°	180°
100	87-97	86-96	87-97
200	80-90	79-89	80-90
400	69-79	68-78	69-79

Note: the 0° is directly in front of the weapon and the 180° azimuth is directly behind the weapon.
Blank is defined as any round that contains propellant but no bullet.

Table 4-4. Predicted Peak for 7.62 mm Blank Round

	Predicted Level, dBP Azimuth		
Distance, meters	0°	90°	180°
100	109-119	106-116	101-111
200	103-113	100-110	94-104
400	92-102	89-99	85-95
800	84-94	81-91	77-87

Note: the 0° is directly in front of the weapon and the 180° azimuth is directly behind the weapon.
Blank is defined as any round that contains propellant but no bullet.

Table 4-5. Predicted Peak for .50 Caliber Blank Round

Distance, meters	Predicted Level, dBP Azimuth		
	0°	90°	180°
100	116-126	110-120	111-121
200	109-119	103-113	104-114
400	97-107	92-102	91-101
800	89-99	84-94	84-94
1200	84-94	79-89	84-94
1600	81-91	75-85	75-85

Note: the 0° is directly in front of the weapon and the 180° azimuth is directly behind the weapon.

Blank is defined as any round that contains propellant but no bullet.

Based on current range records, blank ammunition expenditures average over 1.1 million rounds per year at Fort Knox, with 5.56 mm ammunition accounting for nearly 60 percent (705,243) of the total. Louder machine guns firing 7.62mm and .50 caliber ammunitions, account for 30 percent and 10 percent respectively.

Given several factors, including the interior locations of most training sites and the type of ammunition being fired, the distances listed in the tables indicate that noise impacts beyond the boundary from training with blank ammunition are minimal. This also applies to sensitive land uses contained within the cantonment area. On occasion, training maneuver areas located along the western boundary (TA-9, TA-10 and TA-12) are used for M2 machine gun (.50 Cal) training. These activities could produce Zone II noise levels beyond the boundary, depending upon the actual firing location within the TA.

4.2 LARGE CALIBER AND DEMOLITION NOISE

The large caliber designation includes weapons 20 mm or greater and any weapon that contains explosive charges. This designation also includes all demolition charges. At Fort Knox, training is conducted with a multitude of large caliber weapons including artillery, mortars, aerial gunnery, grenades, and explosive demolition charges. Training operations at Fort Knox occur all year round.

In addition to the firing points and ranges assessed in the Noise Zones, training at Fort Knox also includes utilization of simulators (pyrotechnic and non-pyrotechnic). Simulators are used to provide soldiers with the most realistic training experience possible while keeping soldier safety a priority. Simulator noise levels are much lower than noise levels generated by the munitions they replicate. Simulators are not included in the Noise Zones and are addressed separately via peak noise levels in Section 4.2.2.1.

4.2.1 LARGE CALIBER AND DEMOLITION NOISE ZONES

Figure 4-3 depicts the CDNL Noise Zones for large caliber and demolition operations at Fort Knox. Appendix C lists the large caliber ammunition and explosive detonations expenditures by range and type used to produce the Noise Zones. Range records from FY2016 and FY2017 were averaged to provide a representative sample of training operations at the Fort.

The LUPZ extends beyond the installation boundary east up to 1.2 kilometers (km) (0.7 miles) and southeast approximately 1 km (0.6 miles). Zone II extends beyond the boundary in similar fashion southeast up to 420 m. Zone III extends in two small areas south less than 150 m. On post, the Noise Zones do not enter the cantonment area or affect any noise-sensitive land use. Table 4-6 lists the total and off post acreages for the CDNL Noise Zones.

Table 4-6. Large Caliber and Demolition Noise Zones Acreage

Noise Zone	Noise Zone Acreage	
	Total	Off Post
LUPZ	17,085	2,337
Zone II	19,815	620
Zone III	14,535	7

The Noise Zones extending off post, particularly Zones II and III are concentrated just outside the Yano MPRC, which is used for a number of different large caliber weapons and demolition operations. Land uses beyond the Fort boundary in this area consist of mixed forest lands, wetlands, pasture and grasslands and agricultural uses. As seen in Figure 4-4, population density within the Zones II and III is very low. The zoning in these areas is primarily residential; however, through cooperative planning measures, including the Kentucky 313 Corridor initiative, any new noise-sensitive development is restricted. The LUPZ stretching north into the unincorporated portion of Bullitt County contains the highest concentration of noise-sensitive land use. It is important to remember that the LUPZ is compatible with residential land use; however, the LUPZ is intended as an additional buffer to be used by land use planners to make decisions which will ultimately reduce conflicts due to installation noise producing activities.

Table 4-9 lists the daytime and nighttime ambient population exposure (LandScan™) totals within the CDNL Noise Zones off post. As evidenced in the Table, the population exposure within the LUPZ is highest, particularly at night which is a more representative measure of residential use. Exposure in Zones II and III is low.

Table 4-7. Population Exposure Off Post in CDNL Noise Zones

Population Off Post	Noise Zone		
	LUPZ	Zone II	Zone III
Daytime	80	1	0
Nighttime	303	44	0

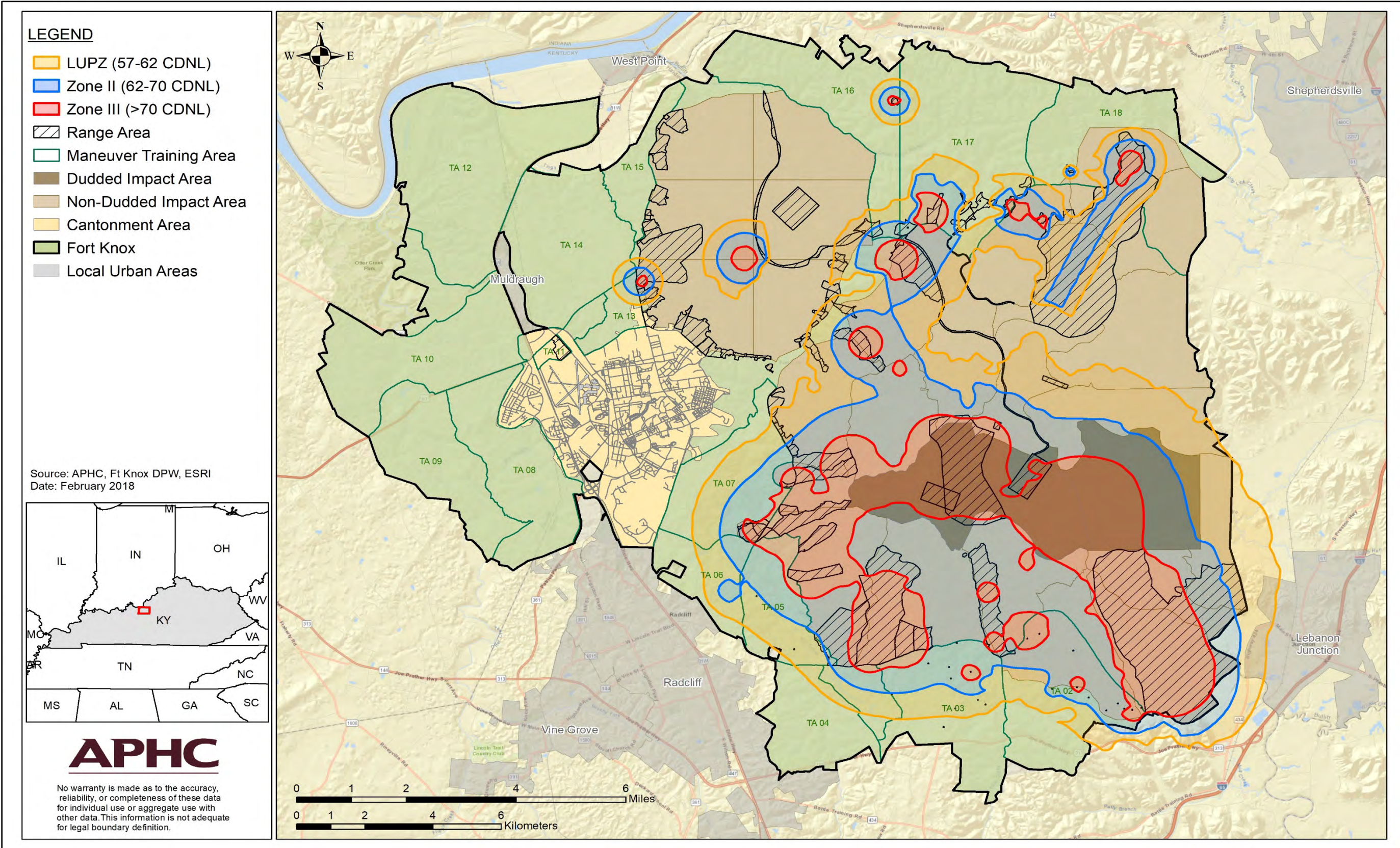


Figure 4-3. Large Caliber and Demolition Operations CDNL Noise Zones

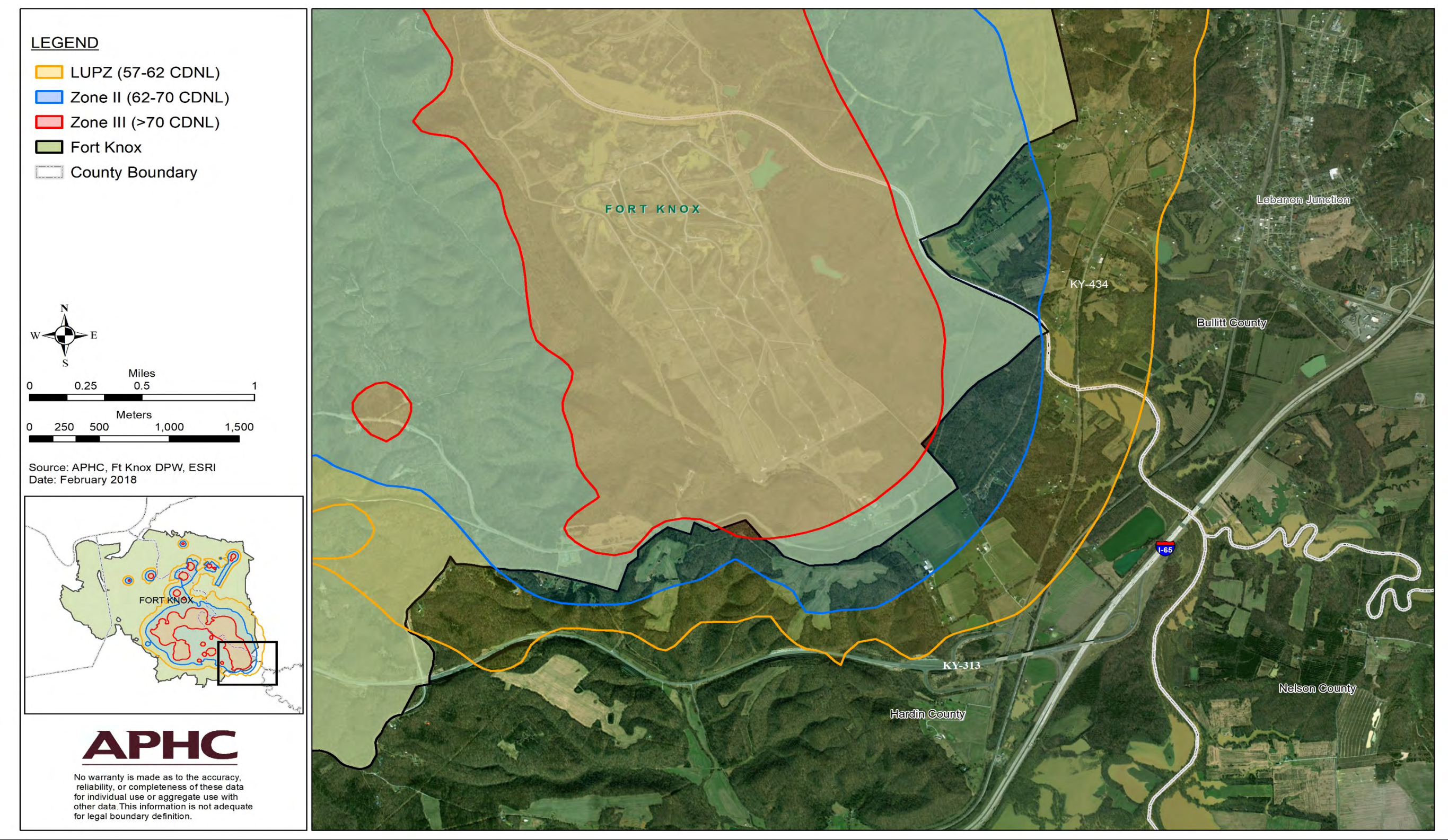


Figure 4-4. Large Caliber and Demolition CDNL Noise Zones II and III Off Post

4.2.2 LARGE CALIBER AND DEMOLITION SINGLE EVENT PEAK LEVELS

Annual average noise levels are the most suitable for long-term land use planning. However, individual training events can be audible outside of a Noise Zone and in some cases objectionable to the surrounding community. Using Peak level assessments can forecast where sound may be loud from singular events. Table 3-2 (Section 3) listed the perceptibility of Peak noise levels. It is worth noting that vibration that often accompanies low-frequency noise from large caliber weapons and demolitions is almost always air-borne (not ground-borne). Neighbors located in the “loud” area on the map may occasionally notice picture or window rattling from air-borne vibration; however, this rattling does not indicate damage, and usually occurs at levels well below those required to cause structural damage (>140 dBP).

Figures 4-6 and 4-7 depict the single event Peak sound level contours for large caliber weapons operations using different weather conditions. Figure 4-6 illustrates unfavorable weather conditions that enhance sound propagation and Figure 4-7 illustrates neutral weather or favorable propagation conditions. Both weather scenarios are provided to demonstrate the influence of meteorological conditions on noise propagation. The same range records (Appendix C) used to produce the CDNL Noise Zones were used to create the Peak noise contours.

Based on the range operations data, one of the single loudest training events on Fort Knox is the detonation of a Mine-Clearing Line Charge or MICLIC. Annual live-fire MICLIC operations average 4 to 6 total shots per year (2016-2017). Due to the relative infrequency of MICLIC operations and the large noise dose it will produce, it was not included in the combined range single event Peak level contours in Figures 4-6 and 4-7. Although the single event contours characterize a “maximum” training scenario (all weapons firing at once), they are intended to represent typical day-to-day training on Fort Knox. Therefore, single event live-fire MICLIC detonations are presented separately. It should be noted that MICLIC operations were included in the cumulative CDNL Noise Zones.

Unfavorable Weather – PK15(met)

Under unfavorable weather, peak sound levels between 115 and 130 dB extend beyond the Fort Knox boundary to the southwest approximately 4.2 km (2.6 miles), enveloping Radcliff and part of Vine Grove; north approximately 2.6 km (miles) into areas of Bullitt County; south 3.7 km (2.2 miles) into Hardin County; and east as far as 4.7 km (2.9 miles). The area east encompasses a large portion of Lebanon Junction, a small portion of Shepherdsville and unincorporated lands in Bullitt County.

The largest concentration of sensitive land use within the contour occurs in the city limits of Radcliff and Lebanon Junction. County areas have much lower population densities; however, due to the size of the contour off post (~33,000 acres), small clusters of residential development are common throughout. This is particularly true along the Highway 313 (south), Highway 44 (north), and Pitts Point Road just west of Shepherdsville.

On post, the 115-130 dBP noise contour encompasses the majority of the cantonment, with the exception of the northwest corner and the City of Muldraugh. Noise-sensitive land uses include family and soldier housing, several schools and the IRAHC.

Peak sound levels above 130 dB extend beyond the boundary in two small areas north and northeast less than 200 m; one small area west, less than 50 m; and to the south in two separate areas, one approximately 290 m and the other as far as 1.2 km (0.7 miles). This greater extension south is attributable to firing at the Yano MPRC and several artillery firing points along the south boundary. Multiple homes adjacent to the installation boundary are located within the 130 dB contour.

On post, peak sound levels above 130 dB extend into the northern tip of the cantonment area from activities at the Heins range. There are no noise-sensitive land uses contained within the contour.

Neutral Weather – PK50(met)

Under neutral weather conditions, noise impacts beyond the installation boundary are greatly reduced. Noise levels between 115 and 130 dB extend beyond the boundary in similar fashion to the unfavorable weather scenario (north-northeast, southwest and south-southeast); however, the contour shows considerable contraction. Noise-sensitive land uses are contained within several of these areas beyond the boundary; although, the largest impact on noise-sensitive land use shifts from the City of Radcliff in the southwest, to the areas geographically southeast of the Fort. The 115-130 dB contour extends approximately 1.8 km (1.1 miles) beyond the boundary southeast, comprising the western edge of Lebanon Junction and portions of Bullitt and Hardin Counties.

