Impulse Blast Noise Analysis

Technical Report for
Marine Corps Installations National Capital Region - Marine Corps Base Quantico

Prepared for:

Marine Corps Installations Command Government and External Affairs, G-7
Marine Corps Installations National Capital Region - Marine Corps Base Quantico, Virginia

March 2016

.

Prepared by:

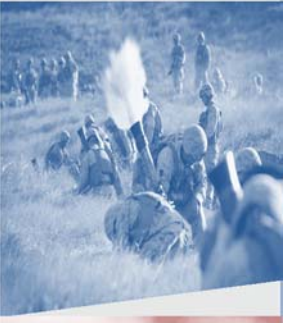
Cardno
Shaping the Future

Under Direction of:

Naval Facilities Engineering Command Atlantic

NAVFAC
Naval Facilities Engineering Command

Contract No. N62470-10-D-3008



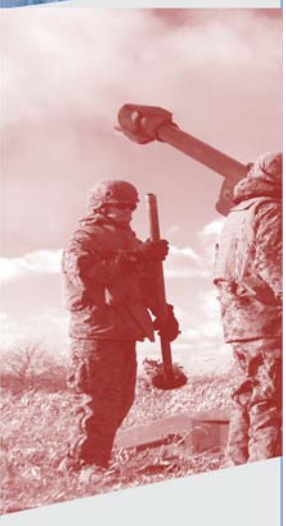


TABLE OF CONTENTS

EXECUTIVE SUMMARY iii

1.0 INTRODUCTION 1

2.0 BACKGROUND 3

3.0 NOISE MODELING METHODOLOGY AND NOISE METRICS 7

3.1 Noise and Noise Metrics 7

3.2 Noise Modeling 8

4.0 MODEL RESULTS AND ANALYSIS 11

4.1 Model Results 11

4.2 Comparison With Average Noise Level Analysis 13

4.3 Noise Sensitive Areas and Noise Complaints 18

4.4 Community-Enacted Peak Noise Land Use Compatibility Examples 20

4.4.1 Clay County, Florida 22

4.4.2 Fairbanks North Star Borough, Alaska 22

4.4.3 Riley County, Kansas 22

4.4.4 City of Fayetteville, North Carolina 23

5.0 CONCLUSION AND RECOMMENDATIONS 25

6.0 REFERENCES 27

APPENDIX A ACRONYMS AND ABBREVIATIONS 32

APPENDIX B RANGE FACILITY MANAGEMENT SUPPORT SYSTEM DATA 36

List of Figures

Figure ES-1 Combined View of Noise Zones and Peak Noise Contours iv

Figure 1-1. General Location of MCINCR-MCBQ 2

Figure 2-1. JLUS (2014) Noise Buffers for Impulsive Noise at MCINCR-MCBQ 4

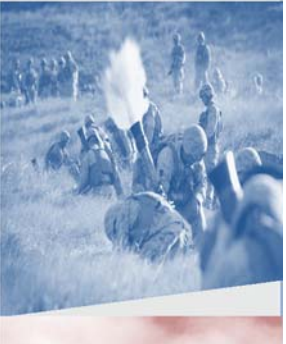
Figure 4-1. PK_{15} Contours for Impulsive Noise at MCINCR-MCBQ. 12

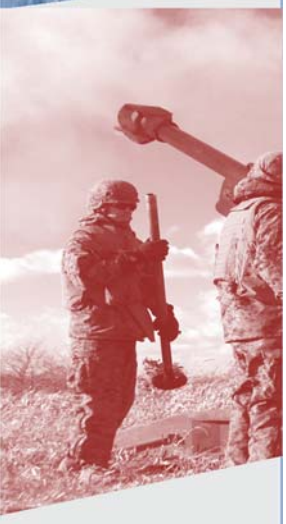
Figure 4-2. CDNL Noise Zones for Large Caliber Weapons at MCINCR-MCBQ 15

Figure 4-3 Combined View of Noise Zones and Peak Noise Contours 17

Figure 4-4. Schools, Churches, and Medical Facilities in the Vicinity of MCINCR-MCBQ 19

Figure 4-5. Noise Complaints Recorded for MCINCR-MCBQ from 2011 to 2013 21





List of Tables

Table ES-1. Risk of Noise Complaints from Impulsive Noise iii

Table 3-1. Risk of Noise Complaints from Impulsive Noise 7

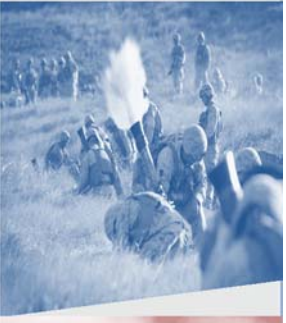
Table 4-1. Calculated Acreages within the Modeled Pk_{15} Contours 11

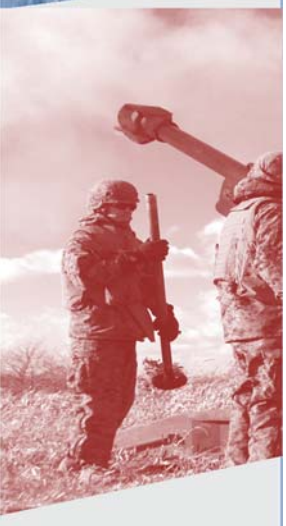
Table 4-2. Population and Housing Estimates within the Modeled Pk_{15} Contours 11

Table 4-3. Noise Zone Definitions for Impulsive Noise 13

Table 4-4. Off-Range Acreage, Housing, and Population Estimates within CDNL Contours[a] 14

Table 4-5. Estimated Peak Noise Levels at Schools in Vicinity of MCINCR-MCBQ 18





EXECUTIVE SUMMARY

At Marine Corps Installations National Capital Region - Marine Corps Base Quantico (MCINCR-MCBQ), noise can be classified as continuous or impulsive, with continuous noise being defined as a sound that has a gradual onset and duration of greater than a few seconds, such as sound resulting from vehicle traffic or aircraft over-flight. Impulsive noise is defined as sudden noise, with rapid onset and a brief duration. This type of noise would result from firing large caliber weapons and from explosive detonations. It can be startling to those nearby, as there is little to no warning of the noise event. The MCINCR-MCBQ noise environment is dominated by impulsive noise, primarily due to activities at the Range Training Area (RTA).

This Impact Blast Noise Analysis Technical Report provides mapping of peak noise contours (using the noise metric Pk_{15}[1]) that indicate areas on- and off-base affected by impact blast noise associated with large caliber weapons and explosives used in operations and training exercises at MCINCR-MCBQ. The analysis of peak noise and development of Pk_{15} noise contours are actions recommended by the Department of Defense (DOD) Noise Working Group to provide communities and decision-makers with a better sense of the overall noise environment when training is occurring. This report supplements the prior average (C-weighted Day-Night Average Noise Level [CDNL]) noise exposure analysis and mapping conducted as part of the MCB Quantico 2006 Range Compatible Use Zone (RCUZ) Study. This study does not affect the MCINCR-MCBQ's RCUZ noise zones and associated land use compatibility recommendations.

The Pk_{15} noise contours provide another useful tool in communicating noise impacts in a simplified manner to those living and/or working near an active range. The U.S. Army Public Health Command has developed guidance tables to assist in predicting the potential for annoyance to the local community, and the potential for military activities generating noise complaints (Table ES-1).

Table ES-1. Risk of Noise Complaints from Impulsive Noise

Risk of Noise Complaint	Sound Level (Pk_{15})	Perceptibility
Low	<115 dB	Audible
Medium	115 to 130 dB	Occasionally noticeable, distinct, may notice vibration/rattle
High	130 to 140 dB	Occasionally very loud, may startle

Source: DOD Noise Working Group 2013a.

Figure ES-1 depicts the Pk_{15} contours and CDNL contours together. It is important to note that this figure displays contours from two different noise metrics and was developed using two different models and datasets. The CDNL contours are from the 2006 RCUZ, which used 2004 data and projected to 2009 conditions. The Pk_{15} contours are from this analysis, which is based on 2014 data. These two contours capture different aspects of the noise and cannot be compared or evaluated in the same manner. Land use recommendations are based on the CDNL, while Pk_{15} indicates the probability of receiving noise complaints based on individual

[1] Pk_{15} is the calculated peak noise level, without frequency weighting, expected to be exceeded by 15 percent of all events that might occur.