On post, sound levels between 115 and 130 dB extend into the northeast portion of the cantonment, but remain north of the Disney Barracks area. There are no noise-sensitive land uses in the contour.

Peak sound levels above 130 dB extend beyond the installation boundary in one small area south of the Yano MPRC approximately 375 m. There are no sensitive land uses within this area. The 130 dB contours on post are contained to range, training site and maneuver areas, and do not extend into the cantonment area.

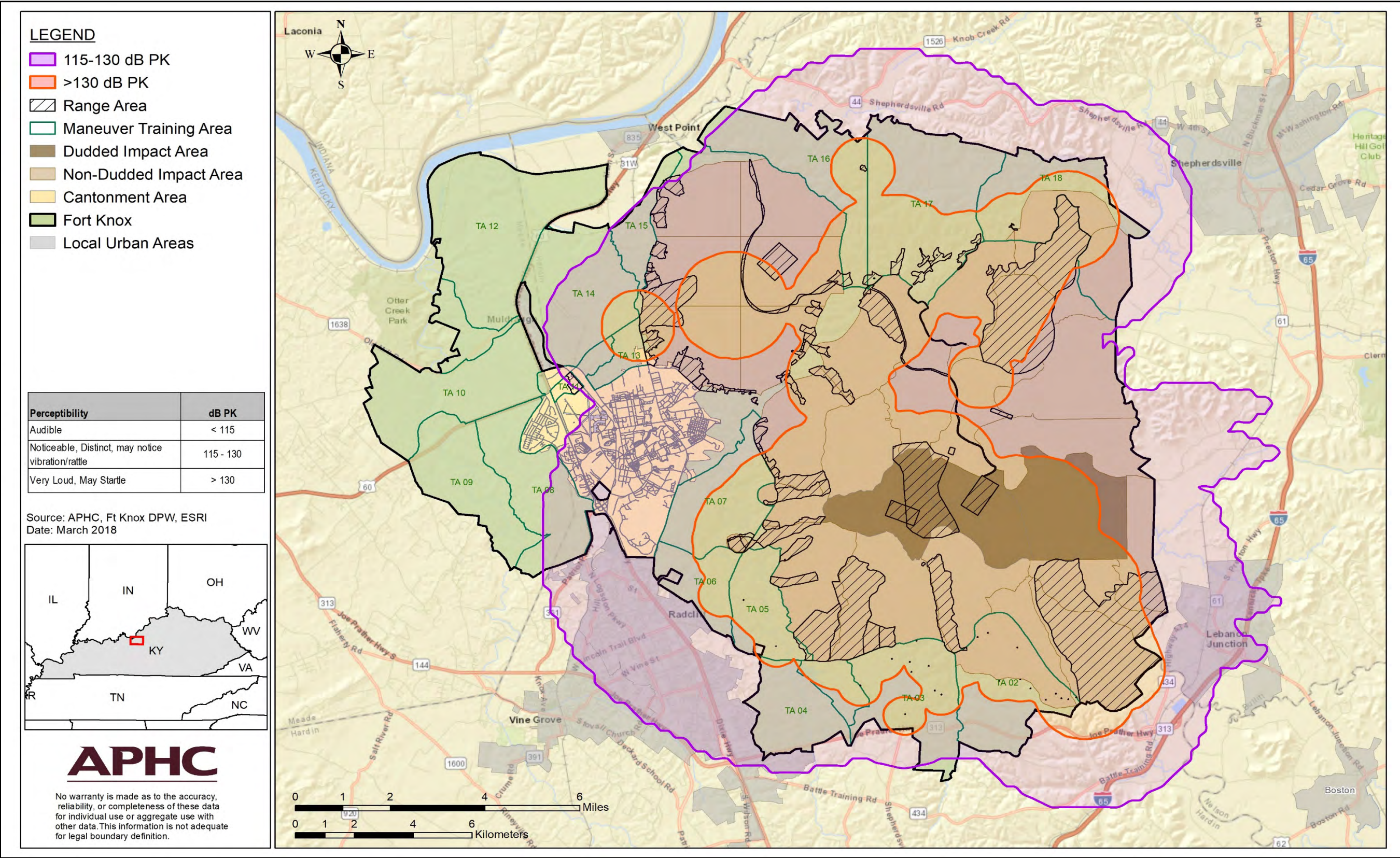


Figure 4-5. Large Caliber and Demolition Operations Unfavorable Weather Conditions PK15(met) Sound Levels

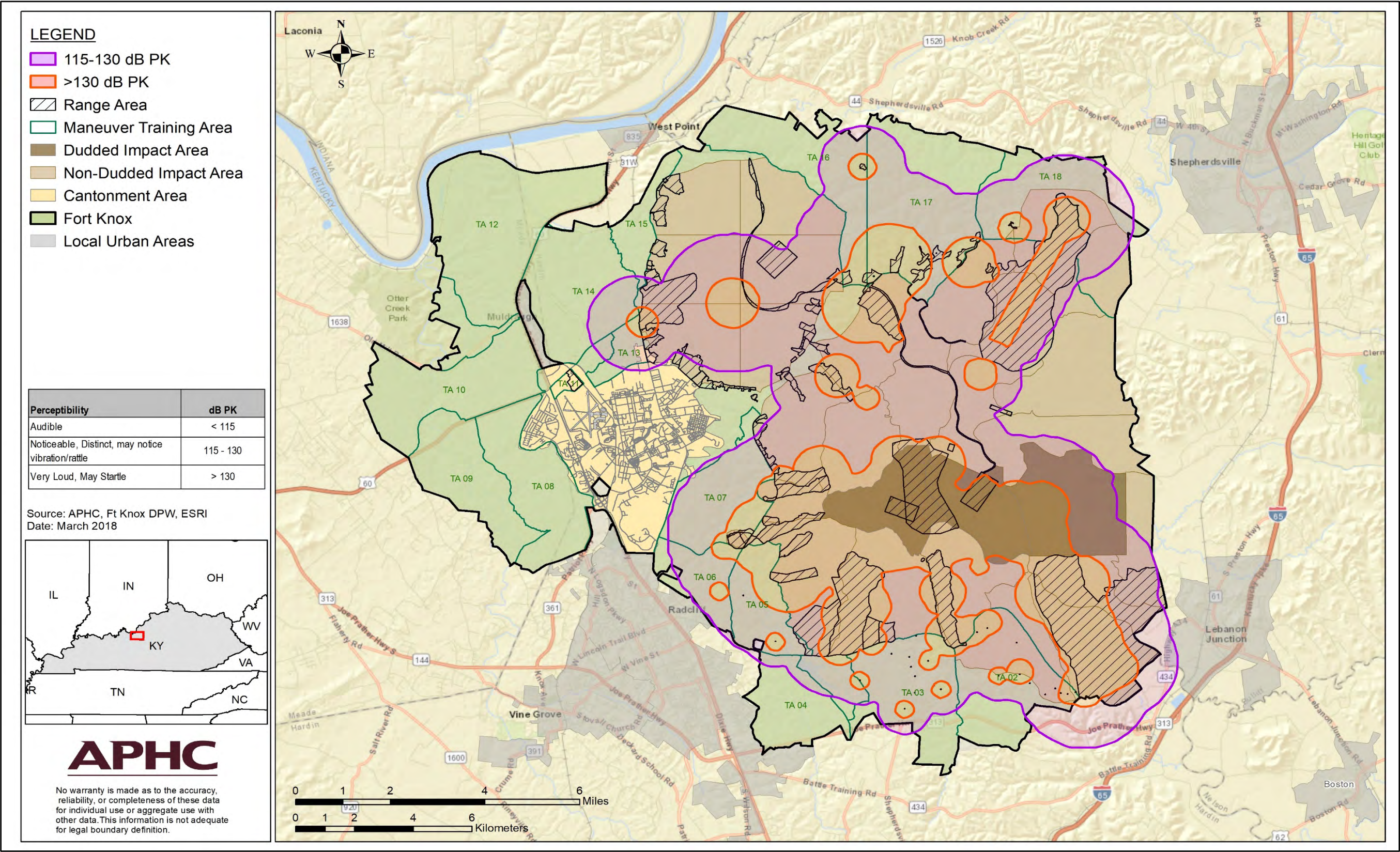


Figure 4-6. Large Caliber and Demolition Operations Neutral Weather Conditions PK50(met) Sound Levels

Mine Clearing Line Charge (MICLIC)

A MICLIC is a rocket-projected explosive line charge which provides a “close-in” breaching capability for maneuver forces. The MICLIC system consists of an M353, 3-1/2 ton or M200A1 2-1/2 ton trailer (or M200 tracked trailer) chassis, a launcher assembly, an M147 firing kit, an M58A3 line charge and a 5-inch MK22 Mod 4 rocket. The line charge is 350 feet long and contains 5 pounds per linear foot (~1750 lbs.) of composition C-4 explosive. It is effective against conventionally fused mines and, when detonated, it provides a lane 8 meters wide by 100 meters long.

Live MICLIC operations take place at the St. Vith, McFarland-Oliver and Steeles ranges. MICLIC training is primarily performed by the 19th Engineer Battalion, stationed on Fort Knox; however, visiting units from the Marines and National Guard also detonate high explosive MICLICs on the Fort.

Individual Peak noise contours were modeled for each range location. The same meteorological conditions (unfavorable versus neutral weather) are applied. The unfavorable versus neutral weather conditions are presented side by side at each range location to further show the influence of weather on propagation and the variance it can produce from the same activity.

Figure 4-7 illustrates the single event Peak levels for a MICLIC detonation at Steeles range. Under unfavorable weather, peak sound levels between 115 and 130 dB extend beyond the Fort Knox boundary southwest up to 9.6 km (5.9 miles), just inside Rineyville Road. This area encompasses portions of Hardin and Meade Counties, including the cities of Radcliff, Vine Grove and Muldraugh, as well as the northern portion of Elizabethtown. Peak sound levels above 130 dB remain just inside the boundary, with the exception of a small enclave of Radcliff which is entirely comprised of Saunders Spring Park. On post, the 115-130 dB contour encompasses the entire cantonment area. Peak sound levels above 130 dB do not enter the cantonment area.

Under neutral weather conditions, peak sound levels between 115 and 130 dB extend beyond the boundary southwest approximately 1.3 km (0.8 miles) passing Highway 31, encompassing parts of Radcliff and Hardin County. Sound levels above 130 dB remain well within the installation boundary. On post, sound levels between 115 and 130 dB extend into the southeast portion of the cantonment area roughly 1 km (0.6 miles). Multiple family housing communities (Pressler Grove, Littlefield Loop, Anderson Greens, Dietz Acres and Moreland Manor) and four schools (MacDonald School, Scott School, Pierce Elementary and Fort Knox High School) are contained within the noise contour. Peak sound levels above 130 dB do not reach the cantonment area.

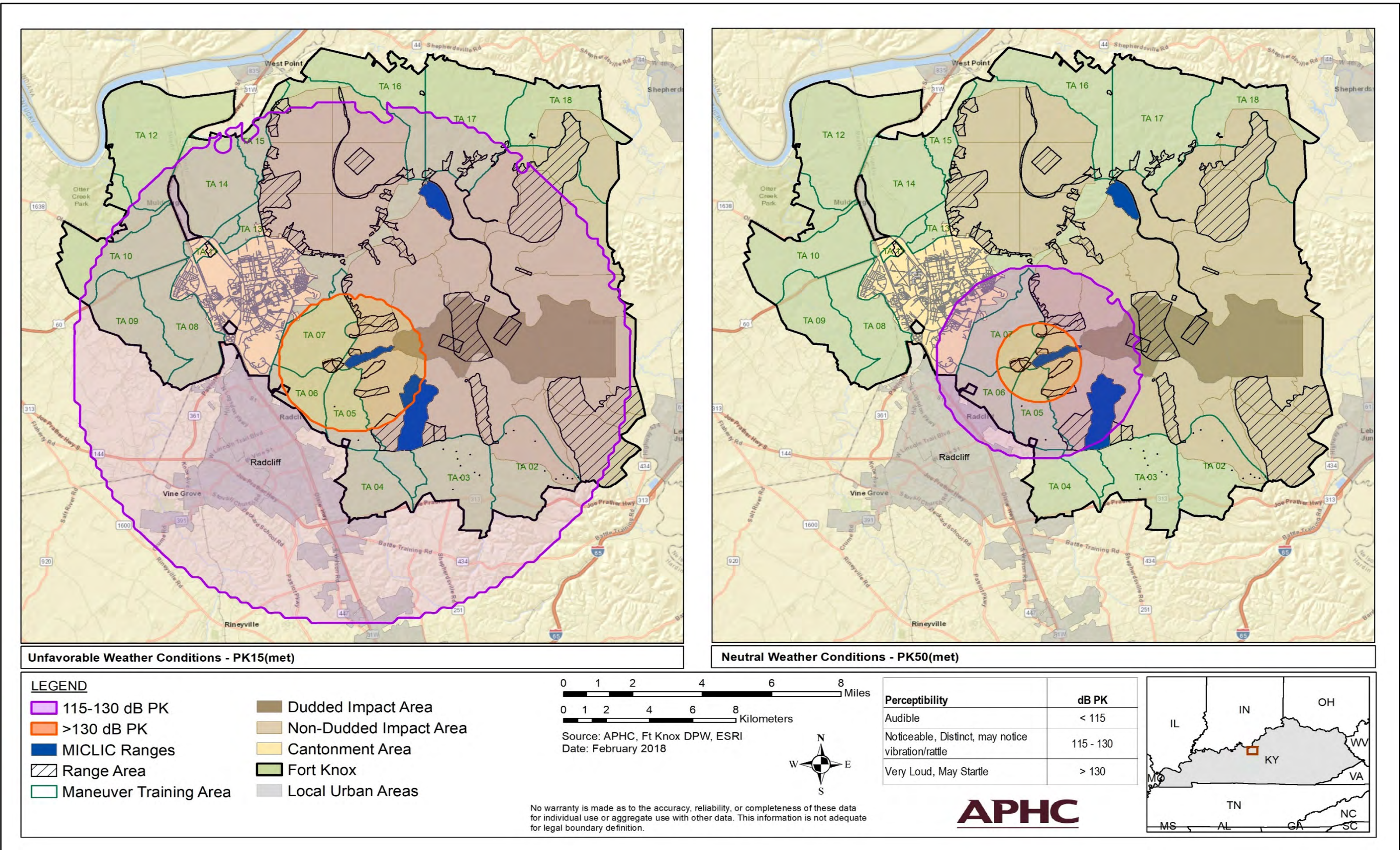


Figure 4-7. Peak MICLIC Sound Levels- Unfavorable and Neutral Weather Conditions at Steele's Range

Figure 4-8 illustrates the single event Peak levels for a MICLIC detonation at St. Vith range, located southeast of the Steeles range. Under unfavorable weather, peak sound levels between 115 and 130 dB extend beyond the Fort Knox boundary west-southwest approximately 8.6 km (5.3 miles); south approximately 9 km (5.5 miles); and east roughly 2.8 km (1.7 miles). The contour contains portions of Meade, Hardin, Bullitt and Nelson Counties, including the cities of Radcliff and Vine Grove, along with portions of Elizabethtown and Lebanon Junction. Individual homes are scattered throughout the noise contour in unincorporated lands, particularly Hardin County, although population density in these areas is low.

On post, the 115-130 dB contour covers a large portion of the cantonment, as far north as the GAAP. Sensitive land uses include troop and family housing communities, schools and the IRAHC. Peak sound levels above 130 dB are contained to the installation boundary and do not enter the cantonment area.

Under neutral weather conditions, peak sound levels between 115 and 130 dB extend beyond the boundary in two separate areas southwest and due south less than 1 km (0.6 miles). These areas encompass the eastern edge of Radcliff and portions of Hardin County. Residential land uses adjacent to the Fort boundary are contained within the noise contour. Sound levels above 130 dB remain relatively localized to the range area. On post, neither Peak contour reaches the cantonment area or contains any noise-sensitive land use.

Figure 4-9 illustrates the single event Peak levels for a MICLIC detonation at McFarland-Oliver range. In general, the noise exposure is shifted north and northeast in this scenario. Under unfavorable weather, peak sound levels between 115 and 130 dB extend beyond the Fort Knox boundary north up to 6.6 km (4.1 miles), east 4.2 km (2.6 miles) and a small area west, just below the cantonment. The contour encompasses portions of Bullitt, Jefferson, and Hardin Counties, and crosses over the Ohio River into Harrison County, Indiana. The City of West Point to the north and Muldraugh are fully contained within the 115-130 dB contour. The western portion of Shepherdsville and a small portion of Radcliff also reside in the contour.