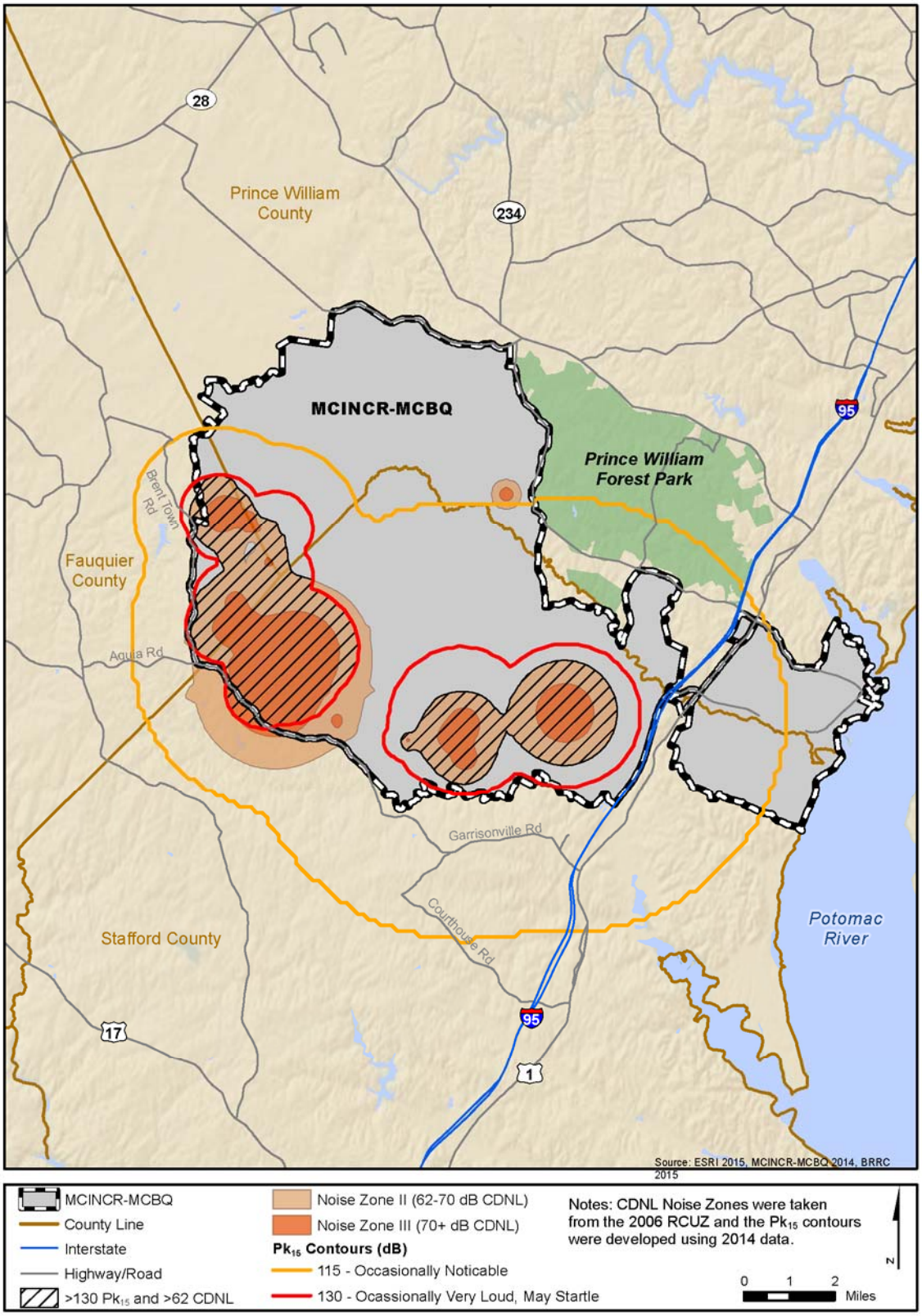
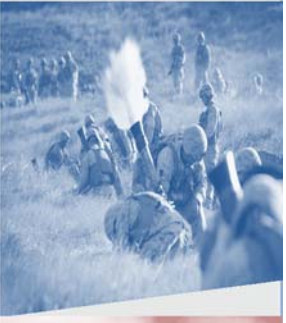
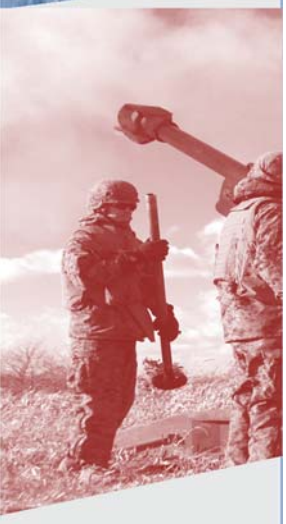


Figure ES-1 Combined View of Noise Zones and Peak Noise Contours





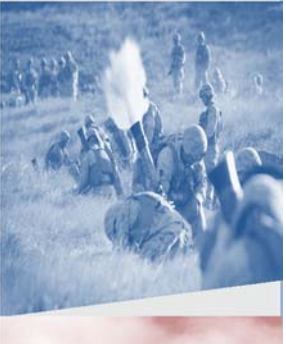
blasts. The intent is to provide a composite view of the two data sets to give an indication of the complete noise environment. While the noise exposure within the contours may vary in duration and/or loudness, occupants within these zones will likely at some point hear training and be aware that they are near a military installation.

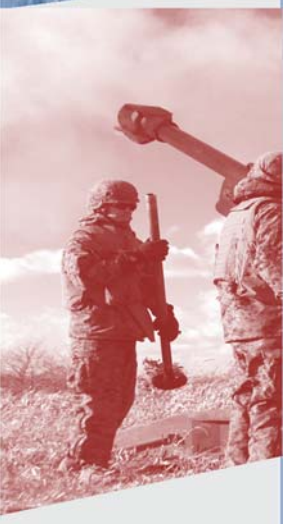
The analysis of MCINCR-MCBQ's peak noise exposure found:

- Pk_{15} noise levels in excess of 140 decibels (dB) peak – the threshold level for damage to human hearing, – is in proximity to range training areas and does not extend off base.
- Structural damage is improbable in areas below the Pk_{15} 140 dB level; therefore, no off-base structures should be damaged from impulsive noise.
- Some portion of the 130 dB and greater Pk_{15} contour falls off-base in western Stafford County, where it overlaps with the CDNL, or average, Noise Zone III and a small area of Noise Zone II.
- A portion of the off-base area within the 115-130 dB contour in western Stafford County is within CDNL Noise Zones II and III. Additionally, in Fauquier County there is a small area near Brent Town Road where the 130 dB and greater Pk_{15} contour overlaps with CDNL Noise Zone II. The vast majority of the off-base land within the 115-130 dB contour is not within Noise Zone II or III. This generally indicates that, although this area is exposed to impulsive noise events, these areas are subject to lower average levels of noise than those areas within Noise Zones II and III.
- The ranges of modeled Pk_{15} noise levels correspond with a risk of noise complaints from impulsive noise as follows:
    - High risk of noise complaints (>130 dB peak, which is typically perceived by the public as "very loud-may startle"): 18,473 acres on-base and 569 acres off-base with some residential areas with an estimated 82 households and resident population of 255, 1 church, and no schools, or medical facilities.
    - Medium risk of noise complaints (115-130 dB peak, perceived by the public as "noticeable and distinct"): 23,337 acres on-base and 34,204 acres off-base with some residential areas with an estimated 17,815 households and resident population of 55,305 as well as 15 schools, 31 churches, and 9 medical facilities (but no hospitals).

While there are no specific DOD/Army Operational Noise program recommendations on implementation of land use controls within the PK_{15} 115 dB and 130 dB noise contours, additional land use planning or controls may be determined to be necessary by the surrounding jurisdictions to limit or preclude noise sensitive land uses within these zones. It is important to stress that the PK_{15} 115 dB and 130 dB noise contours present peak noise exposure, and do not communicate how often training is heard. This is captured in the average (CDNL) noise zones included in the MCINCR-MCBQ RCUZ. Surrounding communities may want to consider frequency of events, which may influence the public's perception of the noise, in implementing proactive planning initiatives; these could include:

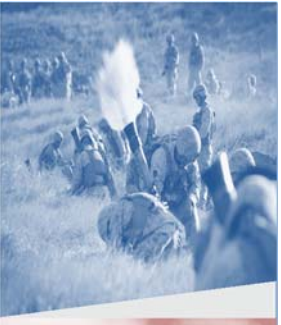
- Real estate disclosure statements that could reduce the likelihood of noise-sensitivity moving into an area impacted by impulse noise.

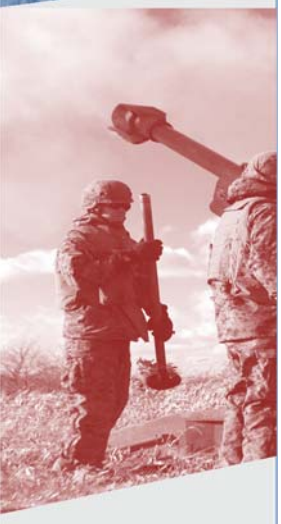




- Encroachment planning, including partnering with the Federal government and other interested stakeholders, to acquire development rights or restrictive use easements on conservation, open, working lands, etc. to place such lands in protective status that would preclude their development and incompatible uses.
- Additional land use planning or controls to limit or preclude noise sensitive land uses within the PK_{15} 115 dB and 130 dB noise contours.

The MCB Quantico 2014 Joint Land Use Study (JLUS) recommended the documentation and modeling of impulse/peak noise at MCINCR-MCBQ (Stafford County, Prince William County, Fauquier County, and MCINCR-MCBQ 2014); taking action on this recommendation was the impetus for this study.





1.0 INTRODUCTION

Marine Corps Installations National Capital Region-Marine Corps Base Quantico (MCINCR-MCBQ) is located on the west bank of the Potomac River, approximately 35 miles south of Washington, D.C., and approximately 20 miles north of Fredericksburg, Virginia (Figure 1-1). The United States Marine Corps (USMC) completed noise modeling for large caliber weapons and explosives used at MCINCR-MCBQ in June of 2015. This effort grew out of the desire to report the potential impulse blast noise-related impacts associated with such uses to the surrounding community in a more understandable way, and to leverage newer modeling methods that may result in more dependability in estimating noise impacts. Impulse blast noise is noise generated during the use of large caliber weapons, artillery, and explosive charges. This report discusses the past processes used to determine noise impacts from impulsive noise, describes the newer modeling methodology employed, and provides a comparison of the two methods. The scope of this analysis is limited to the modeling and impact analysis associated with large caliber weapon and explosive use at MCINCR-MCBQ. Therefore, this report does not provide a comprehensive analysis of noise conditions or potential impacts from all noise-producing activities that occur at MCINCR-MCBQ (e.g., small arms training and aircraft operations).

Section 2 describes the general background of MCINCR-MCBQ and how impulsive noise was reported in the past. Section 3 discusses the noise modeling methodology and general noise metrics used for the analysis. Section 4 describes the model output, compares that to past predictions, and discusses noise sensitive areas and noise complaints. Finally, Section 5 offers conclusions and recommendations.

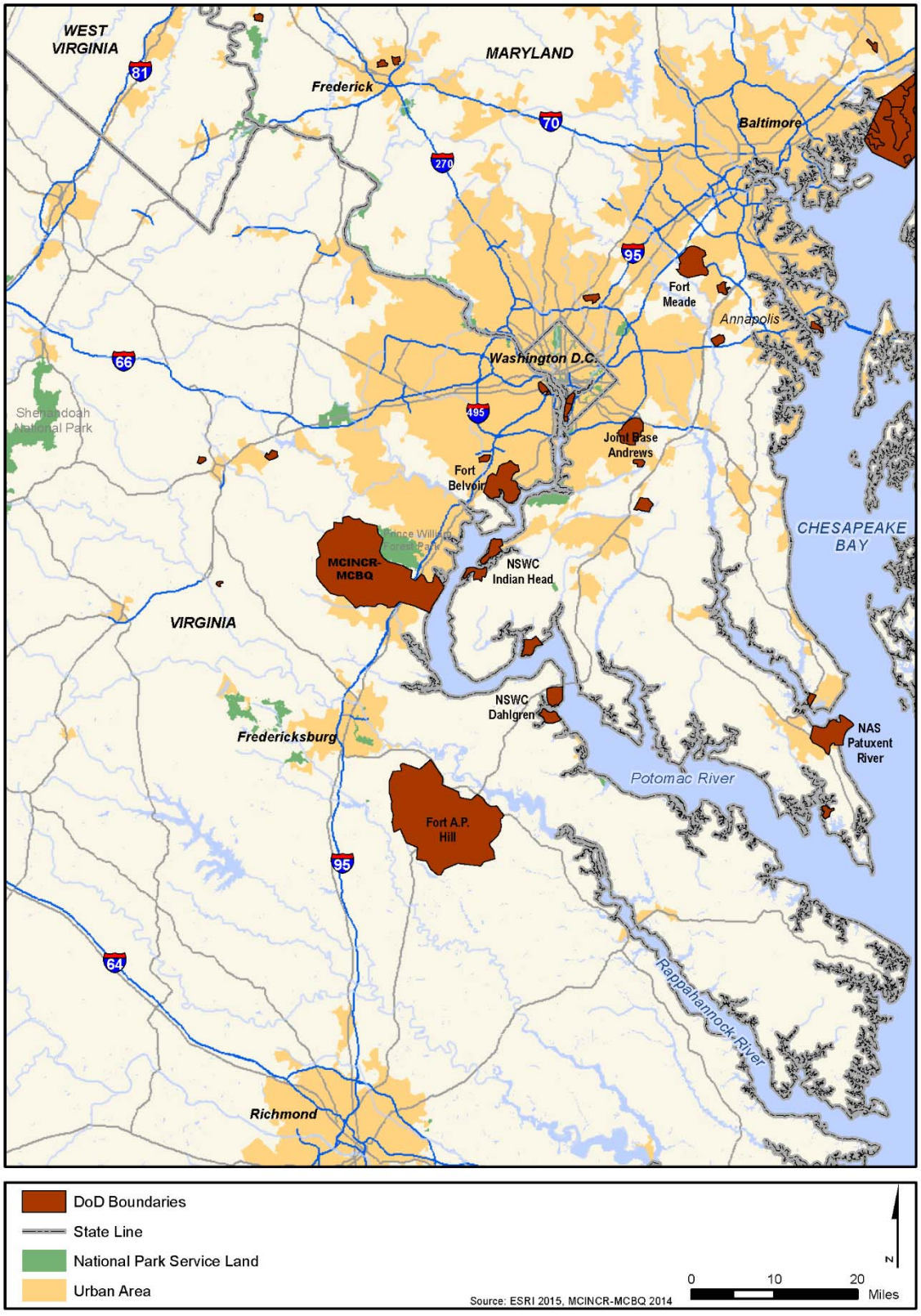
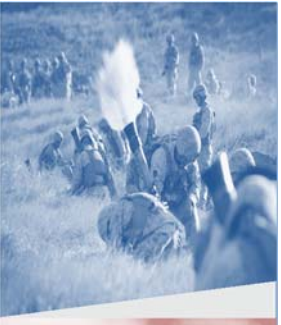
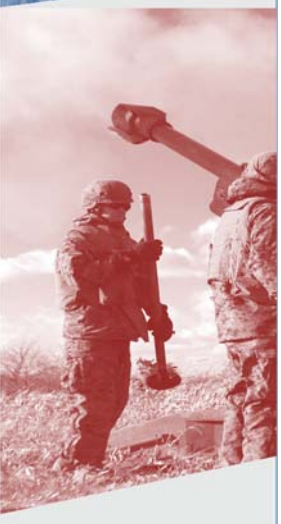


Figure 1-1. General Location of MCINCR-MCBQ





2.0 BACKGROUND

MCINCR-MCBQ is an installation with an important military training mission that involves an active Range Training Area (RTA). The activities that occur at the MCINCR-MCBQ RTA, which are vital for national security, generate loud noises that may impact local communities well outside the installation boundary. Any restrictions or limitations on training (e.g., reducing air and ground combat exercises and explosive ordnance demolition training) would diminish the effectiveness of live fire training and reduce the ability of the United States Marine Corps (USMC) to protect the interests of the United States.

MCINCR-MCBQ is home to several USMC education and training programs and is where all USMC officers begin their training. The Federal Bureau of Investigation Academy and Crime Laboratory and the Drug Enforcement Agency training facilities are also located within the base boundary. Because of its location, its large training areas, and the multitude of USMC, other federal, state, and local users, MCINCR-MCBQ and its RTA complex are in high demand and are valuable national defense assets. The RTA is used to conduct realistic air and ground combat exercises and explosive ordnance demolition training. The ranges can accommodate all weapons normally found in an infantry battalion, including artillery.

When first established in the mid-1940s, the ranges west of United States (U.S.) Interstate 95 were located in rural, sparsely populated rolling hills above the Potomac River. Since that time, the Washington, D.C. Metropolitan Area has rapidly expanded, and the region has experienced development of communities along the Potomac and in Stafford County to the south. Today, much of the area surrounding MCINCR-MCBQ is developed with residential and commercial land uses. Because residential and commercial spaces are located in proximity to the RTA, it is extremely important to determine potential impacts to those residents and facilities that are located off-base and away from the noise associated with the training that occurs on base. Additionally, it is important to be able to effectively report those potential impacts to local community planners, leaders, and the general public.