On post, the 115-130 dB contour encompasses the entire cantonment area. Peak sound levels above 130 dB remain inside the installation boundary and do not propagate far enough to enter the cantonment area. The terrain features in this area along the Salt River have a noticeable effect on the 130 dB contour.

Under neutral weather conditions, peak sound levels between 115 and 130 dB and above are contained to the installation boundary and do not contain any noise-sensitive land uses.

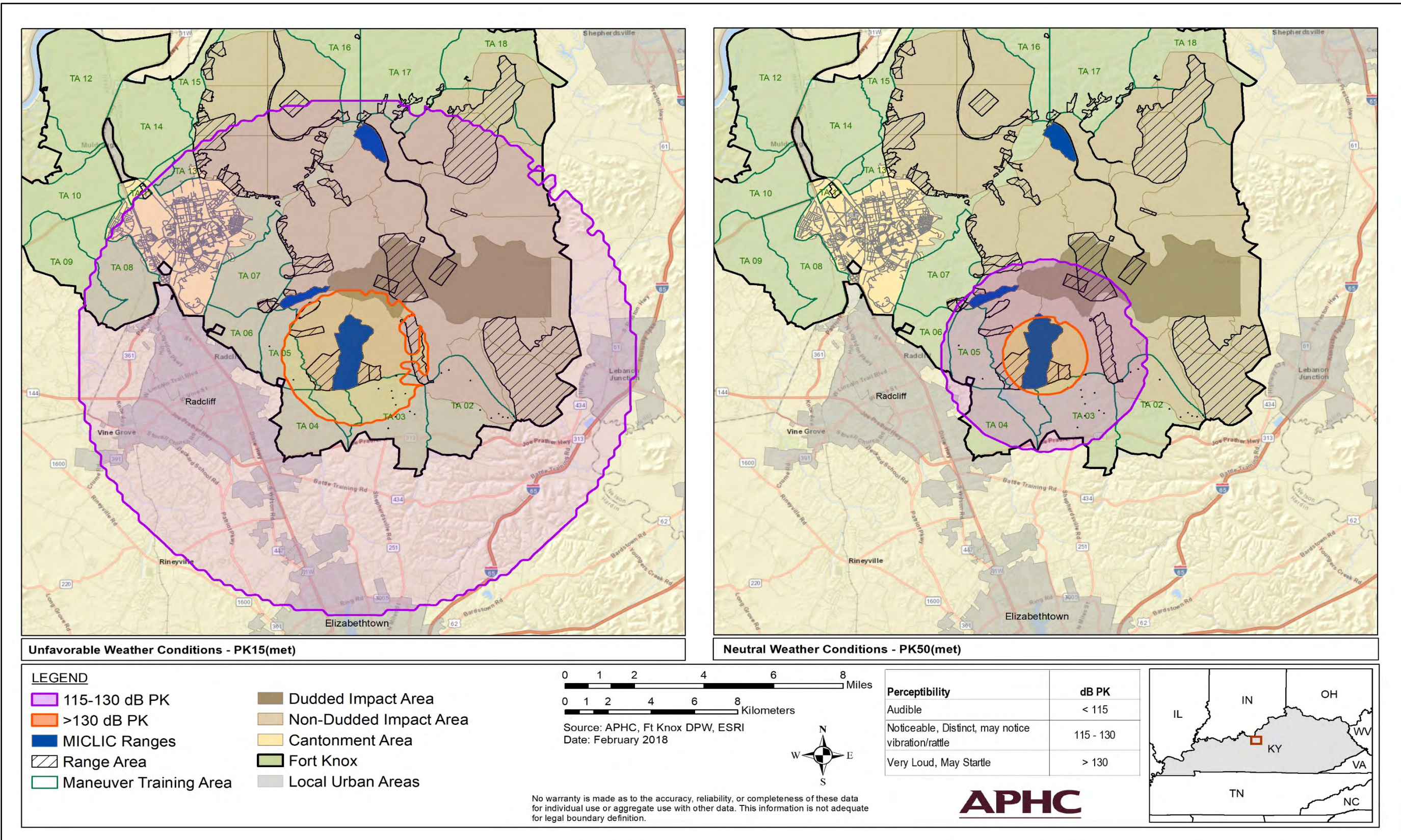


Figure 4-8. Peak MCLIC Sound Levels- Unfavorable and Neutral Weather Conditions at St. Vith Range

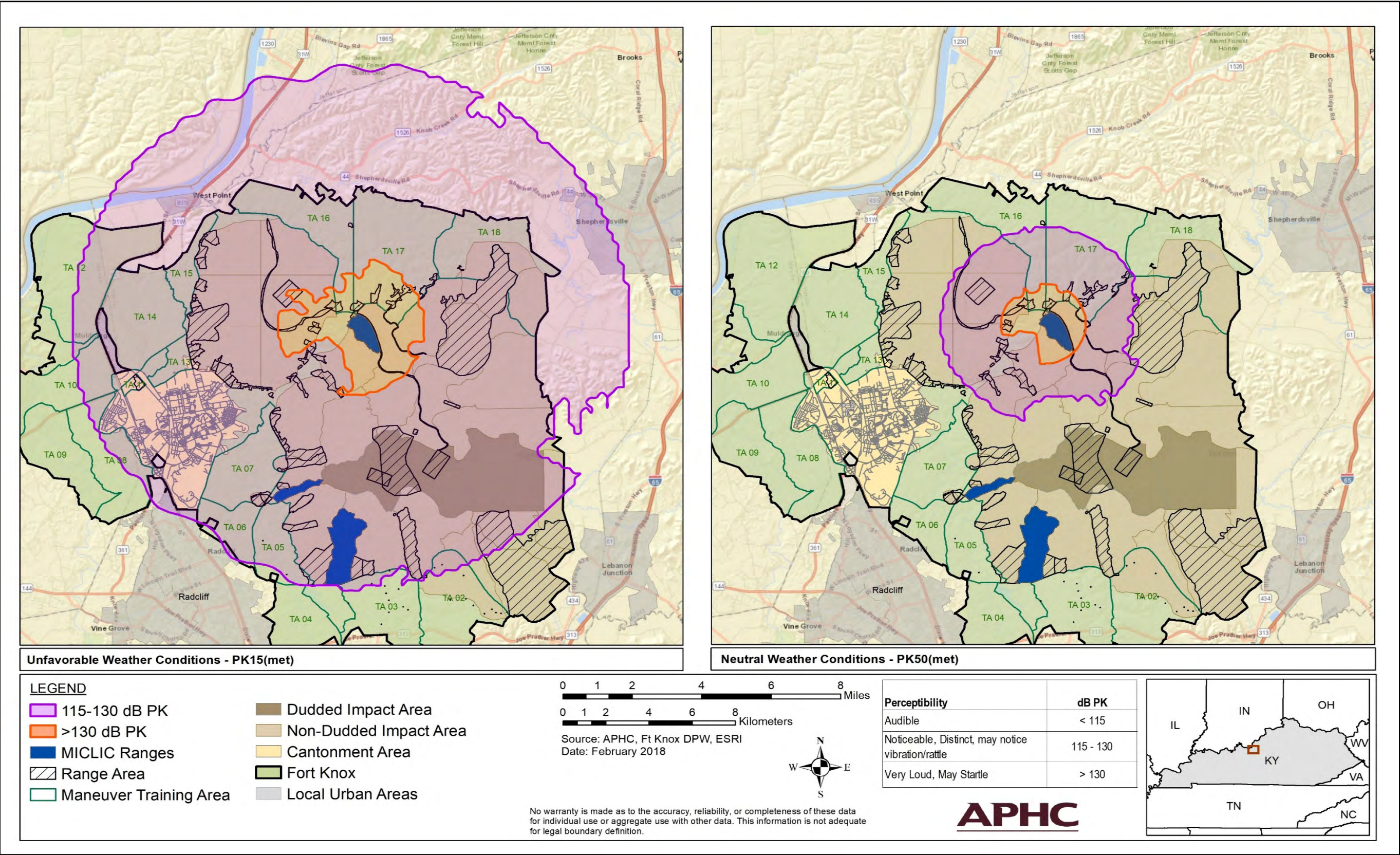


Figure 4-9. Peak MICLIC Sound Levels- Unfavorable and Neutral Weather Conditions at McFarland-Oliver Range

4.3 FUTURE LARGE CALIBER AND DEMOLITION NOISE

A future large caliber weapons discussion is included in this ICUZ to account for the programmed Digital Air-to-Ground Integration Range (DAGIR) project, scheduled to start construction in FY 2019 and be completed and operational in FY 2021. The DAGIR will be constructed on the existing footprint of the Yano MPRC. The range will provide advanced opportunity to practice air ground integration and an extended breadth and depth to the current generic aviation gunnery range. The aviator will train on live-fire engagements against a wide variety of targets, hover and high angle; live-fire convoy, door gunnery engagements and aviation urban operations. The range is expected to support aviation units from active Army, Army National Guard (ARNG) and Reserve Components (RC).

The type of operations at the DAGIR will in effect be similar to the existing air-to-ground activity at the Yano MPRC, however the amount of operations per year will see a substantial increase. Yano currently conducts aerial gunnery firing from AH-64, CH-47, OH-58, and UH-60/HH-60 helicopters, with ammunition expenditures including 7.62mm and 30mm guns, 2.75 inch rockets, and Hellfire missiles. The DAGIR layout and firing configuration are expected to be similar to the existing layout. Ingress and egress by aircraft to the range as well as firing altitudes are also expected to remain the same. With regards to noise modeling, the increase in ammunition expenditures at the DAGIR will have an effect on the cumulative (annual) CDNL Noise Zones, but will not alter the single event Peak noise contours from either weather scenario.

Because the range is not yet operational, Standards in Training Commission (STRAC) expenditures were used as a baseline estimate to calculate the expected noise impacts. The STRAC estimates include usage from four Combat Aviation Brigades (CAB), assuming two active Army CABs, one ARNG CAB and one RC CAB. Combined with the current activity at Yano MPRC, this STRAC scenario represents a 'worse-case' for operational noise, as it is likely that no more than 75 percent of STRAC expenditure levels would actually be received.

4.3.1 FUTURE LARGE CALIBER AND DEMOLITION NOISE ZONES

Figure 4-10 depicts the CDNL Noise Zones for large caliber and demolition operations with the additional STRAC rounds added to the DAGIR/Yano MPRC. Appendix C lists the large caliber ammunition and explosive detonations expenditures by range and the additional STRAC numbers used to produce the Noise Zones.

The additional aerial gunnery rounds at the DAGIR/Yano MPRC further extend the LUPZ beyond the boundary east up to 2.7 km (1.6 miles) and southeast approximately 1.3 km (0.8 miles). Zone II also extends further along and beyond the east boundary as far as 1.2 km (0.7 miles). Zone III extends beyond the boundary in three separate areas, up to 500 m. Table 4-8 compares the acreage totals for the current and future CDNL Noise Zones. On post, the Noise Zones do not enter the cantonment area or affect any noise-sensitive land use.

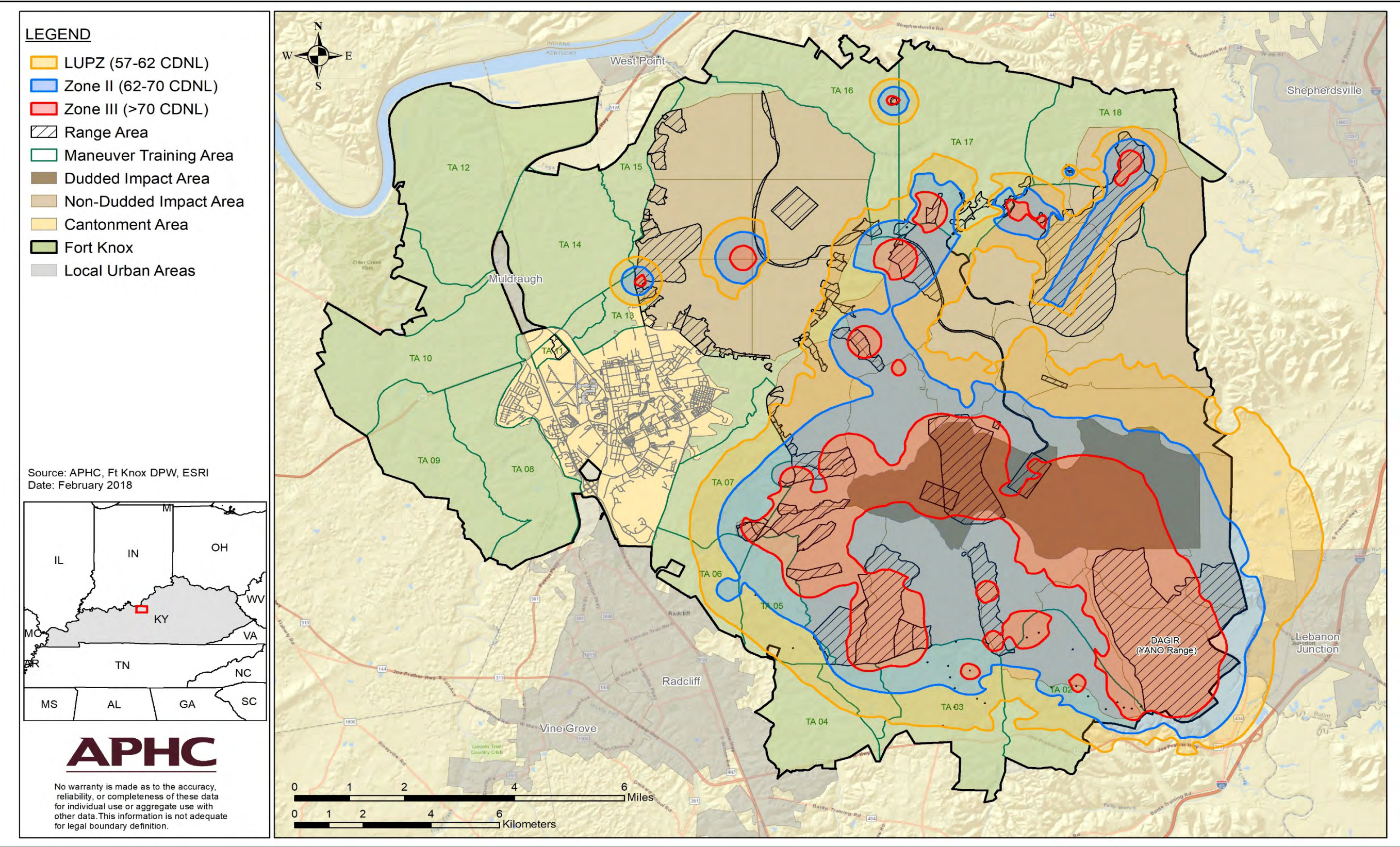


Figure 4-10. Future Large Caliber and Demolition CDNL Noise Zones with DAGIR Operations

Table 4-8. Existing vs. Future Large Caliber and Demolition Noise Zone Acreages

Noise Zone	Existing Noise Zone Acreage		Future Noise Zone Acreage	
	Total	Off Post	Total	Off Post
LUPZ	17,085	2,337	18,959	4,213
Zone II	19,815	620	20,128	1,186
Zone III	14,535	7	16,088	75

Table 4-9 compares the daytime and nighttime ambient population exposure (LandScan™) totals for the current and future CDNL Noise Zones extending off post. Once again the LUPZ containing portions of Lebanon Junction and unincorporated Bullitt County, contain the highest concentration of noise-sensitive land use. Although the Zone II population exposure sees a marked increase over current operations, particularly at night, the total exposure remains relatively low. Several residences adjacent to the installation boundary along Newton Farm Road are contained within the Zone III area east of Rolling Fork River. Zone III is considered incompatible with residential land use.

Table 4-9. Population Exposure Off Post in Existing vs. Future CDNL Noise Zones

Population Off Post	Noise Zone		
	LUPZ	Zone II	Zone III
Existing Noise Zones			
Daytime	80	1	0
Nighttime	303	44	0
Future Noise Zones			
Daytime	567	18	0
Nighttime	805	87	9

It should be noted that during DAGIR construction at Yano, normal aerial gunnery operations will be moved to the Wilcox and/or St. Vith ranges to accommodate training. This increase in activity will generate additional noise at these range locations, which may produce temporary impacts to land use beyond the boundary.

4.4 SIMULATOR NOISE

Simulator noise levels vary depending on the type (i.e., artillery, ground burst, grenade, IED) but typically, the variation will be limited to a few decibels. Table 4-10 gives an approximation of anticipated noise levels under neutral and unfavorable weather conditions. The levels were generated using the BNOISE2 computer program, and then verified by comparing the levels with results from noise monitoring studies (U.S. Army 1983, U.S. Army 1984, U.S. Army 1989). Based on Table 4-10, under neutral weather conditions, the risk of complaints will be low beyond 500 m as the Peak level would not exceed 115 dBP. Under unfavorable weather conditions, such as during a temperature inversion, or when there is a strong wind blowing in the direction of the receiver, the distance to a 115 dBP level increases to approximately 800 m.