In the past, due to limitations in modeling capability, MCINCR-MCBQ reported potential peak noise impacts using standard, fixed distances from an impulsive noise source. Specifically, in the 2006 Range Compatible Use Zone (RCUZ) Study and MCB Quantico 2014 Joint Land Use Study (JLUS), the potential for impacts from impulse noise are represented as follows:

- A map that depicts 1-, 3-, and 5-mile radius distances from existing impulse noise source locations (Figure 2-1).
- Multiple tables that present probabilities for calculated peak sound pressure levels (Lpk) at these various distances with various noise sources (artillery, ground charges, etc.) (Stafford County, Prince William County, Fauquier County, and MCINCR-MCBQ 2014).

The utility of this type of analysis is limited, as this method does not take into account all impulsive noise sources, each source is calculated individually, and results are presented in a fairly complex table.

The Department of Defense (DOD) Noise Working Group now recommends the development of peak contours, and the 2014 JLUS recommended the documentation and modeling of impulse/peak noise at MCINCR-MCBQ (Stafford County, Prince William County, Fauquier County, and MCINCR-MCBQ 2014). Peak noise contours are intended to provide communities

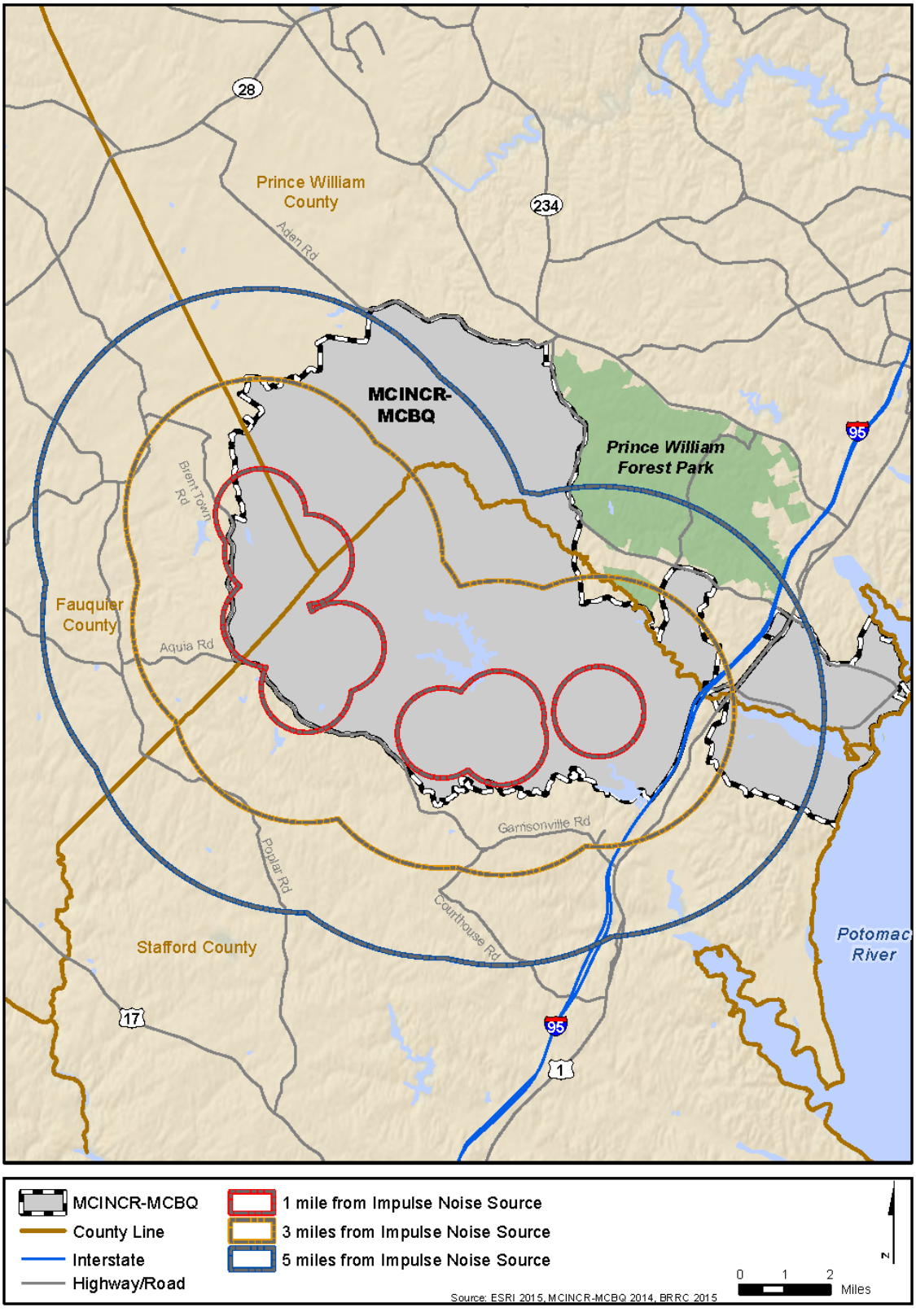
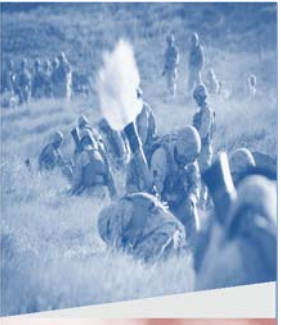
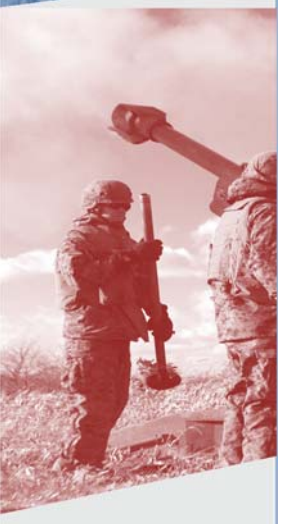


Figure 2-1. JLUS (2014) Noise Buffers for Impulsive Noise at MCINCR-MCBQ

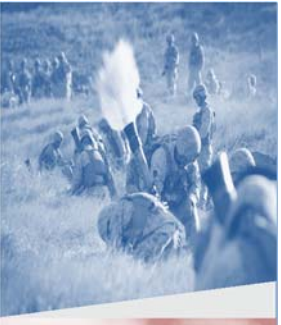


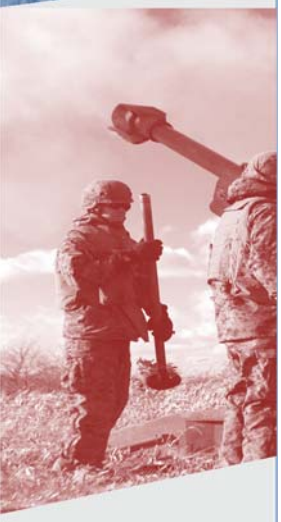


and decision-makers with a better sense of the actual noise environment when training is occurring. The peak contours supplement other noise contours based on averaged sound levels.

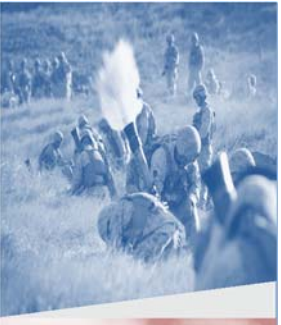
While there are no specific DOD/Army Operational Noise program recommendations on implementation of land use controls within peak noise contours, additional land use planning or controls may be determined to be necessary by the surrounding jurisdictions to limit or preclude noise sensitive land uses within these zones. It is important to stress that the peak noise contours present peak noise exposure, and do not communicate how often training is heard. This is captured in the average (C-weighted Day-Night Average [CDNL]) noise zones included in the MCINCR-MCBQ RCUZ. Surrounding communities may want to consider frequency of events, which may influence the public's perception of the noise, in implementing proactive planning initiatives; these could include:

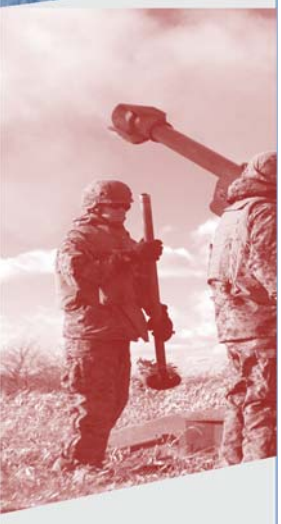
- Real estate disclosure statements that could reduce the likelihood of noise-sensitivity moving into an area impacted by impulse noise.
- Encroachment planning, including partnering with the Federal government and other interested stakeholders to purchase development rights or acquire restrictive use easements on conservation, open, working lands, etc., in order to place such lands in a protective status that would preclude their development and uses incompatible with the military training mission.
- Additional land use planning or controls to limit or preclude noise sensitive land uses within the PK_{15} 115 decibels (dB) and 130 dB noise contours.