Table 4-10. Predicted Peak Noise Levels for Typical Army Simulators

Distance from source (Meters)	Neutral Weather Conditions PK50(met) dBP	Unfavorable Weather Conditions PK15(met) dBP
100	134	136
200	125	130
300	120	127
400	117	123
500	114	121
600	111	118
700	109	116
800	107	114

Simulators on Fort Knox are used at multiple collective training facilities and training site areas. As with non-fixed small arms training, simulators may be deployed during exercises in locations near the installation boundary. However, when compared to the high explosive demolition activities that take place at Fort Knox, in most cases, the noise from simulator training is not expected to create a risk of complaints.

5 AIRCRAFT NOISE ASSESSMENT

5.1 GENERAL

Fort Knox accommodates a broad spectrum of aviation training and maintenance activities. Godman Army Airfield (GAAF) is the only approved instrument landing facility on Fort Knox. GAAF provides support to Army, Air Force, Army and Air National Guard, and Marine Corps units flying rotary- and fixed-wing aircraft, as well as Unmanned Aerial System (UAS) aircraft. There are also multiple helicopter airstrips and landing zones (LZs) located throughout the training complex. Temporary landing areas can also be approved by the appropriate authority.

Fort Knox airspace is managed by the Fort Knox AT&A Officer and controlled by the GAAF tower and Airfield Operations. Regulated airspace on Fort Knox consists of the GAAF airspace, defined by a five statute mile radius around the airfield, and the R3704 Special Use Area (SUA) airspace. Military rotary- and fixed-wing aircraft can utilize four SUAs within the training complex for local flying, terrain and tactical navigation, aerial gunnery and weapons qualification, and parachute operations. There are six authorized drop zones (DZ) on Fort Knox: ROSZOV, Zoomer, Matero Circular, Tracy Circular, Atcher and Medley. Parachute operations are primarily conducted during week days as they are controlled by the GAAF tower.

Parts of the R3704 area which cover the range complex are activated on a daily, or as needed basis by Range Operations during range firing and training operations. Range Operations also has approval authority for use of all airstrips, TAs, and LZs within the Fort Knox training complex.

Maintenance Test Flights (MTF) are conducted in the local MTF area located west of the Fort boundary. This area extends as far north as Interstate 64; south to the Western Kentucky Parkway; and west to the City of Cloverport, KY.

5.2 GODMAN ARMY AIRFIELD

GAAF is located on 524 acres in the northwest corner of the cantonment area, bounded by US Highway 31W, and just south of the City of Muldraugh. The airfield has two main runways designated 18/36, oriented north to south and 15/33, running northwest to southeast which support fixed-wing and rotary-wing aircraft. A third smaller runway designated 5/23, which orients northeast to southwest, is used by rotary-wing aircraft only. GAAF elevation is approximately 755 feet above mean sea level (MSL).

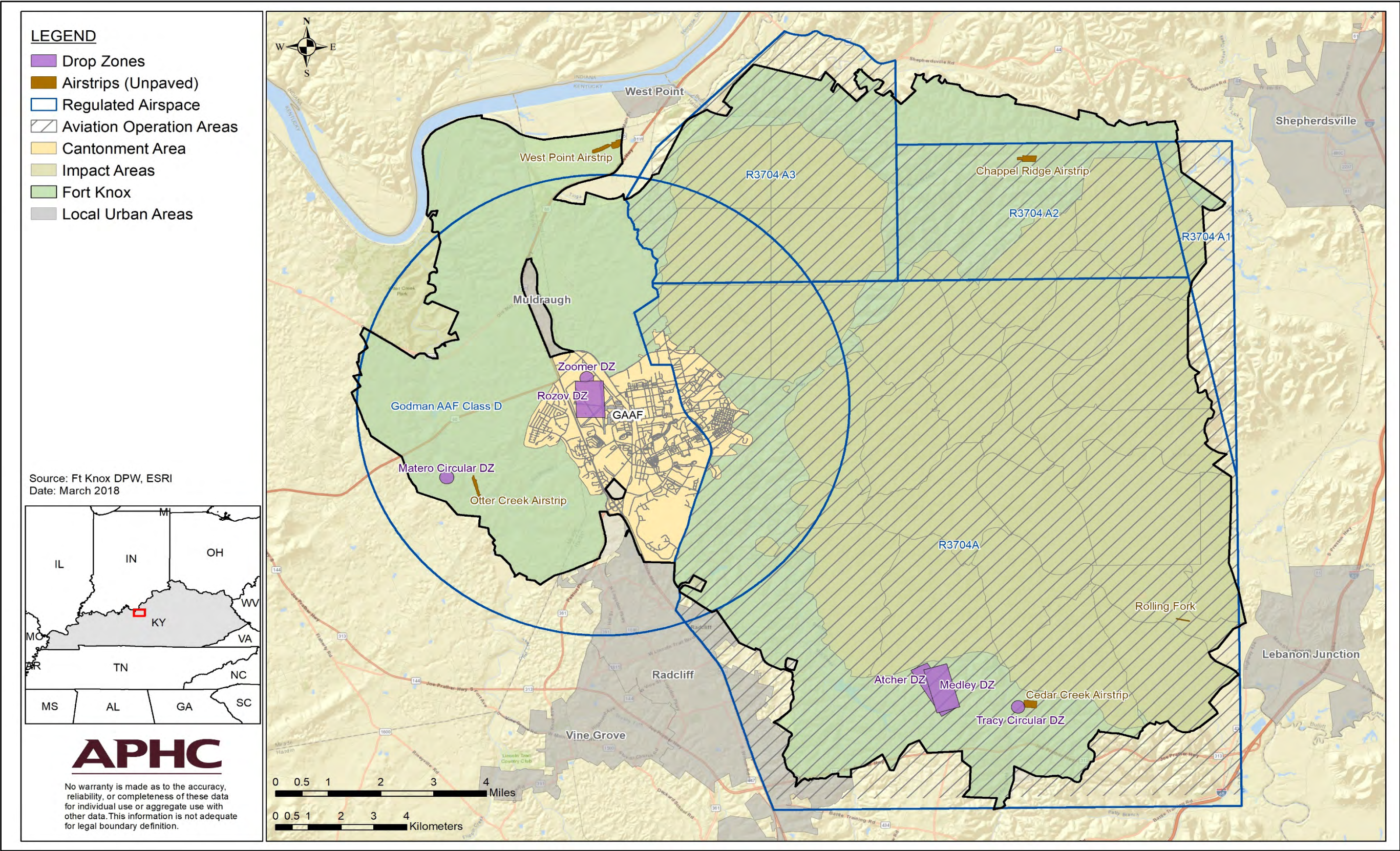


Figure 5-1. Regulated Airspace and Aviation Operation Areas on Fort Knox

5.2.1 GODMAN ARMY AIRFIELD NOISE ZONES

The number of military aircraft operations at an airfield varies from day to day. However, the NOISEMAP modeling software requires input of a specific number of daily aircraft flights and aircraft maintenance engine run-up operations. Thus, operations are calculated for an average annual day (AAD), meaning that operations are averaged across all 365 days of the year. The AAD was used in this assessment to generate A-Weighted Day-Night Average Sound Level (ADNL) Noise Zones for GAAF. Airfield Operations personnel provided aircraft tower counts at GAAF for twelve consecutive months (October 2016 -September 2017). Appendix C contains the traffic count summary inputs for the Noise Zones.

Figure 5-2 illustrates the Noise Zones for all GAAF aircraft operations. Table 5-1 lists the total and off post acreage for each Noise Zone. The LUPZ extends just south of the installation boundary along Veterans Memorial Highway into undeveloped land, and north encompassing roughly half the City of Muldraugh. The LUPZ is heavily influenced by the closed traffic pattern from Runway 18/36. Zones II and III remain contained to the installation boundary and do not extend into Muldraugh.

Table 5-1. GAAF Aircraft Noise Zones Acreage

Noise Zone	Noise Zone Acreage	
	Total	Off Post
LUPZ	4,744	193
Zone II	793	0
Zone III	15	0

On post, the LUPZ encompasses portions of the cantonment area west and south of the airfield. Several large family housing communities west of Highway 31West are contained within the LUPZ, as well as the Van Voorhis, Walker and Mudge Schools. Zone II extends south of the airfield along the flight track as far as the Bullion Depository, including portions of the Custer and Matthews Place family housing communities. Zone III remains contained to the runway. Table 5-2 lists the population exposure within the Noise Zones. It is important to note that the majority of all aircraft flights at GAAF (~98%) occur during daytime hours.

Table 5-2. Population Exposure On and Off Post in ADNL Noise Zones

Population	Noise Zone		
	LUPZ	Zone II	Zone III
Off Post			
Daytime	519	0	0
Nighttime	691	0	0
On Post (Cantonment)			
Daytime	2,428	7	0
Nighttime	4,277	15	0

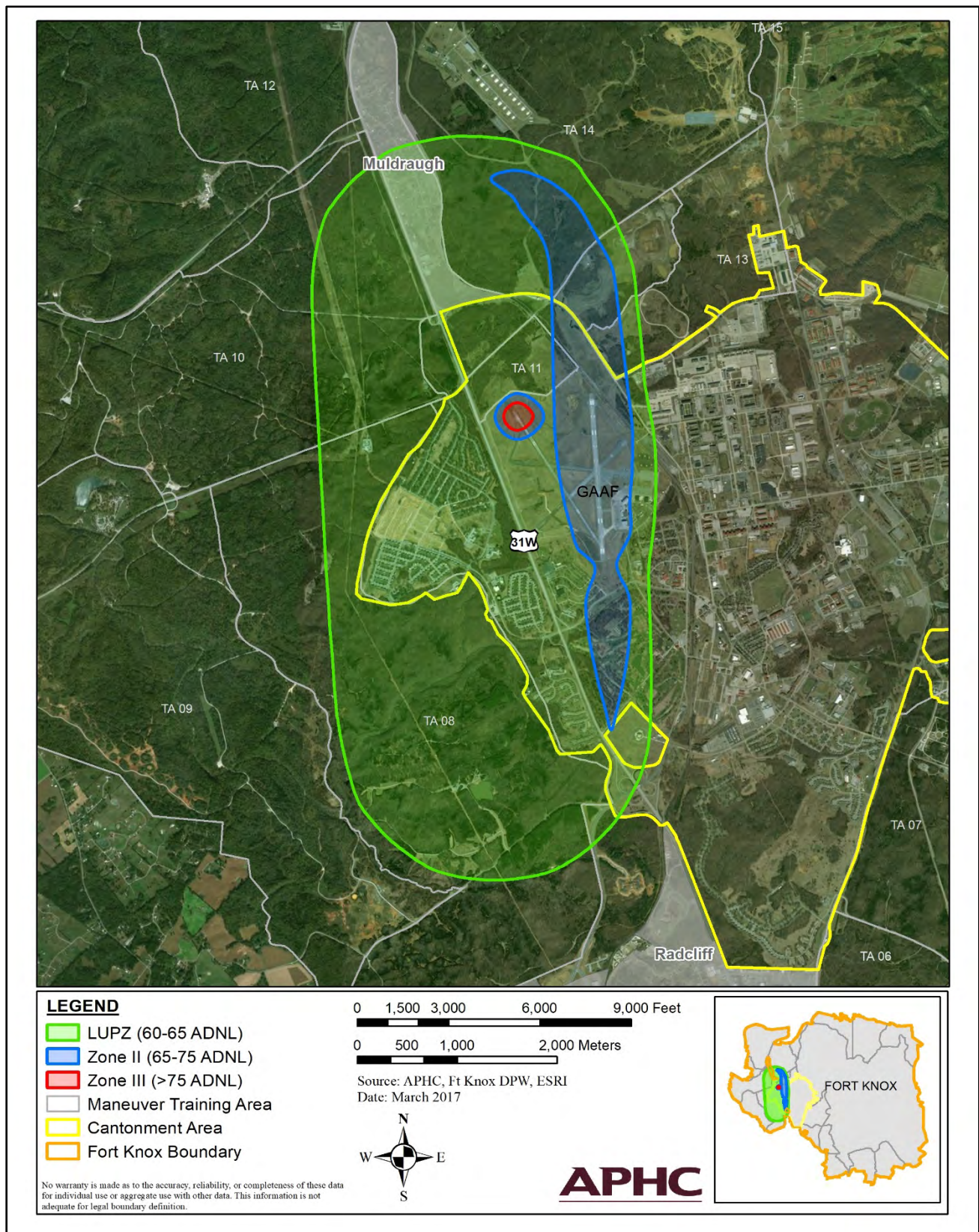


Figure 5-2. Godman AAF ADNL Noise Zones

5.3 ANNOYANCE POTENTIAL FROM SINGULAR OVERFLIGHT

Although the annual impacts of noise in and around the airfield are considered minimal, there are instances where individual aircraft overflights, training in the airspace beyond the airfield, or operating within TAs that can generate noise levels some individuals might find disruptive and/or annoying. This can be particularly true for military aircraft which tend to perform training activities which are repetitive and at low altitude. Rotary-wing aircraft moving within flight corridors along the installation boundary and C-130 fixed-wing aircraft utilizing the drop zones are just a few examples of these activities.

As with range noise, singular aircraft overflight is often the culprit of noise complaints received by an installation. Scandinavian Studies (Rylander 1974) found that a good predictor of annoyance at airfields with 50 to 200 operations per day is the maximum level of the 3 loudest events. While annoyance levels may be lower along less-frequented aviation routes and flight corridors, the Rylander study serves as an indicator for annoyance potential from intermittent overflights and using the maximum sound level provides a measure of the intrusiveness of an individual event. Maximum sounds levels from military rotary-wing and fixed-wing aircraft which commonly use the airspace and facilities at Fort Knox are listed in Tables 5-3 and 5-4. These levels are compared against the levels listed in Table 5-5 to determine the percent of the population that may consider itself highly annoyed from a singular overflight.

Table 5-3. Maximum A-Weighted Sound Levels for Rotary-Wing and Tiltrotor Aircraft

Slant Distance (feet)	Maximum Sound Level, dBA ¹				
	UH-60 ² 70 KIAS	CH-47 ² Light ^130 KIAS	CH-47 ² Heavy* ^120 KIAS	MH-6 ³ ^90 KIAS	MV-22 ² ^67 KIAS
200	86	101	98	83	98
500	77	93	89	75	89
1,000	71	87	83	68	82
1,500	67	83	79	64	78
2,000	64	80	76	62	75
2,500	61	78	74	59	72

¹ During flyover at constant airspeed.

* Heavy = sling load

² Obtained via AAM Program (Wyle 2013)

KIAS = Knots Indicated Air Speed

³ Obtained via SELCALC Program (USAF 2005)

^ Only KIAS available in single track mode

Table 5-4. Maximum A-Weighted Sound Levels for Fixed-Wing Aircraft

Slant Distance (Feet)	Maximum Sound Level , dBA ¹				
	C-130 970 C TIT 170 kts	C-17 90% NC 250 kts	C-12 90% RPM 160 kts	C-5 2.5 EPR 250 kts	C-35 1500 lbs 160 kts
500	92	97	79	114	84
1,000	85	89	73	108	77
1,500	80	84	69	101	73
2,000	77	79	67	97	69
2,500	75	76	65	89	67
5,000	66	73	57	77	58

¹ Obtained via SelCalc Program (U.S. Air Force 2005)

Table 5-5. Percentage of Population Highly Annoyed from Aircraft Noise

Maximum Sound Level , dBA	Highly Annoyed
90	35%
85	28%
80	20%
75	13%
70	5%

Source: Rylander 1974

Taking the Rylander correlation one step further, the SelCalc Program (U.S. Air Force 2005) was used to calculate the distance in ground track from zero to where the maximum A-weighted noise level would decay to 70 dBA or below threshold for annoyance. This takes into account not only those directly under a flight path but those to the side of a passing aircraft, where noise levels may remain high enough to cause annoyance up to one-half mile away.

Tables 5-6 through 5-8 are based on typical Above Ground Level (AGL) altitudes for military rotary-wing aircraft, cargo fixed-wing aircraft and the M-22 tiltrotor (Marine Corps) aircraft. All of these aircraft have the potential to operate at relatively low altitudes at or near the Fort Knox boundary, or just beyond in the local airspace depending on the type of training mission.

The tables (5-6 through 5-8) list the ground track distance, maximum sound level, and subsequent annoyance potential, and represent the best strategy for predicting areas that may be impacted based on annoyance potential from singular overflight. Current flight routes can be amended or future routes can be delineated based on the distances in the Tables, to further avoid the overflight of noise-sensitive areas. As an example, Figure 5-3 illustrates the overflight annoyance potential for the UH-60 at 500 feet AGL.

Table 5-6. Rotary-Wing Overflight Annoyance Potential¹

Source	Ground Track Distance ²	dBA Maximum ³	Population Highly Annoyed ⁴
UH-60 – 500' AGL 70 KIAS	0'	77	16%
	1320' (1/4 mile)	68	2%
	1760' (1/3 mile)	64	<1%
UH-60 – 1000' AGL 70 KIAS	0'	71	7%
	1320' (1/4 mile)	67	1%
	1760' (1/3 mile)	65	<1%
CH-47 Light – 500' AGL 130 KIAS	0'	93	+35%
	1320' (1/4 mile)	94	+35%
	1760' (1/3 mile)	93	+35%
	2640' (1/2 mile)	90	+35%
	5280' (1 mile)	70	5%
CH-47 Light – 1000' AGL 130 KIAS	0'	87	31%
	1320' (1/4 mile)	85	28%
	1760' (1/3 mile)	84	26%
	2640' (1/2 mile)	83	25%
	5280' (1 mile)	81	22%
CH-47 Heavy* – 500' AGL 120 KIAS	0'	89	34%
	1320' (1/4 mile)	77	16%
	1760' (1/3 mile)	74	11%
	2640' (1/2 mile)	70	5%
	5280' (1 mile)	63	<1%
CH-47 Heavy* – 1000' AGL 120 KIAS	0'	83	25%
	1320' (1/4 mile)	77	16%
	1760' (1/3 mile)	75	13%
	2640' (1/2 mile)	70	5%
	5280' (1 mile)	63	<1%
MH-6 – 500' AGL	0'	75	13%
	1320' (1/4 mile)	64	<1%
	1760' (1/3 mile)	61	<1%
MH-6 – 1000' AGL	0'	68	2%
	1320' (1/4 mile)	63	<1%
	1760' (1/3 mile)	61	<1%

¹ Percent annoyance shown is based upon 50 to 200 overflights per day. (Rylander 1974)

² Distance between receiver and the point on Earth at which the aircraft is directly overhead.

³ Obtained via AAM Program (Wyle 2013)

⁴ Calculated percentage based upon regression using the known values in Table 5-5.

+35% The Rylander studies did not include sampling in excess of 90 dBA.

* Heavy = sling load

Table 5-7. Fixed-Wing Overflight Annoyance Potential¹

Source	Ground Track Distance ²	dBA Maximum ³	Population Highly Annoyed ⁴
C-130 – 500' AGL	0'	92	+35%
	1320' (1/4 mile)	80	20%
	1760' (1/3 mile)	77	16%
	2640' (1/2 mile)	72	8%
	5280' (1 mile)	62	<1%
C-130 – 1000' AGL	0'	85	28%
	1320' (1/4 mile)	79	19%
	1760' (1/3 mile)	77	16%
	2640' (1/2 mile)	72	8%
	5280' (1 mile)	64	<1%
C-130 – 2000' AGL	0'	77	16%
	1320' (1/4 mile)	75	13%
	1760' (1/3 mile)	74	11%
	2640' (1/2 mile)	71	7%
	5280' (1 mile)	64	<1%
C-17 – 500' AGL	0'	97	+35%
	1320' (1/4 mile)	84	26%
	1760' (1/3 mile)	80	20%
	2640' (1/2 mile)	73	10%
	5280' (1 mile)	62	<1%
C-17 – 1000' AGL	0'	89	34%
	1320' (1/4 mile)	82	23%
	1760' (1/3 mile)	79	19%
	2640' (1/2 mile)	74	11%
	5280' (1 mile)	63	<1%
C-17 – 2000' AGL	0'	79	19%
	1320' (1/4 mile)	77	16%
	1760' (1/3 mile)	75	13%
	2640' (1/2 mile)	72	8%
	5280' (1 mile)	64	<1%

¹ Percent annoyance shown is based upon 50 to 200 overflights per day. (Rylander 1974)

² Distance between receiver and the point on Earth at which the aircraft is directly overhead.

³ Obtained via SelCalc Program (U.S. Air Force 2005)

⁴ Calculated percentage based upon regression using the known values in Table 5-5.

+35% The Rylander studies did not include sampling in excess of 90 dBA.

Table 5-8. MV-22 Tiltrotor Aircraft Overflight Annoyance Potential¹

Source	Ground Track Distance ²	dBA Maximum ³	Population Highly Annoyed ⁴
MV-22 – 500' AGL 67 KIAS	0'	89	34%
	1320' (1/4 mile)	71	7%
	1760' (1/3 mile)	68	2%
	2640' (1/2 mile)	64	<1%
MV-22 – 1000' AGL 67 KIAS	0'	82	23%
	1320' (1/4 mile)	73	10%
	1760' (1/3 mile)	70	5%
	2640' (1/2 mile)	64	<1%

¹ Percent annoyance shown is based upon 50 to 200 overflights per day. (Rylander 1974)

² Distance between receiver and the point on Earth at which the aircraft is directly overhead.

³ Obtained via AAM Program (Wyle 2013)

⁴ Calculated percentage based upon regression using the known values in Table 5-5.

+35% The Rylander studies did not include sampling in excess of 90 dBA.

KIAS = Knots Indicated Air Speed

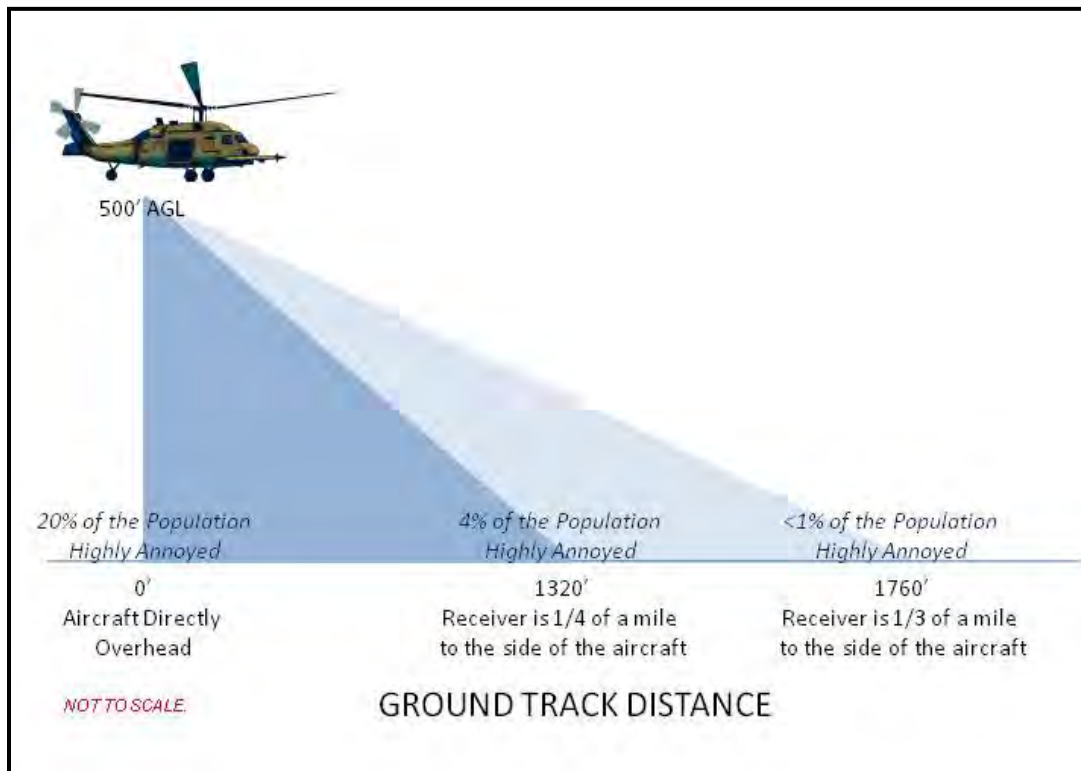


Figure 5-3. UH-60 Singular Overflight Annoyance Potential Illustration

5.3.1 UNMANNED AERIAL SYSTEM AIRCRAFT

Unmanned Aerial System (UAS) operations at Fort Knox are predominately limited to the RQ-11 Raven and RQ-20 Puma reconnaissance, surveillance and intelligence aircraft. Both are small hand-launched UAS, powered by a pusher propeller electric motor. Launch, recovery, and flight operations all take place within the SUA R3704 airspace. Restricted Operating Zones (ROZ) are established by Range Control for operating Units. Raven aircraft are generally confined to a specific range or ROZ and operate at or below 1,000 feet AGL. Puma aircraft commonly operate in larger ROZ areas supporting combined exercises and remain at or below 3,000 feet AGL.

The Cedar Creek and Chappel Ridge airstrips can support launch and recovery for larger RQ-7 Shadow tactical reconnaissance aircraft, although these operations are infrequent. Shadow training missions are also flown within the confines of the R3704 airspace. In general, noise impacts from UAS aircraft are considered minimal, based on the size, operating altitudes and training locations used on Fort Knox.

5.3.2 AIRCRAFT NOISE ABATEMENT

The following noise abatement procedures specific to aircraft are taken from the Fort Knox Regulation 95-1, Fort Knox Flight Rules:

- *Noise abatement practices and procedures will be briefed during mission planning and adhered to during the mission/operation.*
- *All measures possible will be taken to minimize flight activities which will adversely affect quality of life of the citizens in communities surrounding Fort Knox.*
- *Altitude restrictions and safe operation procedures are in accordance with Federal Aviation Regulation Part 91 and the Fort Knox Flight Rules. Plan to fly as high as possible based on cloud clearances.*

a. The minimum altitude within the Local Flying Area is 500 feet AGL.

b. Traffic pattern noise abatement:

(1) The standard traffic pattern for runways 15/33 and 18/36 is to the west of the airfield. The cross-wind and base legs should be extended to avoid direct over flight of Fort Knox housing areas on the downwind leg.

(2) Non-standard traffic patterns to the east should be minimized as much as possible to avoid over flight of the Fort Knox cantonment area.

(3) The traffic pattern for runway 05/23 is to the northwest. Southeast patterns are discouraged in order to avoid over flight of the airfield facilities, housing areas, and the Fort Knox cantonment area.

Designated noise abatement areas in Fort Knox Regulation 95-1 include the city limits of Lebanon Junction, Radcliff, Vine Gove and Shepherdsville.

6 NOISE RELATED LAND USE PLANNING AND POLICY

6.1 INTRODUCTION

Implementation of the ICUZ program is intended to be a joint effort between Fort Knox and the adjacent communities. The role of Fort Knox is to minimize noise impacts on the surrounding local communities by operational activities on the installation. The role of the communities is to ensure that development in the surrounding area is compatible with accepted planning, zoning, and development principles and practices to protect the installation's mission.

6.2 ACHIEVING LAND USE COMPATIBILITY

Achieving land use compatibility requires both flexibility and creativity from land use planners, installation commanders, and the citizenry. The previous sections of this document detailed the environmental noise impacts. The following sections detail land use planning tools which are available to both the installation and local communities.

6.3 REGIONAL LAND USE PLANNING

Regional planning in the State of Kentucky is conducted through fifteen separate Area Development Districts (ADDs), comprised of county groupings. These regional organizations assist in the formulation and implementation of local and region-wide planning efforts, while also serving as forums and clearinghouses and providing technical assistance to their respective regions. Specifically, ADD programs include workforce and economic development, transportation and infrastructure planning, water/wastewater planning, hazard mitigation and disaster preparedness planning, agriculture planning, broadband planning, tourism, healthcare and aging services and GIS mapping.

Each ADD is governed by a Board of Directors comprised of elected officials from both the counties and communities within the district, as well as non-elected citizen members representing a cross-section of the region's social and economic institutions. The Kentucky Council of ADDs oversees all fifteen districts, with each individual ADD selecting two members from their regional board to serve on the council.

Since Fort Knox spans over 3 counties it is included in two separate ADDs; the Lincoln Trail ADD (LTADD) and Kentuckiana Regional Planning Development Agency (KIPDA). Hardin and Meade counties are two of eight counties serviced by the LTADD, while Bullitt County is one of seven counties (five in Kentucky and two in Indiana) serviced by KIPDA.

6.4 JOINT LAND USE STUDY (JLUS)

The JLUS is a collaborative land use planning effort involving the military installation and adjacent local governments that evaluate the planning rationale necessary to support and encourage compatible development of land surrounding the installation. It is a means for the installation and local governments to develop a plan that effectively addresses the long-term land use needs of the

surrounding communities, yet still provides the military with the mission flexibility it needs to meet training doctrine.

The JLUS program is sponsored by the Department of Defense Office of Economic Adjustment (OEA) (DODI, 2004), which provides technical and financial assistance to the planning agencies for developing plans that are consistent, when economically feasible, with the noise, accident potential, and safety concerns from an installation's training and operations. The cost of the plan is shared between the OEA and the partners involved.

The scope of the program is divided into three major tasks:

1. Impact Analysis. Impact analysis provides an in-depth review of existing and proposed land use patterns; drainage (as it effects land use designations); mission encroachment; transportation improvements, existing and proposed routes; and noise/vibration.
2. Land Use and Mission Compatibility Plan. Examines the above findings to identify conflicts in land use and provide alternative land use solutions; to project the impact on growth potential for adjacent areas; and to project the impact of military missions on the surrounding jurisdictions.
3. Implementation. Lists a series of actions and/or recommendations for adoption by local jurisdictions to resolve land use conflicts and move toward a compatible land use plan for the installation, the adjacent counties and municipalities, and the communities therein.

While the study report makes certain recommendations, each participating jurisdiction must decide which recommendations are best suited to their particular needs. Implementation follows the final recommendations at the discretion of elected officials in each jurisdiction and the installation military command.

Fort Knox and its partners completed the JLUS process in June 2008. An Executive Committee was established consisting of the chief elected official of each affected local unit of government; a representative of the Commanding General at Fort Knox; and the executive directors of the KIPDA and the Lincoln Trail ADDs. The Lincoln Trail ADD served as the project administrator and legal grantee for funds from the OEA. The JLUS Executive Committee engaged CGI-International, Inc., a private planning consulting firm to assist in the preparation of technical studies, analysis and report preparation, as well as infrastructure analysis, engineering and public participation and input (www.ltadd.org).

The larger JLUS study area consists of the three counties adjacent to Fort Knox, however a smaller primary study was used, to include those areas likely to experience the greatest impact. This primary area, represented by a five- and ten-mile radius around Fort Knox (see Figure 6-1), was established through a number of factors, including the Noise Zones and contours from the 1992 ICUZ study.

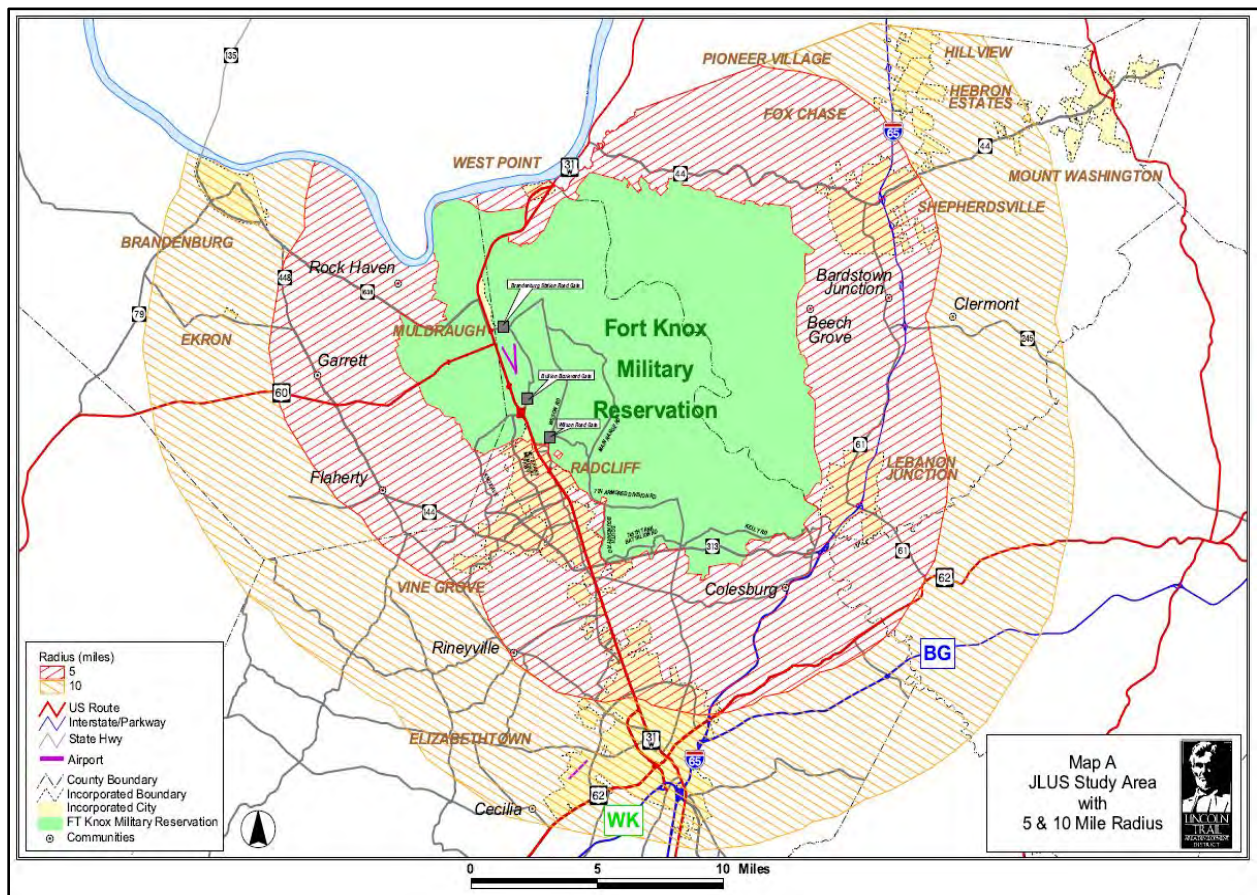


Figure 6-1. JLUS 2008 Primary Study Areas

The JLUS produced four overarching goals and 21 separate objectives which established the framework for the plan. The full JLUS and appendices can be found on the LTADD Website at: <http://www.ltadd.org/>

At the time of this ICUZ study, initial proceedings for an update to the current JLUS were under way. Funding is secured, and once again the LTADD will take the lead on the JLUS update.