(This page intentionally left blank)





3.0 NOISE MODELING METHODOLOGY AND NOISE METRICS

3.1 NOISE AND NOISE METRICS

Noise is a prominent issue in the vicinity of military installations, especially if those installations include ranges and/or aircraft operations. At MCINCR-MCBQ, noise can be classified as continuous or impulsive, with continuous noise being defined as a sound that has a gradual onset and duration of greater than a few seconds, such as sound resulting from vehicle traffic or aircraft over-flight. Impulsive noise is defined as sudden noise, with rapid onset and a brief duration. This type of noise would result from firing large caliber weapons and from explosive detonations. This type of noise can be startling to those nearby, as there is little to no warning of the noise event.

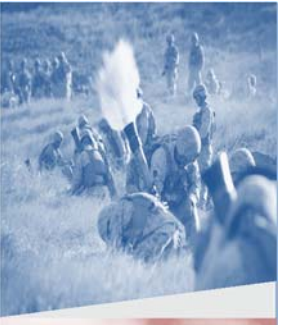
MCINCR-MCBQ is dominated by impulsive noise, primarily due to activities at the RTA. Noise metrics for modeling and reporting impulsive noise are generally the Day-Night Average Sound Level (DNL) and Lpk. The DNL metric is a cumulative measure of sound energy that takes into account sound levels occurring over a 24-hour period. This metric is the federally recommended metric for reporting cumulative community noise exposure. For large caliber weapons, this metric is "C" weighted, to account for vibration and low frequency noise impacts. This is commonly referred to as CDNL. The Lpk metric measures the highest instantaneous, un-weighted sound level over any given time period. This metric is used to quantify impulsive noise, and to ascertain the probability of noise complaints from the local community. More specifically, the Lpk 15 (typically reported as Pk_{15}) is the metric where the sound level reported is expected to be exceeded by 15 percent of all events that might occur. Conversely, this would indicate that 85 percent of all events would be less than the calculated Pk_{15} values. The Pk_{15} metric is represented as a contour line on a map, with areas outside a contour line having a lesser value, and areas inside a contour having greater value. As an example, if 100 artillery rounds were fired at MCINCR-MCBQ, 85 would produce sound levels below the estimated contour line, while 15 rounds would exceed the contours' value. The U.S. Army Public Health Command has developed guidance tables to assist in predicting the potential for annoyance to the local community, and the potential for military activities generating noise complaints. Table 3-1 shows these values.

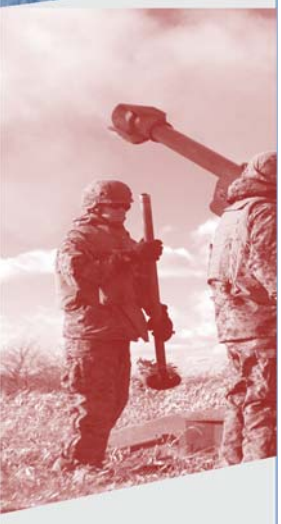
Table 3-1. Risk of Noise Complaints from Impulsive Noise

Risk of Noise Complaint	Sound Level (Pk_{15})	Perceptibility
Low	<115 dB	Audible
Medium	115 to 130 dB	Occasionally noticeable, distinct, may notice vibration/rattle
High	130 to 140 dB	Occasionally very loud, may startle

Source: DOD Noise Working Group 2013a.

Peak levels above 140 dB represent the threshold for permanent physiological damage to unprotected human ears and structural damage claims (Department of the Army 2007). It is widely recognized that structural damage is improbable below 140 dB Peak (DOD Noise Working Group 2013a). Peak levels in the low 120 dBs may cause the rattling of windows or loose ornaments (e.g., pictures on walls) which can annoy occupants, but are below levels necessary to cause structural damage (DOD Noise Working Group 2013a).



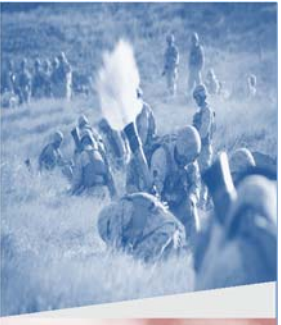


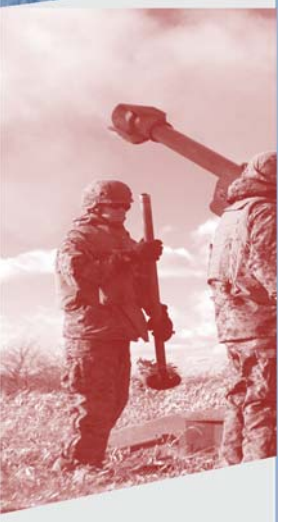
With respect to non-auditory health effects, the reaction of people to a given noise environment is extraordinarily complicated. The scientific community has dedicated considerable effort since the mid-1950s researching noise metrics and associated noise levels that best relate to community response to noise. This research has centered around two types of effects: psychological effects (long-term community annoyance, speech interference, sleep disturbance, effects on children's learning, and interference with work performance) and physiological effects (primarily noise-induced hearing loss, as well as other postulated medical health effects such as cardiovascular disease). Most of this research has been focused on aircraft noise. With respect to blast noise, the CDNL metric is correlated with long-term community annoyance and the peak noise analysis provides additional information on the risk of complaints from blast noise and physiological effects of hearing loss at the peak exposure threshold of 140 dB (DOD Noise Working Group 2013b, U.S. Army Public Health Command 2014). Current research concludes that it is as yet impossible to determine causal relations between health disorders and noise exposure, despite well-founded hypotheses. However, these findings do not exclude the possibility that noise can result in adverse health effects indirectly. Exposure to high noise levels can elevate blood pressure and also stress hormone levels. However, the response to loud noise is typically short in duration. After the noise stops, the physiological effects reverse and the levels return back to normal (DOD Noise Working Group 2009).

In the 2006 MCB Quantico RCUZ study, CDNL contours for the current and projected future (2009) range activities on the installation were estimated using noise modeling software. The 2006 RCUZ study did not model Pk_{15} contours for operations at MCINCR-MCBQ. The purpose of the Impulse Blast Noise Analysis from July 2015 is to provide the modeling results and an explanation for range operations at MCINCR-MCBQ, as reported in only the Pk_{15} metric. It is important to note that CDNL and Pk_{15} contours cannot be directly compared to one another because they measure different aspects of impulse noise. CDNL contours measure the average sound energy over a 24-hour period. This would include the intense sound energy from artillery and large caliber weapons as well as the long periods of quiet that occur at MCINCR-MCBQ in a 24-hour period. Pk_{15} is not a measure of average noise. Instead, Pk_{15} is a measure of single event noise, specifically the single loudest noise event at any point on the map, with no accounting for either the frequency of occurrence, the number and magnitude of lesser impulse noise events, or any periods of quiet between noise events.

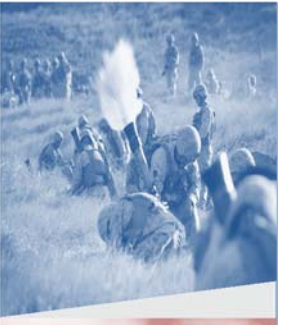
3.2 Noise Modeling

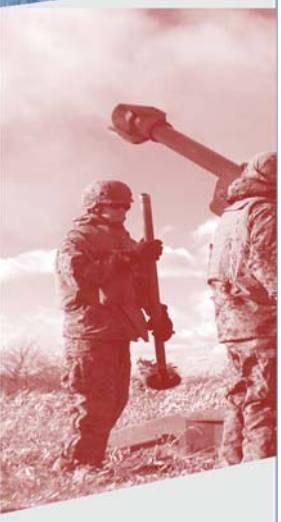
The U.S. Government-owned Blast Noise Version 2 Noise Modeling Software (BNoise2) was used to noise model the Pk_{15} metric. BNoise2 is the standard DOD-approved software for assessing potential noise impacts from large weapons (20 millimeter [mm] and greater) and explosives. BNoise2 considers the type of weapon and ammunition, number and time of rounds fired, range attributes, and weather. It also accounts for the spectrum and directivity of muzzle blast and projectile sonic boom, which facilitates accurate calculation of propagation and frequency weighting.