6.5 ARMY COMPATIBLE USE BUFFER (ACUB) PROGRAM

Along with the aforementioned Noise Zones, the Army has a specific program designed to limit the effects of encroachment. The ACUB program was borne out of a 2002 expansion of the Private Lands Initiative (10 USC §2684a) allowing military departments to partner with private organizations to establish conservation easements or buffer areas around active installations.

These partnerships are beneficial in a number of ways:

- Benefit to Fort Knox:
 - Manages development adjacent to and near Fort Knox
 - Protects effective training space up to the installation boundaries
 - Averts training restrictions
 - Mitigates against noise and smoke complaints
- Benefit to Community Partners:
 - Protects Fort Knox’s mission and strength, effecting jobs and local economy
 - Does not remove lands from tax base
 - Maintains local agricultural and nature lands
- Benefit to Landowners:
 - Maintains current, compatible land uses
 - Provides cash in hand
 - Retain rights to ownership and management of land

Fort Knox started its ACUB program in 2006 as a result of the BRAC decisions of 2005. The primary partner for the ACUB, through cooperative agreement, was once again the LTADD. Additional partners include the U.S. Forest Service, U.S. Fish & Wildlife Department, the Kentucky Division of Conservation, and the Nature Conservancy. The ACUB identified four Priority Areas around Fort Knox, essentially buffering the TA perimeters or corridor battle spaces to the north, south, east, and west.

6.6 LAND USE PLANNING OPTIONS

The following land use planning tools are available to help local governments create areas of compatible use around military installations. Many on the list are already in use; however, Fort Knox and local governments are strongly encouraged to revisit and/or update any of these options to find the equitable solutions that best work for their situation. These planning tools may be used individually or in combination.

Zoning. The most common method of land use control is *zoning*, or the partitioning of areas into sections reserved for different purposes. This method is an exercise of the police powers of state and local governments that designates the uses permitted in each parcel of land. It normally consists of a zoning ordinance that delineates the various use districts and a zoning map based on the land use element of the community’s comprehensive general plan.

Easements. Easements can be an effective and permanent form of land use control; in many instances, better than zoning when trying to resolve an installation’s compatibility issues. Easements are permanent (with the title held by the purchaser until sold or released), work equally

well within different jurisdictions, are enforceable through civil courts, and may be acquired often at a fraction of the cost of the land value. Another consideration may be that the land is left free for full development with noise-compatible uses.

Subdivision Regulations. Subdivision regulations are a means by which local governments can ensure that proper lot layout, design, and improvements are included in new residential or commercial developments. These requirements may be anything from dictating the width of the roads to placement of the water and/or sewer systems. Since most local governments require some type of public dedication of open space when approving development plans, the installation may lobby to have a provision added to the subdivision regulations that requires this open space to be located nearest the installation boundary to create a buffer.

Disclosure of Noise Levels. Since noise levels in a community can be effectively modeled, as well as measured and recorded, making noise level information readily available can sometimes be all it takes to discourage incompatible land uses. These noise levels can be disclosed in several ways, including ordinances (or amendments to existing ordinances), deeds, posting noise levels on any sale/lease/rent sign, and initiating voluntary programs among local realtors to provide potential buyers with noise level/contour mapping.

Deed Restrictions/Covenants. A deed is a document conveying ownership of land from one party to another, and restrictions called *covenants* can be added to the deed to specify restrictions on the use of the land. These covenants are on top of the restrictions already imposed by the current zoning of the property and in many instances may supersede zoning by prohibiting specified uses that would otherwise be allowed. Restrictive covenants “run with the land” that is, no matter how often the land is resold, these covenants remain in effect until the specified length of the covenant has expired. In order to utilize this option, the installation must already own or must acquire the property. Then, when reselling the property, the installation specifies which uses are permitted on the land thereby preventing incompatible uses (such as residential housing) for as long as the restrictions remain in effect.

6.7 LOCAL NOISE RELATED LAND USE POLICY

The Kentucky 313 Corridor appears as both a land use group and planning area within Hardin County’s Comprehensive Development Guide (2014) and is of significant importance to Fort Knox. The 313 corridor is unincorporated county lands located along Kentucky Highway 313 south of Fort Knox’s boundary out to Highway 434. In an effort to protect any further encroachment upon Fort Knox within this area and protect its residents from noise impacts generated by Fort Knox, Hardin County established the Kentucky 313 Corridor to limit noise-sensitive development. The existing land use in this area is primarily forest and open pasture lands with sparse single-family residential use at very low density. A portion of the land is affected by the floodplain along the Rolling Fork River. Guidelines for development of the 313 Corridor are set forth in the Comprehensive Development Guide (<http://hcpdc.com>) and are as follows:

Recommended Land Use Pattern and Development Criteria: The following are recommended land use types for the Kentucky 313 Corridor generally. Also provided are general guidelines for development in Kentucky 313 Corridor.

- *Residential uses are discouraged.*
- *Where residential uses are allowed they should be very low density uses, such as Residential Estate.*
- *Development within the floodplain is discouraged.*
- *The requirements of the Kentucky 313 Corridor, outlined in the Development Guidance System, should continue to be applied to this area.*
- *Development in this area should be undertaken in a way mindful of the impacts of the Military reservation and in particular the noise impacts.*
- *The Regional Wastewater Facilities Plan identifies this area as part of a rural watershed and does not propose a regional wastewater treatment solution in the next twenty year planning period. The continued use of on-site treatment/disposal systems is expected. As development occurs, construction of decentralized wastewater collection and treatment systems with long-term management, operation and maintenance is desired.*

The Residential Estate Zone (R3) is defined in Section 3-3 of the Hardin County Development Guidance System, Zoning Ordinance (2009) as the following:

RESIDENTIAL ESTATE ZONE (R3)

A. INTENT

This Zone is intended for very low density development of single family dwellings, located where private or public water supply is available and individual on-site wastewater treatment is permitted by the Hardin County Health Department.

Any development of this area is heavily scrutinized and if allowed lots sizes are restricted to a minimum of ten acres. Further dimension and area regulations for residential land use are set forth in the Zoning Ordinance and are as follows:

C. DIMENSION AND AREA REGULATIONS

The regulations on the dimensions and area for lots and yards are set forth as follows:

1. Minimum Lot Size;

- *Open Space Subdivision Design (Special Provisions, Pg. 146);*
- *10.0 acres for property having access to a government maintained roadway;*

2. Minimum Lot Frontage - 300';

3. Minimum Width to Length Ratio – 1:3 until 300' of frontage;

4. Minimum Front Yard Setback - 40'; or 70' for property 3 acres or greater.

5. Minimum Side Yard Setback - 10'; 20' for property 3 acres or greater; 100' for Subdivision lots platted after the adoption of this ordinance and adjoining A-1, I-1, I-2 zones

6. Minimum Rear Yard Setback - 15'; 50' for property 3 acres or greater; 100' for Subdivision lots platted after the adoption of this ordinance and adjoining A-1, I-1, I-2 zones

7. Street Construction – New subdivision streets must intersect with government maintained roads with a minimum of 40 foot dedicated right-of-way and a minimum 18-foot paved road surface. To achieve street connectivity the Commission may approve secondary streets to intersect with other government maintained roads.

7 SUMMARY

The primary focus of the ICUZ study is to quantify the noise environment from military training sources and define the most appropriate uses of noise-impacted areas. The principle noise sources at Fort Knox are small and large caliber weapons and demolition training and aircraft operations.

7.1 SMALL ARMS WEAPONS

Small Arms Ranges

Fort Knox has a large number of small arms ranges which are used frequently throughout the year. Multiple ranges concurrently firing can be a common daily occurrence on the installation. The Noise Zones from small arms firing are primarily contained to the range and impact areas in the eastern half of the installation. Zone III is entirely contained within the installation boundary. Zone II extends beyond the boundary in four separate areas to the north, northeast, and south-southeast. The area southeast contains a small portion of the City of Lebanon Junction. Individual homes in county lands are also scattered through these areas, although development in general is limited.

On post the Noise Zones extend into the northeast end of the cantonment. The land uses within these Noise Zones are mostly compatible. Zone III contains motor pool facilities and parking lots. A small portion of Zone II does contain some enlisted barracks.

Non-Fixed Firing Ranges

Training activities which require the firing of small arms blank ammunition occur in multiple training sites and collective training facilities throughout the Fort. A large majority of the TAs can also support these operations. In most cases, weapons fire takes place far enough from the boundary that noise impacts would be considered minimal.

7.2 LARGE CALIBER WEAPONS AND EXPLOSIVES

Land Use Compatibility

The cumulative large caliber and demolition operations Noise Zones show impacts to sensitive land uses are limited to the areas beyond the southeast boundary. The Noise Zones extending off post, particularly Zones II and III are concentrated just outside the Yano MPRC. There are no noise-sensitive land uses contained within Zone III. Zone II contains residential land uses scattered throughout Hardin and Bullitt Counties, albeit in low density. Further development of these areas is expected to be limited, as planning measures are currently in place restricting large scale development. The LUPZ extends further east, encompassing a portion of Lebanon Junction and considerably more noise-sensitive land uses. On post, the Noise Zones do not extend into the cantonment area or affect any sensitive land use.

Single Event Levels

Peak levels correlate with the receiver's perception of noise and can be a good predictor of complaints. Peak levels are included in this study as a supplement to land use compatibility Noise Zones. Individuals in an area experiencing peak sound levels between 115 and 130 dB may

describe events as noticeable and distinct. Peak sound levels above 130 dB are generally objectionable, and are often described as very loud and startling. Peak levels can vary significantly for the same activity based upon weather conditions. Peak sound levels in this study were modeled with two meteorological conditions (unfavorable and neutral weather) applied.

Under unfavorable weather, peak sound levels between 115 and 130 dB extend beyond the Fort boundary to the south, southwest, north, and east. The largest noise exposure to single events occurs southwest in the City of Radcliff and east within Lebanon Junction; although, small clusters of residential development and individual homes are present throughout. Peak sound levels above 130 dB extend beyond the boundary in several areas north-northeast and south. Homes adjacent to the installations southern boundary are located within the 130 dB contour.

On post, the 115-130 dB Peak contour encompasses the majority of the cantonment, with the exception of the northwest corner. Noise-sensitive land uses include family and soldier housing, several schools and the IRAHC. Peak sound levels above 130 dB extend into the northern tip of the cantonment area as a result from activities at the Heins range. There are no noise-sensitive land uses contained within the 130 dB contour.

The absence of the downwind propagation effect greatly reduces noise impacts under neutral weather conditions. Noise levels between 115 and 130 dB still extend beyond the boundary north-northeast, southwest and south-southeast; however, to a much lesser degree. Impacts to noise-sensitive land use shifts from areas southwest to the areas southeast, including the western edge of Lebanon Junction and portions of Bullitt and Hardin Counties. Peak sound levels above 130 dB extend beyond the installation boundary in one small area south of the Yano MPRC. There are currently no sensitive land uses within this area.

On post, sound levels between 115 and 130 dB extend into the northeast portion of the cantonment, but remain north of the barracks area. There are no noise-sensitive land uses in the contour. The 130 dB contours on post are contained to range, training site and maneuver areas, and do not extend into the cantonment area.

MICLIC Single Event Levels

In addition to day-to-day operations, single event peak sound levels were modeled for live MICLIC operations. These operations are relatively infrequent compared to other demolition activities; however, the large net explosive weight of the MICLIC make it one of the loudest single training events on Fort Knox. Depending on mission and unit, three different range areas (St. Vith, McFarland-Oliver and Steeles) are used to detonate MICLICs.

Noise impacts beyond the boundary are highly dependent upon weather conditions and the range used for detonation. This is particularly true in the unfavorable weather scenario, where the 115-130 dB noise contour shifts focus from areas south when firing at St. Vith and Steeles ranges to areas north when detonating from McFarland-Oliver range. In all cases, peak sound levels above 130 dB remain contained to the installation boundary, with the exception of a small enclave of Radcliff which is entirely comprised of Saunders Spring Park.

On post, MICLIC operations under unfavorable weather produce peak sound levels between 115-130 dB which blanket the cantonment area regardless of detonation point. Sounds levels above 130 dB do not enter the cantonment area or affect any sensitive land use.

7.3 AVIATION ACTIVITY

The cumulative Noise Zones at GAAF show minimal impacts beyond the installation boundary, with the exception of the City of Muldraugh, an incorporated city which is completely surrounded by Fort Knox and lies just north of the airfield. Due to its location and proximity to GAAF, a large portion of Muldraugh is contained within the LUPZ. Zones II and III remain contained to the installation boundary and do not extend into Muldraugh.

On post, the LUPZ encompasses portions of the cantonment area west and south of the airfield, including several large family housing communities west of Highway 31W and several schools. Zone II extends south of the airfield along the flight track as far as the Bullion Depository, including portions of several family housing communities. Zone III remains contained to the runway.

UAS operations at Fort Knox are predominately limited to the RQ-11 Raven and RQ-20 Puma reconnaissance, surveillance and intelligence aircraft. Launch, recovery, and flight operations all take place within the restricted R3704 airspace and/or the confines of the Fort Knox boundary. In general, noise impacts from UAS aircraft are considered minimal, based on the size, operating altitudes and training locations used on Fort Knox.

All aircraft operating outside of Fort Knox restricted airspace either in or out of designated flight corridors or within military operations areas have the potential to cause annoyance and complaints. Pilots utilizing Fort Knox airspace are instructed to adhere to designated noise abatement procedures to help mitigate the effects of aircraft noise at Fort Knox and beyond, including minimum flight altitudes and avoidance areas.

7.4 RECOMMENDATIONS

The ICUZ is a proactive planning tool, which can help guide future development in surrounding communities. At a minimum, local municipal governments are encouraged to support public disclosure of all Noise Zones and supplemental metrics which may convey how military training operations affect the noise environment.

The ICUZ study describes the noise characteristics of a specific operational environment, and as such, will change if a significant operational change is made. Therefore, if Fort Knox's mission, training, or training facilities undergo changes, the ICUZ should be reviewed to determine if the current noise assessment is sufficient. At a minimum, it is recommended that every five years the ICUZ and/or Noise Zones be updated to incorporate pertinent changes to the noise environment.

A GLOSSARY OF TERMS

A-Weighted Sound Level – a sound level (in decibels) that has been weighted to correspond with the non-linear sensitivity of the human ear. A-weighting discriminates against the lower frequencies and is used to measure most common military sounds such as transportation and small-arms fire.

Ambient Noise – the background noise that is usually present at a particular location; anything from cars on a highway, to insects in the woods.

Atmospheric Refraction – the bending and/or focusing of sound waves by the varying layers and densities of the earth’s atmosphere.

C-Weighted Sound Level – like A-weighting, this is another sound level weighting technique that is used to normalize the low, impulsive sounds to the range of human hearing. It is used when measuring low frequency sound such as those from large arms, demolitions, and sonic booms.

Day-Night Average Sound Level (DNL) – the 24-hour average frequency-weighted sound level, in decibels, from midnight to midnight, obtained after the addition of 10 decibel “penalties” to sound levels between midnight and 7 a.m. and 10 p.m. to midnight (0000 to 0700 hours and 2200 to 2400 hours). A-weighting (ADNL) is understood unless otherwise specified, but C-weighting (CDNL) is also common.

Decibels (dB) – a logarithmic sound pressure unit of measure.

Equivalent Sound Level (LEQ) – the level of a constant sound which, in a given situation and time period, has the same energy as does a time varying sound. For noise sources which are not in continuous operation, the equivalent sound level may be obtained by summing individual sound exposure level (SEL) values and normalizing them over the appropriate time period.

Frequency – the number of complete oscillation cycles per unit of time. The unit of frequency is the Hertz.

Frequency Weighting – the process of factoring in certain frequencies more or less heavily in order to bring the sound measurement more in line with the characteristics of the receiver (and thus make the numbers more meaningful to the task at hand). Example: A- or C-weighting to specifically parallel the sensitivity of the human ear.

Hertz – the unit of frequency equal to once cycle per second.

Impulse (or Impulsive) Noise – noise of short duration (typically less than one second), high intensity, abrupt onset and rapid decay, and often rapidly changing spectral composition. Impulsive noise is characteristically associated with such sources as explosions, impacts, the

discharge of firearms, the passage of supersonic aircraft (creating sonic booms), and many industrial processes.

Land Use Planning Zone (LUPZ) – The Land Use Planning Zone (LUPZ) is a subdivision of Zone I. The LUPZ is 5 dB lower than the Zone II.

Large Caliber/Arms – conventional military weapons over 20 millimeters in diameter.

Noise – any sound without value or unwanted sound.

Noise Level Reduction – the difference, in decibels, between the sound level outside a building and the sound level inside a designated room in the building (usually A-weighted). The NLR is dependent upon the transmission loss characteristics of the building surfaces exposed to an exterior noise source, the particular noise characteristics of the exterior noise source, and the acoustic properties of the designated room in the building.

Noise Zone III – the area around a noise source in which the C-weighted day-night sound level (CDNL) is greater than 70 dB (demolition and large caliber weapons), the A-weighted day-night level (ADNL) is greater than 75 dB (aviation), or the dB Peak is greater than 104 (small caliber weapons).

Noise Zone II – the area around a noise source in which the CDNL is 62-70 dB (demolition and large caliber weapons), the ADNL is 65-75 dB (aviation), or the dB Peak is 87-104 (small caliber weapons).

Noise Zone I – included all areas around a noise source in which the CDNL is less than 62 dB (demolition and large caliber weapons), the ADNL is less than 65 dB (aviation), or the dB Peak is less than 87 (small caliber weapons). This area is usually suited for all types of land use activities.

Peak – Peak is a single-event sound level without weighting.

PK15(Met) – PK15(met) is a computer modeled single-event peak level that is exceeded only 15 percent of the time by the loudest munitions type detonation. This metric accounts for variations caused by weather conditions and favors noise propagation. The PK15(met) metric does not communicate any information about how often the loudest munitions type is detonated.

PK50(Met) - is similar to the PK15(met) except that it represents the peak noise level that is exceeded 50 percent of the time. This metric also accounts for weather but assumes conditions which are not favorable for noise propagation.

Propagation – the process by which sound travels through space or material; may be affected by such things as weather, terrain, and barriers.

Slant Distance – the straight-line distance between two points not at the same elevation as contrasted with ground distance. Also known as slant range.

Small Arms – conventional military weapons .50 caliber and below in diameter.

Sound Exposure Level (SEL) – the total energy of a sound event normalized to a specific amount of time (e.g., one second) so that sounds of different durations may be compared directly.

Unweighted Peak Sound Level – the peak, single event sound level without weighting, without taking into account berms or other attenuation, and without any particular certainty.

B LAND USE GUIDELINES

Land use recommendations vary based on the type of noise source. The Federal Interagency Committee on Urban Noise (FICUN, 1980) guidelines in Table B-1 are applicable to A-weighted noise sources such as aircraft and traffic. Using the FICUN guidelines, the Army in conjunction with recommendations of the National Academy of Sciences Committee on Hearing, Bioacoustics and Biomechanics (CHABA 1981), developed Noise Zone limits for weapons and explosive noise. Tables B-2 and B-3 contain land use recommendations for land within the weapons and explosive Noise Zones.

TABLE B-1. FICUN GUIDELINES

SLUCM No.	LAND USE	NOISE ZONES AND ADNL LEVELS (dBA)						
		Noise Zone I		Noise Zone II		Noise Zone III		
		0-55	55-65	65-70	70-75	75-80	80-85	85+
10	Residential							
11	Household Units	Yes	Yes*	25 ¹	30 ¹	No	No	No
12	Group Quarters	Yes	Yes*	25 ¹	30 ¹	No	No	No
13	Residential Hotels	Yes	Yes*	25 ¹	30 ¹	No	No	No
14	Mobile Home Parks or Courts	Yes	Yes*	No	No	No	No	No
15	Transient Lodgings	Yes	Yes*	25 ¹	30 ¹	35 ¹	No	No
16	Other Residential	Yes	Yes*	25 ¹	30 ¹	No	No	No
20, 30	Manufacturing							
21	Food & Kindred Products	Yes	Yes	Yes	Yes ²	Yes ³	Yes ⁴	No
22	Textile Mill Products	Yes	Yes	Yes	Yes ²	Yes ³	Yes ⁴	No
23	Apparel/Other Finished Products	Yes	Yes	Yes	Yes ²	Yes ³	Yes ⁴	No
24	Lumber & Wood Products	Yes	Yes	Yes	Yes ²	Yes ³	Yes ⁴	No
25	Furniture & Fixtures	Yes	Yes	Yes	Yes ²	Yes ³	Yes ⁴	No
26	Paper & Allied Products	Yes	Yes	Yes	Yes ²	Yes ³	Yes ⁴	No
27	Printing, Publishing & Allied Products	Yes	Yes	Yes	Yes ²	Yes ³	Yes ⁴	No
28	Chemicals & Allied Products	Yes	Yes	Yes	Yes ²	Yes ³	Yes ⁴	No
29	Petroleum Refining & Related Industries	Yes	Yes	Yes	Yes ²	Yes ³	Yes ⁴	No
31	Rubber & Misc Plastic Products - Manufacturing	Yes	Yes	Yes	Yes ²	Yes ³	Yes ⁴	No
32	Stone, Clay & Glass Products Manufacturing	Yes	Yes	Yes	Yes ²	Yes ³	Yes ⁴	No
33	Primary Metal Industries	Yes	Yes	Yes	Yes ²	Yes ³	Yes ⁴	No
34	Fabricated Metal Products - Manufacturing	Yes	Yes	Yes	Yes ²	Yes ³	Yes ⁴	No
25	Professional, Scientific & Controls	Yes	Yes	Yes	25	30	No	No
39	Miscellaneous Manufacturing	Yes	Yes	Yes	Yes ²	Yes ³	Yes ⁴	No
40	Transportation Communication & Utilities							
41	Railroad, Rapid Rail Transit & Street Rail	Yes	Yes	Yes	Yes ²	Yes ³	Yes ⁴	Yes ⁴
42	Motor Vehicle Transportation	Yes	Yes	Yes	Yes ²	Yes ³	Yes ⁴	Yes ⁴
43	Aircraft Transportation	Yes	Yes	Yes	Yes ²	Yes ³	Yes ⁴	Yes ⁴
44	Marine Craft Transportation	Yes	Yes	Yes	Yes ²	Yes ³	Yes ⁴	Yes ⁴
45	Highway & Street Right-of-Way	Yes	Yes	Yes	Yes ²	Yes ³	Yes ⁴	Yes ⁴
46	Automobile Parking	Yes	Yes	Yes	Yes ²	Yes ³	Yes ⁴	No
47	Communications	Yes	Yes	Yes	25 ⁵	30 ⁵	No	No
48	Utilities	Yes	Yes	Yes	Yes ²	Yes ³	Yes ⁴	Yes ⁴
49	Other Transportation, Communication & Utilities	Yes	Yes	Yes	25 ⁵	30 ⁵	No	No

TABLE B-1. FICUN GUIDELINES, cont'd

SLUCM No.	LAND USE	NOISE ZONES AND ADNL LEVELS (dBA)						
		Noise Zone I		Noise Zone II		Noise Zone III		85+
		0-55	55-65	65-70	70-75	75-80	80-85	
50	Trade							
51	Wholesale Trade	Yes	Yes	Yes	Yes ²	Yes ³	Yes ⁴	No
52	Retail - Building Materials, Hardware/Farm	Yes	Yes	Yes	Yes ²	Yes ³	Yes ⁴	No
53	Retail - General Merchandise	Yes	Yes	Yes	25	30	No	No
54	Retail - Food	Yes	Yes	Yes	25	30	No	No
55	Retail - Auto, Marine, Aircraft & Parts	Yes	Yes	Yes	25	30	No	No
56	Retail - Apparel & Accessories	Yes	Yes	Yes	25	30	No	No
57	Retail - Furniture, Furnishings & Equipment	Yes	Yes	Yes	25	30	No	No
58	Retail - Eating & Drinking Facilities	Yes	Yes	Yes	25	30	No	No
59	Other Retail Trade	Yes	Yes	Yes	25	30	No	No
60	Services							
61	Finance, Insurance & Real Estate Services	Yes	Yes	Yes	25	30	No	No
62	Personal Services	Yes	Yes	Yes	25	30	No	No
62.4	Cemeteries	Yes	Yes	Yes	Yes ²	Yes ³	Yes ⁴	Yes ⁶
63	Business Services	Yes	Yes	Yes	25	30	No	No
64	Repair Services	Yes	Yes	Yes	Yes ²	Yes ³	Yes ⁴	No
65	Professional Services	Yes	Yes	Yes	25	30	No	No
65.1	Hospitals, Nursing Homes	Yes	Yes*	25*	30*	No	No	No
65.1	Other Medical Facilities	Yes	Yes	Yes	25	30	No	No
66	Contract Construction Services	Yes	Yes	Yes	25	30	No	No
67	Government Services	Yes	Yes*	Yes*	25*	30*	No	No
68	Educational Services	Yes	Yes*	25*	30*	No	No	No
69	Miscellaneous Services	Yes	Yes	Yes	25	30	No	No
70	Cultural Entertainment & Recreational							
71	Cultural Activities, Including Churches	Yes	Yes*	25*	30*	No	No	No
71.2	Nature Exhibits	Yes	Yes*	Yes*	No	No	No	No
72	Public Assembly	Yes	Yes	Yes	No	No	No	No
72.1	Auditoriums, Concert Halls	Yes	Yes	25	30	No	No	No
72.11	Outdoor Music Shells, Amphitheaters	Yes	Yes*	No	No	No	No	No
72.2	Outdoor Sports Arenas, Spectator Sports	Yes	Yes	Yes ⁷	Yes ⁷	No	No	No
73	Amusements	Yes	Yes	Yes	Yes	No	No	No
74	Recreational Activities	Yes	Yes*	Yes*	25*	30*	No	No
75	Resorts, Groups & Camps	Yes	Yes*	Yes*	Yes*	No	No	No
76	Parks	Yes	Yes*	Yes*	Yes*	No	No	No
79	Other Cultural, Entertainment & Recreation	Yes	Yes*	Yes*	Yes*	No	No	No

TABLE B-1. FICUN GUIDELINES, cont'd

SLUCM No.	LAND USE	NOISE ZONES AND ADNL LEVELS (dBA)						
		Noise Zone I		Noise Zone II		Noise Zone III		
		0-55	55-65	65-70	70-75	75-80	80-85	85+
80	Resource Product & Extract							
81	Agriculture (Except Livestock) ¹¹	Yes	Yes	Yes ⁸	Yes ⁹	Yes ¹⁰	Yes ¹⁰	Yes ¹⁰
81.5 to 81.7	Livestock Farming & Animal Breeding	Yes	Yes	Yes ⁸	Yes ⁹	No	No	No
82	Agricultural Related Activities	Yes	Yes	Yes ⁸	Yes ⁹	Yes ¹⁰	Yes ¹⁰	Yes ¹⁰
83	Forestry Activities & Related Services	Yes	Yes	Yes ⁸	Yes ⁹	Yes ¹⁰	Yes ¹⁰	Yes ¹⁰
84	Fishing Activities & Related Services	Yes	Yes	Yes	Yes	Yes	Yes	Yes
85	Mining Activities & Related Services	Yes	Yes	Yes	Yes	Yes	Yes	Yes
89	Other Resource Production & Extraction	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes:

SLCUM Standard Land Use Coding Manual

Yes Land use and related structures compatible without restrictions.

No Land use and related structures are not compatible and should be prohibited.

ADNL A-weighted day-night sound level

Yes^x "Yes" but with restrictions. Land use and related structures generally compatible; see footnotes.

25, 30, 35 Land use and related structures generally compatible; measures to achieve noise level reduction (NLR) of 25, 30 or 35 must be incorporated into design and construction of structure.

25*, 30*, 35* Land use generally compatible with NLR; however, measures to achieve an overall NLR do not necessarily solve noise difficulties and additional evaluation is warranted.

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

Footnotes:

- * The designation of these uses as "compatible" in this zone reflects individual Federal agencies' 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.
- a) Although local conditions may require residential use, it is discouraged in 65-70 ADNL and strongly discouraged in 70-75 ADNL. The absence of viable alternative development options should be determined and an evaluation indicating that a demonstrated community need for residential use would not be met if development were prohibited in these zones should be conducted prior to approval.
 - b) Where the community determines that residential uses must be allowed, measures to achieve outdoor to indoor NLR of at least 25 dB (65-70 ADNL) and 30 dB (70-75 ADNL) should be incorporated into building codes and be considered in individual approvals. Normal construction can be expected to provide a NLR of 20 dB, thus the reduction requirements are often stated as 5, 10, or 15 dB over standard construction and normally assume mechanical ventilation and closed windows year round. Additional consideration should be given to modifying NLR levels based on peak noise levels.
 - c) NLR criteria will not eliminate outdoor noise problems. However, building location and site planning, design, and use of berms and barriers can help mitigate outdoor noise exposure particularly from ground level transportation sources. Measures that reduce noise at a site should be used wherever practical in preference to measures that only protect interior spaces.
- x² Measures to achieve NLR of 25 must be incorporated into the design and construction of portions of these buildings where the public is received, office areas, noise-sensitive areas, or where the normal noise level is low.
- x³ Measures to achieve NLR of 30 must be incorporated into the design and construction of portions of these buildings where the public is received, office areas, noise-sensitive areas, or where the normal noise level is low.
- x⁴ Measures to achieve NLR of 35 must be incorporated into the design and construction of portions of these buildings where the public is received, office areas, noise-sensitive areas, or where the normal noise level is low.
- x⁵ If noise-sensitive, use indicated NLR; if not, use is compatible.
- x⁶ No buildings.
- x⁷ Land use compatible provided special sound reinforcement systems are installed.
- x⁸ Residential buildings require a NLR of 25.
- x⁹ Residential buildings require a NLR of 30.
- x¹⁰ Residential buildings not permitted.
- x¹¹ In areas with ADNL greater than 80, land use not recommended, but if community decides use is necessary, hearing protection devices should be worn by personnel.