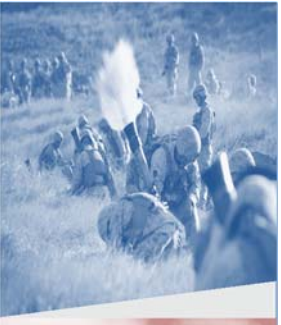


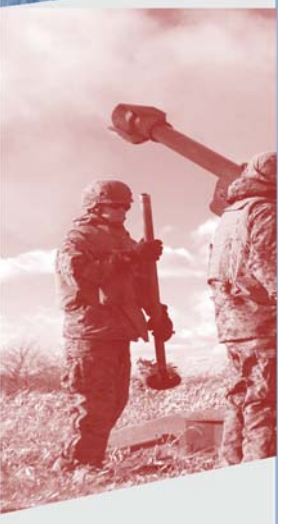
For the July 2015 Impulse Blast Noise effort, 2014 Range Facility Management Support System (RFMSS) data provided by MCINCR-MCBQ (Appendix B) was used as the basic input for the noise modeling. The MCINCR-MCBQ RTA is available for use 24/7, 365 days per year. However, most use is between 0700 and 2200 hours, on non-federal holiday weekdays. A combined total of 2,450 training events (which can include multiple noise-producing training activities) occur at the RTA live-fire ranges annually. The three demolition ranges are scheduled for a combined total of approximately 460 events annually.





(This page intentionally left blank)





4.0 MODEL RESULTS AND ANALYSIS

4.1 MODEL RESULTS

The output of the BNoise2 modeling is a set of noise contours. For this effort, two contour lines were provided: the 130 dB Pk_{15} and the 115 dB Pk_{15}. These two lines represent where 15 percent of the time, sound level would be expected to exceed 130 and 115 dB. These contours can be seen in Figure 4-1. No 140 dB Pk_{15} noise contour was generated. As noted in Section 3-1, hearing conservation is not a concern until peak noise levels reach 140 dB.

As discussed in Section 3.0, the 115 and 130 dB Pk_{15} sound levels were selected to coincide with the risk for noise complaints as shown in Table 3-1. The 130 dB Pk_{15} contour is almost completely contained within the MCINCR-MCBQ boundary (Figure 4-1). However, approximately 570 acres of the 130 dB Pk_{15} area is off-base, primarily along the west side of the installation. The 115 dB-130 Pk_{15} area extends well off-base, mainly to the west and south. Approximately 34,204 acres of the land within the 115-130 dB Pk_{15} area are off-base. Table 4-1 shows the calculated acreages within the modeled contours for both on- and off-base, with "on-base" being defined as within the property line of MCINCR-MCBQ.

Table 4-1. Calculated Acreages within the Modeled Pk_{15} Contours

Noise Level (Pk_{15})	Acreage		
	On Base	Off Base	Total
115-130 dB	23,337	34,204	57,541
>130 dB	18,473	569	19,042
Total	***41,810***	***34,773***	***76,583***

The modeled results cover a similar area and are within the 5-mile noise buffers that MCINCR-MCBQ used in the past for assessing the potential impacts from impulsive noise to the surrounding communities (see Figure 2-1). There is a high degree of similarity between the 1-mile buffer and the area within the 130 dB Pk_{15} contour. There are no off-base areas within the130 dB Pk_{15} contour that are not within the 1-mile buffer area. However, the area within the 115-130 dB Pk_{15} contour does not align with the distance buffers. The area within the 115-130 dB Pk_{15} contour extends almost to the 5-mile buffer to the northeast, east, and southeast of the RTA, but is within the 3-mile buffer to the north and west of the base. To the south of the RTA, the area within the 115-130 dB Pk_{15} contour is generally between the 3- and 5-mile buffer.

The estimated population and number of housing units were also calculated within the modeled contours. Population and household numbers are estimations based on the 2010 Census data. These estimations are derived by assuming an equal distribution of population and households within each census block, then applying what percentage of the land area of the block falls within the modeled contours. This is a somewhat imprecise estimation of population and housing because population tends to be clustered in certain areas and sparse in others. The Census block data also included on-base population and housing numbers.

Table 4-2. Population and Housing Estimates within the Modeled Pk_{15} Contours

Noise Level (Pk_{15})	Estimated Population[1]	Estimated Households
115-130 dB	55,305	17,815
>130 dB	255	82
Total	***55,560***	***17,897***

Source: U.S. Census Bureau 2010; Blue Ridge Research and Consulting 2015.

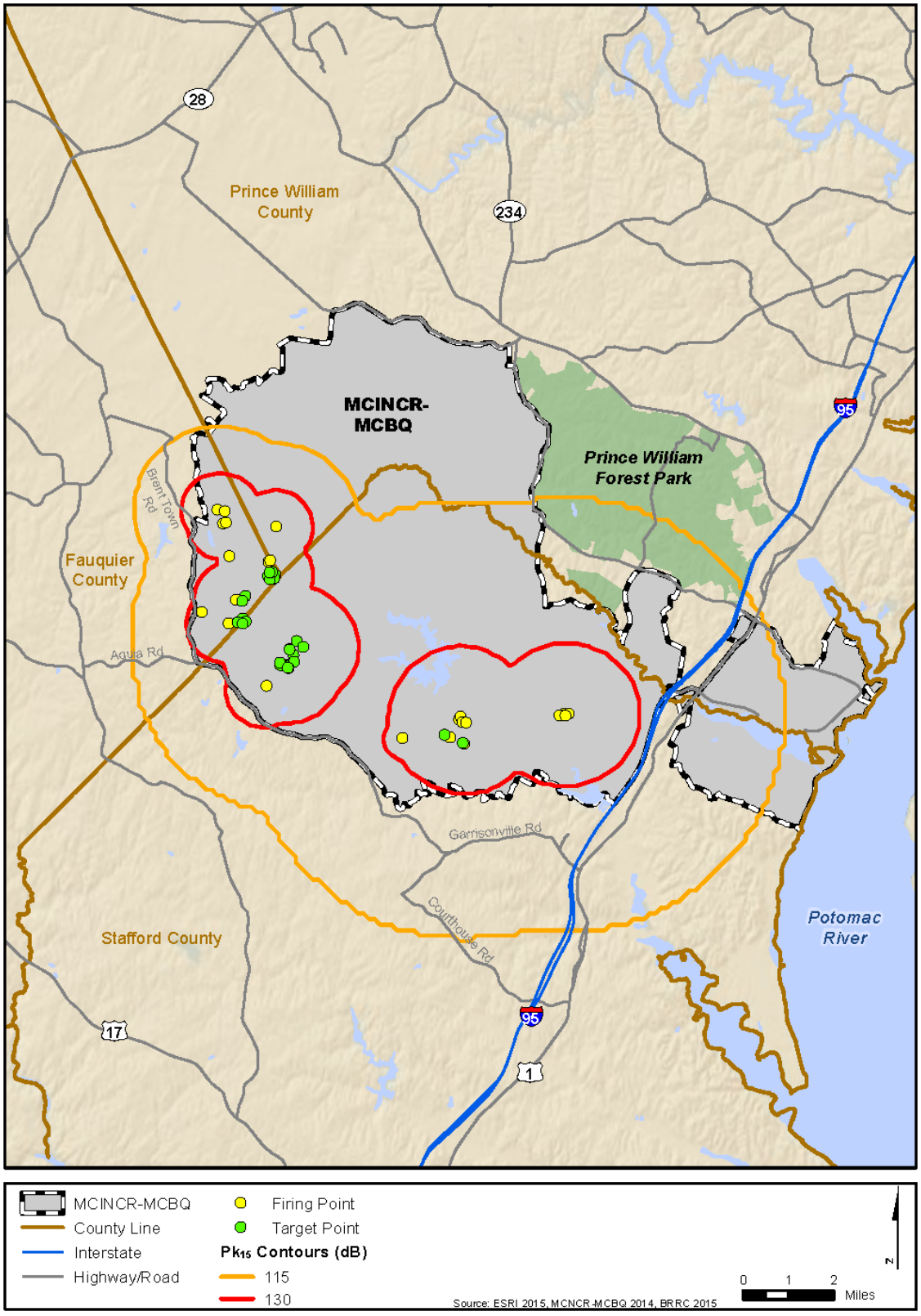
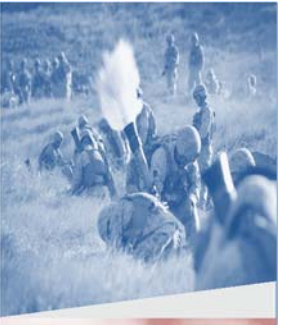
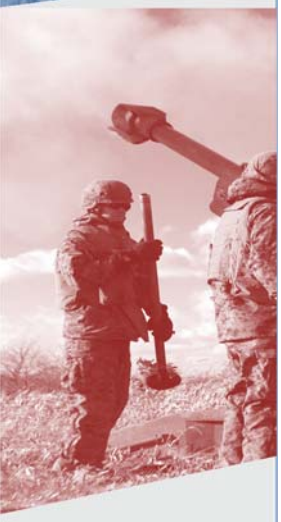


Figure 4-1. PK_{15} Contours for Impulsive Noise at MCINCR-MCBQ.