TABLE B-2. LAND USE COMPATIBILITY FOR SMALL ARMS NOISE

LAND USE		SUGGESTED LAND USE COMPATIBILITY	
SLUCM NO.	LAND USE NAME	Noise Zone II 87-104 dBP	Noise Zone III >104 dBP
10	Residential		
11	Household units	N ¹	N
11.11	Single units: detached	N ¹	N
11.12	Single units: semidetached	N ¹	N
11.13	Single units: attached row	N ¹	N
11.21	Two units: side-by-side	N ¹	N
11.22	Two units: one above the other	N ¹	N
11.31	Apartments: walk-up	N ¹	N
11.32	Apartment: elevator	N ¹	N
12	Group quarters	N ¹	N
13	Residential hotels	N ¹	N
14	Mobile home parks or courts	N ¹	N
15	Transient lodgings	25	N
16	Other residential	N ¹	N
20	Manufacturing		
21	Food and kindred products; manufacturing	Y ²	Y ³
22	Textile mill products; manufacturing	Y ²	Y ³
23	Apparel and other finished products; products made from fabrics, leather, and similar materials; manufacturing	Y ²	Y ³
24	Lumber and wood products (except furniture); manufacturing	Y ²	Y ³
25	Furniture and fixtures; manufacturing	Y ²	Y ³
26	Paper and allied products; manufacturing	Y ²	Y ³
27	Printing, publishing, and allied industries	Y ²	Y ³
28	Chemicals and allied products; manufacturing	Y ²	Y ³
29	Petroleum refining and related industries	Y ²	Y ³
30	Manufacturing (continued)		
31	Rubber and misc. plastic products; manufacturing	Y ²	Y ³
32	Stone, clay and glass products; manufacturing	Y ²	Y ³
33	Primary metal products; manufacturing	Y ²	Y ³
34	Fabricated metal products; manufacturing	Y ²	Y ³
35	Professional scientific, and controlling instruments; photographic and optical goods; watches and clocks	25	35
39	Miscellaneous manufacturing	Y ²	Y ³
40	Transportation, communication and utilities		
41	Railroad, rapid rail transit, and street railway transportation	Y ²	Y ³
42	Motor vehicle transportation	Y ²	Y ³
43	Aircraft transportation	Y ²	Y ³
44	Marine craft transportation	Y ²	Y ³
45	Highway and street right-of-way	Y ²	Y ³
46	Automobile parking	Y ²	Y ³
47	Communication	25	35
48	Utilities	Y ²	Y
49	Other transportation, communication and utilities	25	35

TABLE B-2. LAND USE COMPATIBILITY FOR SMALL ARMS NOISE, cont'd

LAND USE		SUGGESTED LAND USE COMPATIBILITY	
SLUCM NO.	LAND USE NAME	Noise Zone II 87-104 dBP	Noise Zone III >104 dBP
50	Trade		
51	Wholesale trade	Y ²	Y ³
52	Retail trade – building materials, hardware and farm equipment	25	35
53	Retail trade – including shopping centers, discount clubs, home improvement stores, electronics superstores, etc.	25	35
54	Retail trade – food	25	35
55	Retail trade – automotive, marine craft, aircraft and accessories	25	35
56	Retail trade – apparel and accessories	25	35
57	Retail trade – furniture, home, furnishings and equipment	25	35
58	Retail trade – eating and drinking establishments	25	35
59	Other retail trade	25	35
60	Services		
61	Finance, insurance and real estate services	25	35
62	Personal services	25	35
62.4	Cemeteries	Y ²	Y ³
63	Business services	25	35
63.7	Warehousing and storage	Y ²	Y ³
64	Repair services	Y ²	Y ³
65	Professional services	25	N
65.1	Hospitals, other medical facilities	N	N
65.16	Nursing homes	N	N
66	Contract construction services	25	35
67	Government services	25	35
68	Educational services	35	N
68.1	Child care services, child development centers, and nurseries	35	N
69	Miscellaneous		
69.1	Religious activities	35	N
70	Cultural, entertainment and recreational		
71	Cultural activities (& churches)	35	N
71.2	Nature exhibits	N	N
72	Public assembly	N	N
72.1	Auditoriums, concert halls	35	N
72.11	Outdoor music shells, amphitheaters	N	N
72.2	Outdoor sports arenas, spectator sports	N	N
73	Amusements	Y	N
74	Recreational activities (including golf courses, riding stables, water recreation)	N	N
75	Resorts and group camps	N	N
76	Parks	N	N
79	Other cultural, entertainment and recreation	N	N

TABLE B-2. LAND USE COMPATIBILITY FOR SMALL ARMS NOISE, cont'd

LAND USE		SUGGESTED LAND USE COMPATIBILITY	
SLUCM NO.	LAND USE NAME	Noise Zone II 87-104 dBP	Noise Zone III >104 dBP
80	Resource production and extraction		
81	Agriculture (except live- stock)	Y ⁴	Y ⁵
81.5	Livestock farming	Y ⁴	N
81.7	Animal breeding	Y ⁴	N
82	Agriculture related activities	Y ⁴	Y ⁵
83	Forestry activities	Y ⁴	Y ⁵
84	Fishing activities	Y	Y
85	Mining activities	Y	Y
89	Other resource production or extraction	Y	Y

Notes:

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

dBP- unweighted Peak decibel level

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

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

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

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

25, 30, or 35 – The numbers refer to noise level reduction (NLR) levels. NLR (outdoor to indoor) is achieved through the incorporation of noise attenuation into the design and construction of a structure. Land use and related

Note 1:

a. Although local requirements for on- or off-base housing may require noise-sensitive land uses within Noise Zone II, such land use is generally not recommended. The absence of viable alternative development options should be determined and an evaluation should be conducted locally prior to local approvals indicating that a demonstrated community need for the residential use would not be met if development were prohibited in these zones. Existing residential development is considered as pre-existing, non-conforming land uses.

b. Where the community determines that these uses must be allowed, measures to achieve outdoor to indoor NLR of at least 30 decibels (dB) in Noise Zone II should be incorporated into building codes and be considered in individual approvals.

c. Normal permanent construction can be expected to provide an NLR of 20 dB, thus the reduction requirements are often stated as 10 dB over standard construction and normally assume mechanical ventilation, upgraded sound transmission class ratings in windows and doors, and closed windows year round.

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

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

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

Note 4. Residential buildings require an NLR of 30.

Note 5. Residential buildings are not permitted.

TABLE B-3. LAND USE COMPATIBILITY: DEMOLITION AND LARGE ARMS NOISE

LAND USE		SUGGESTED LAND USE COMPATIBILITY		
SLUCM NO.	LAND USE NAME	LUPZ CDNL or CNEL 57-62	Noise Zone II CDNL or CNEL 62-70	Noise Zone III CDNL or CNEL 70+
10	Residential	Y ¹	N ^{2,3}	N ³
11	Household units	Y ¹	N ^{2,3}	N ³
11.11	Single units: detached	Y ¹	N ^{2,3}	N ³
11.12	Single units: semidetached	Y ¹	N ^{2,3}	N ³
11.13	Single units: attached row	Y ¹	N ^{2,3}	N ³
11.21	Two units: side-by-side	Y ¹	N ^{2,3}	N ³
11.22	Two units: one above the other	Y ¹	N ^{2,3}	N ³
11.31	Apartments: walk-up	Y ¹	N ^{2,3}	N ³
11.32	Apartment: elevator	Y ¹	N ^{2,3}	N ³
12	Group quarters	Y ¹	N ^{2,3}	N ³
13	Residential hotels	Y ¹	N ^{2,3}	N ³
14	Mobile home parks or courts	Y ¹	N ^{2,3}	N ³
15	Transient lodgings	Y	Y	N
16	Other residential	Y ¹	N ^{2,3}	N ³
20	Manufacturing			
21	Food and kindred products; manufacturing	Y	Y ⁴	Y ⁴
22	Textile mill products; manufacturing	Y	Y ⁴	Y ⁴
23	Apparel and other finished products; products made from fabrics, leather, and similar materials; manufacturing	Y	Y ⁴	Y ⁴
24	Lumber and wood products (except furniture); manufacturing	Y	Y ⁴	Y ⁴
25	Furniture and fixtures; manufacturing	Y	Y ⁴	Y ⁴
26	Paper and allied products; manufacturing	Y	Y ⁴	Y ⁴
27	Printing, publishing, and allied industries	Y	Y ⁴	Y ⁴
28	Chemicals and allied products; manufacturing	Y	Y ⁴	Y ⁴
29	Petroleum refining and related industries	Y	Y ⁴	Y ⁴
30	Manufacturing (continued)			
31	Rubber and misc. plastic products; manufacturing	Y	Y ⁴	Y ⁴
32	Stone, clay and glass products; manufacturing	Y	Y ⁴	Y ⁴
33	Primary metal products; manufacturing	Y	Y ⁴	Y ⁴
34	Fabricated metal products; manufacturing	Y	Y ⁴	Y ⁴
35	Professional scientific, and controlling instruments; photographic and optical goods; watches and clocks	Y	N	N
39	Miscellaneous manufacturing	Y	Y ⁴	Y ⁴
40	Transportation, communication and utilities			
41	Railroad, rapid rail transit, and street railway transportation	Y	Y	Y
42	Motor vehicle transportation	Y	Y	Y
43	Aircraft transportation	Y	Y	Y
44	Marine craft transportation	Y	Y	Y

TABLE B-3. LAND USE COMPATIBILITY: DEMOLITION AND LARGE ARMS NOISE, cont'd

LAND USE		SUGGESTED LAND USE COMPATIBILITY		
SLUCM NO.	LAND USE NAME	LUPZ CDNL or CNEL 57-62	Noise Zone II CDNL or CNEL 62-70	Noise Zone III CDNL or CNEL 70+
45	Highway and street right-of-way	Y	Y	Y
46	Automobile parking	Y	Y	Y
47	Communication	Y	N	N
48	Utilities	Y	Y	Y
49	Other transportation, communication and utilities	Y	Y	N
50	Trade			
51	Wholesale trade	Y	Y	N
52	Retail trade – building materials, hardware and farm equipment	Y	Y	N
53	Retail trade – including shopping centers, discount clubs, home improvement stores, electronics superstores, etc.	Y	Y	N
54	Retail trade – food	Y	Y	N
55	Retail trade – automotive, marine craft, aircraft and accessories	Y	Y	N
56	Retail trade – apparel and accessories	Y	Y	N
57	Retail trade – furniture, home, furnishings and equipment	Y	Y	N
58	Retail trade – eating and drinking establishments	Y	Y	N
59	Other retail trade	Y	Y	N
60	Services			
61	Finance, insurance and real estate services	Y	Y	N
62	Personal services	Y	Y	N
62.4	Cemeteries	Y	Y	Y
63	Business services	Y	Y	N
63.7	Warehousing and storage	Y	Y ⁴	Y ⁴
64	Repair services	Y	Y	N
65	Professional services	Y	Y	N
65.1	Hospitals, other medical facilities	Y ¹	N	N
65.16	Nursing homes	Y ¹	N	N
66	Contract construction services	Y	Y	N
67	Government services	Y	Y	N
68	Educational services	Y ¹	N	N
68.1	Child care services, child development centers, and nurseries	Y ¹	N	N

TABLE B-3. LAND USE COMPATIBILITY: DEMOLITION AND LARGE ARMS NOISE, cont'd

LAND USE		SUGGESTED LAND USE COMPATIBILITY		
SLUCM NO.	LAND USE NAME	LUPZ CDNL or CNEL 57-62	Noise Zone II CDNL or CNEL 62-70	Noise Zone III CDNL or CNEL 70+
69	Miscellaneous			
69.1	Religious activities	Y ¹	N	N
70	Cultural, entertainment and recreational			
71	Cultural activities (& churches)	Y ¹	N	N
71.2	Nature exhibits	Y ¹	N	N
72	Public assembly	Y ¹	N	N
72.1	Auditoriums, concert halls	Y ¹	N	N
72.11	Outdoor music shells, amphitheaters	Y ¹	N	N
72.2	Outdoor sports arenas, spectator sports	Y	N	N
73	Amusements	Y	Y	N
74	Recreational activities (including golf courses, riding stables, water recreation)	Y	N	N
75	Resorts and group camps	Y	N	N
76	Parks	Y	N	N
79	Other cultural, entertainment and recreation	Y	N	N
80	Resource production and extraction			
81	Agriculture (except live- stock)	Y	Y	Y
81.5	Livestock farming	Y	N	N
81.7	Animal breeding	Y	N	N
82	Agriculture related activities	Y	Y	Y
83	Forestry activities	Y	Y	Y
84	Fishing activities	Y	Y	Y
85	Mining activities	Y	Y	Y
89	Other resource production or extraction	Y	Y	Y

Note 1: LUPZ- Land Use Planning Zone is a subdivision of Land Use Zone I and functions as a buffer for Noise Zone II. Communities and individuals often have different views regarding acceptable or desirable levels of noise. To address this, some local governments have implemented land use planning measures beyond Noise Zone II limits. In addition to mitigating current noise impacts, implementing such controls within the LUPZ can create a buffer to prevent the possibility of future noise conflicts.

Note 2: Although local requirements for on- or off-base housing may require noise-sensitive land uses within Noise Zone II, such land use is generally not compatible within Noise Zone II. Measures to achieve overall noise level reduction inside structures do not solve noise difficulties outside the structure. Barriers are not effective reducing the noise from artillery and armor, the detonation of either large caliber military munitions or a large quantity of explosives. Additionally, noise level reduction inside structures does not mitigate the vibration generated by the low-frequency energy of large caliber weapons firing and detonations.

Note 3: Within Zones, existing “noise sensitive land uses are considered as pre-existing incompatible land uses. In most cases these uses are not a risk to either mission sustainment or a community’s quality of life. Most long-term members near Army installations or activities acknowledge hearing military operations and activities but they are usually not alarmed or bothered by the noise.

Note 4: Although noise levels may be compatible, caution should be exercised in siting any activity which may be sensitive to vibration.

D REFERENCES

DOD, 2015, Department of Defense Instruction 4165.57, Air Installations Compatible Use Zones (AICUZ), May 2011, as amended March 2015.

DODI, 2004, Department of Defense Instruction 3030.3, Joint Land Use Study (JLUS) Program.

FICUN, 1980, Guidelines for Considering Noise in Land Use Planning and Control.

Fort Knox, 2008, Fort Knox Kentucky, Joint Land Use Study Update, Prepared by the Lincoln Trail Area Development District for the Fort Knox JLUS Executive Committee, June 2008.

Fort Knox, 2016, Fort Knox Regulation 95-1, Aviation, Fort Knox Flight Rules, Directorate of Plans, Training, Mobilization and Security: Airfield Division, April 2016.

Fort Knox, 2016a, Range Component Master Plan Report, Directorate of Plans, Training, Mobilization and Security, December 2016.

Fort Knox, 2017, US Army Garrison Fort Knox, Real Property Master Plan Digest, Directorate of Public Works, January 2017.

Fort Knox, 2017a, Significant Fort Knox Facts, Fort Knox Public Affairs Office, August 2017.

Hardin County, 2014, Planning For Growth, Comprehensive Development Guide: 2014 Comprehensive Plan, Hardin County Planning and Development Commission.

Pater, 1976, "Noise Abatement Program for Explosive Operations at NSWC/DL," Presented at the 17th Explosives Safety Seminar of the DOD Explosives Safety Board.

Public Law 92-574, 1972, 92nd U.S. Congress, Noise Control Act of 1972.

Public Law 95-609, 1978, 95th U.S. Congress, Quiet Communities Act of 1978.

Rylander, *et al.*, 1974, "Re-Analysis of Aircraft Noise Annoyance Data against the dBA Peak Concept," Journal of Sound and Vibration, Volume 36, pages 399-406.

Siskind, 1989, "Vibrations and Airblast Impacts on Structures from Munitions Disposal Blasts," Proceedings, Inter-Noise 89, G. C. Maling, JR., editor, pages 573-576.

University of Utah, 1958, Explosives Research Group Report No. 12, Measurement of Air and Ground Shock Disturbances Arising from Demolition Activities at Letterkenny Ordnance Depot.

U.S. Air Force, 2005, SELcalc2 Noise Model, Wright-Patterson Air Force Base, OH.

U.S. Air Force, 2013, Noisemap – BaseOps 7.357 - AAM, Wright-Patterson Air Force Base, OH.

U.S. Army 1983, USAEHA Environmental Noise Assessment No. 52-34-0415-83, Noise Levels from Machine Guns, Grenade and Artillery simulators from Training at Sudbury Annex, Fort Devens, MA, 23-24 March 1983.

U.S. Army, 1984, Army Environmental Hygiene Agency, Environmental Noise Assessment No. 52-34-0442-84, Noise Measurement Study, Camp Bullis, Texas, 27 February – 2 March 1984.

U.S. Army 1989, USAEHA Environmental Noise Assessment No. 52-34-0447-89, Results of Monitoring Edgewood Area Field Training Exercise Site, Aberdeen Proving Ground, MD, June 1989.

U.S. Army, 1999, Center for Health Promotion and Preventive Medicine, Health Hazard Assessment Report on the 40mm XM1001 Canister Cartridge for the MK-19 Mod 3 Grenade Machine Gun, No. 69-37-2735-00, November 1999.

U.S. Army, 2007, Army Regulation 200-1, Environmental Protection and Enhancement, Chapter 14 Operational Noise.

U.S. Army, 2009, U.S. Army Center for Health Promotion and Preventive Medicine, Operational Noise Program, U.S. Army Fort Knox Installation Operational Noise Management Plan, September 2009.

U.S. Army, 2009a, U.S. Army Construction Engineering Research Laboratories, BNOISE2 Computer Model, Version 1.3 2009-11. 30.

U.S. Army, 2015, U.S. Army Engineer Research and Development Center (ERDC), SARNAM Computer Model, Version 2015-07-27

U.S. Army Knox, 2018. Homepage, URL: <http://www.knox.army.mil>

U.S. Census Bureau, 2018. Homepage, URL: <http://www.census.gov>