4.2 Comparison With Average Noise Level Analysis

DOD Instruction 4165.57, *Air Installation Compatible Use Zones Program*; Marine Corps Order 11010.36, *Air Installation Compatible Use Zones Program*; and Marine Corps Order 3550.11, *Range Air Installations Compatible Use Zones Program,* provide recommendation for compatible land use within noise zones for average aircraft noise levels. Within DOD, the Army Operational Noise program (outlined in Chapter 14 of Army Regulation 200-1) addresses all operational noise types and is the lead program addressing blast noise. The Army guidance provides guidelines for land use compatibility (Department of the Army 2007). The average noise exposure on a community is translated into noise zones, defined by the averaged dB levels of impulsive noise (CDNL) within these zones (Table 4-3). The recommendations for sensitive land use (e.g., housing, hospitals, and schools) summarized in Table 4-3 are further detailed below.

- Although local conditions such as availability of developable land or costs may require noise-sensitive land uses in Zone III, noise-sensitive land uses are not considered compatible and are strongly discouraged in Zone III; considered an area of severe noise exposure.
- Noise sensitive land uses are generally not compatible in Noise Zone II; considered an area of substantial noise exposure. All viable alternatives should be explored to limit non-sensitive activities such as industry, manufacturing, transportation, and agriculture within this zone.
- Noise sensitive land uses are generally acceptable within Noise Zone I; an area of moderate to minimal noise exposure. While Noise Zone I may be subject to lower average noise exposure levels, military operations may be loud enough to be noticeable or distinct on occasion.
- The Land Use Planning Zone is a subdivision of Noise Zone I, where noise exposure is 5 dB less than Noise Zone I. Noise sensitive land uses are generally acceptable in this zone.

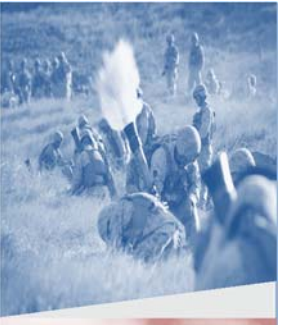
While noise-sensitive land uses are generally acceptable within Noise Zone I and the Land Use Planning Zone, communities and individuals often have different views regarding what level of noise is acceptable or desirable. Local governments may choose to implement land use planning measures within these zones to address these differences and prevent possible future noise conflicts.

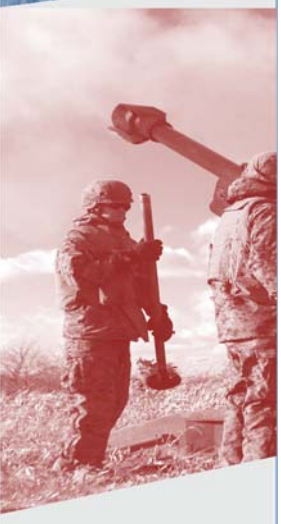
Table 4-3. Noise Zone Definitions for Impulsive Noise

Noise Zone	Impulsive (CDNL)	Noise Sensitive Land Use Recommendations
Land Use Planning Zone	57-62	Generally acceptable
I	<62	Generally acceptable
II	62-70	Strongly discouraged
III	>70	Not recommended

Source: Army Public Health Command 2005, DOD 2011, Department of the Navy 2008.
Notes: Noise sensitive land uses include housing, schools, and medical facilities.

The CDNL contours developed for the 2006 RCUZ Study for MCINCR-MCBQ are shown in Figure 4-2. Because these contours are derived from an average of sound levels over a given





period (including long periods of quiet), they are much smaller in size that the 115 dB and greater Pk_{15} contours reported in this analysis.

Table 4-4 shows the estimated households and population within Noise Zones II and III. Residential areas that fall within Noise Zones II and III are considered incompatible, as residential land use is considered a noise sensitive use that is not recommended in Noise Zone II or III. The 63 residential units that are estimated to fall within Noise Zone III are within Stafford County along the southwestern edge of the installation. While the area is not overly populated, these residents have the potential to have the greatest amount of disturbance from impulsive noise.

Table 4-4. Off-Range Acreage, Housing, and Population Estimates within CDNL Contours[a]

Noise Zone	Estimated Impacts		
	Acres	Households	Population
II (62-70 dB)	1,893	528	1,590
III (>70 dB)	286	63	194

Source: MCB Quantico 2006, U.S Census Bureau 2010.
Note: a. Because these estimate are based on 2010 U.S. Census data, they are different from those reported in the 2006 RCUZ.

This impulsive noise analysis modeled Pk_{15} contours for large caliber weapons and detonations at MCINCR-MCBQ (see Figure 4-1). The Pk_{15} metric is used to report the potential for noise complaints by the surrounding community. The Pk_{15} metric can also be described as "occasionally noticeable" for the 115 dB Pk_{15} contour, or "occasionally loud, may startle" for areas within the 130 dB Pk_{15} contour. While this metric does not trigger specific DOD land use recommendations, it can assist communities to make informed decisions with regard to developing high-density residential areas or noise sensitive facilities in areas nearby an installation. Noise sensitive uses such as residences, schools, churches, and hospitals are considered less compatible within the 115 dB and greater Pk_{15} noise contour. Within the 130 dB Pk_{15} contour, the community may want to consider land use controls to preclude noise sensitive land uses, given the high risk of complaints.

In instances where MCINCR-MCBQ operations may only generate infrequent high peak levels in the community, land use controls may not be warranted, though prior public notification should be given. The Pk_{15} metric, used to describe impulsive noise, does not provide information about the frequency of noise events. How often an individual receptor within the Pk_{15} contours is exposed to noise events of a particular magnitude varies greatly, based on both location of the receptor and the location and type of operation causing the noise event at MCINCR-MCBQ. The best representation of frequency of noise events is the CDNL contour, as this metric provides the cumulative exposure and takes into account both the magnitude of each type of event, and how often each event occurs. Because CDNL does not provide a very good measure of the maximum magnitude of the impulse noise that may be experienced, it is often presented in conjunction with an impulse noise study (using Pk_{15}), so that both maximum noise level and total average noise energy are represented.

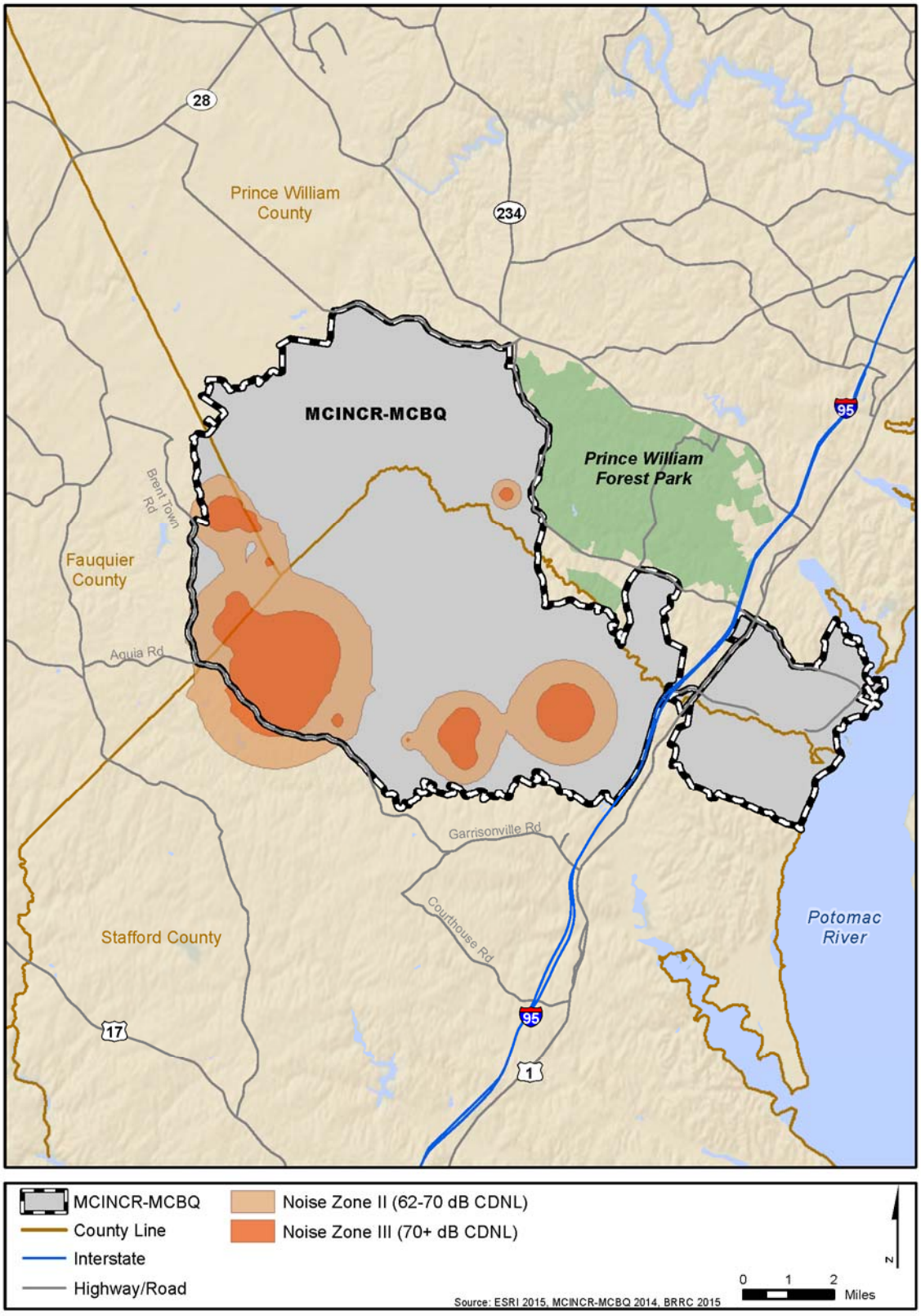
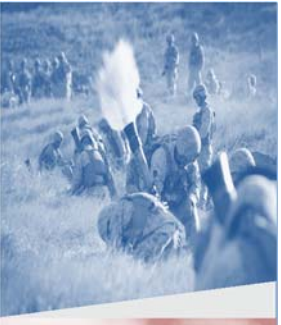


Figure 4-2. CDNL Noise Zones for Large Caliber Weapons at MCINCR-MCBQ



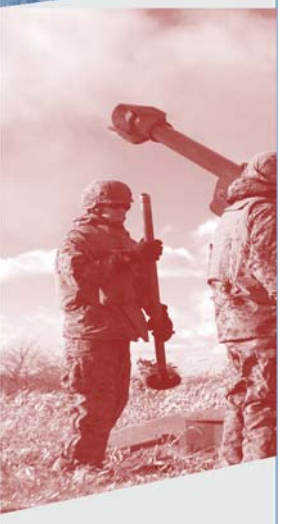


Figure 4-3 depicts the Pk_{15} contours (see Figure 4-1) and CDNL contours (see Figure 4-2) together. It is important to note that Figure 4-1 displays contours from two different noise metrics developed using two different models and datasets. The CDNL contours are from the 2006 RCUZ, which used 2004 data and projected to 2009 conditions. The Pk_{15} contours are from this analysis, which is based on 2014 data. **These two contours capture different aspects of noise and cannot be compared or evaluated in the same ways.** Land use recommendations are based on the CDNL, while Pk_{15} indicate the probability of receiving noise complaints based on individual blasts. The intent is to provide a composite view of the two data sets to give an indication of the complete noise environment. While the noise exposure within the contours may vary in duration and/or loudness, occupants within these zones will likely at some point hear training and be aware that they are near a military installation.

The combined noise exposure map shows that some portion of the 130 dB and greater Pk_{15} contour falls off-base in western Stafford County, where it overlaps with CDNL, or average, Noise Zone III and a small area of Noise Zone II. A portion of the off-base area within the 115-130 dB contour in western Stafford County is within CDNL Noise Zones II and III. Additionally, in Fauquier County there is a small area near Brent Town Road where the 130 dB and greater Pk_{15} contour overlaps with CDNL Noise Zone II. The vast majority of the off-base land within the 115-130 dB contour is not within Noise Zone II or III.

In summary, the combined CDNL Noise Zones and Pk_{15} noise exposure map provides a more complete picture of the noise environment, which the installation and the community can use to focus compatible land use efforts. This analysis shows that the majority of the noise effects and the majority of incompatible land use pressures in the vicinity of MCINCR-MCBQ occur in Stafford County.

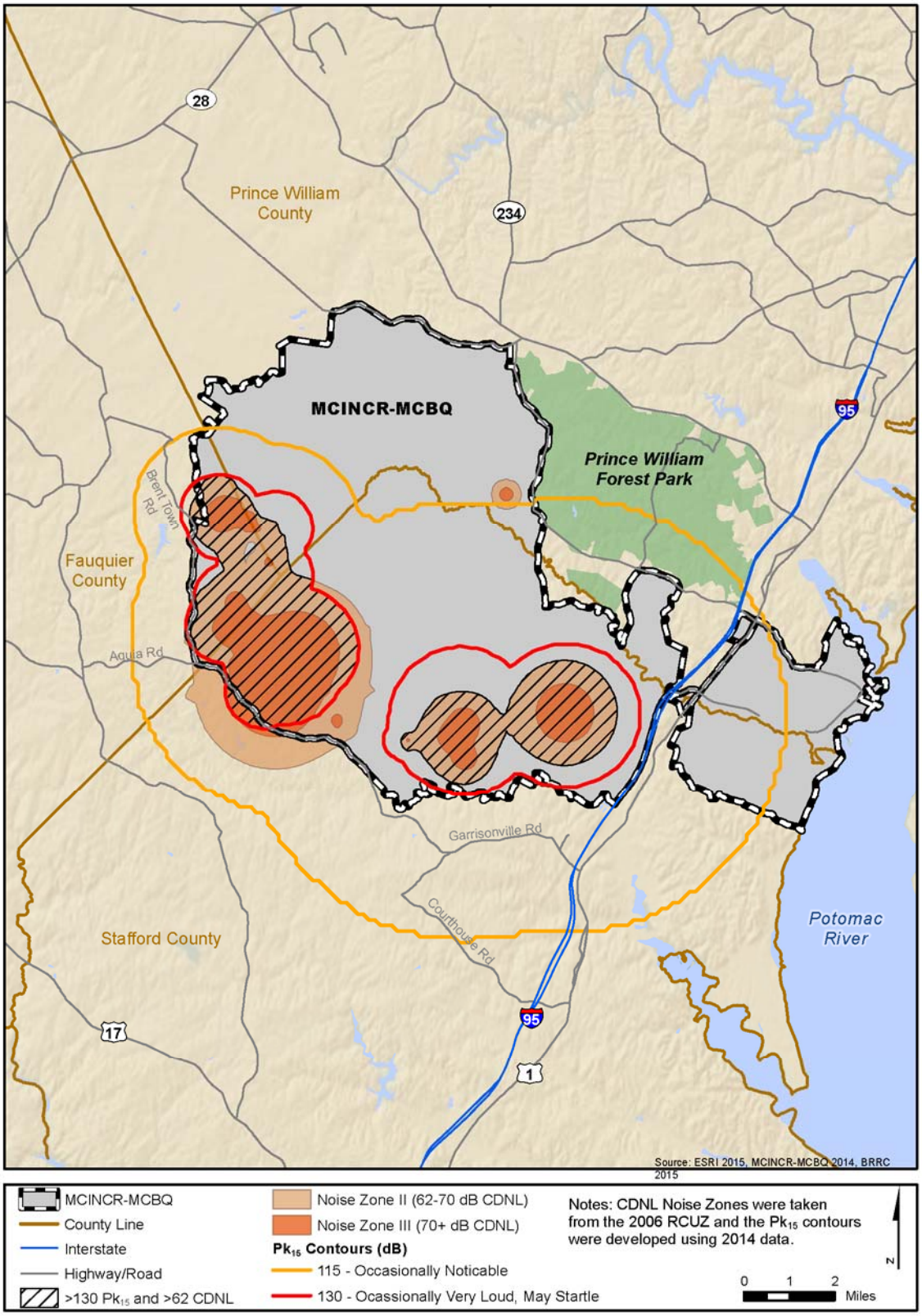
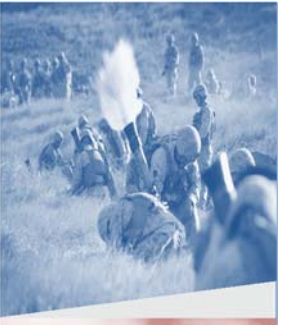
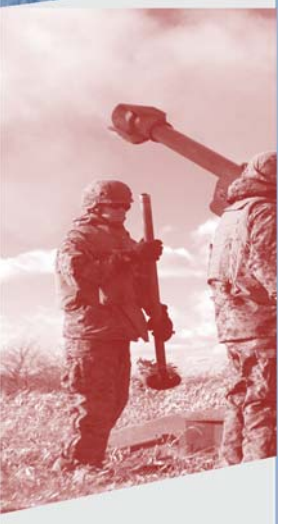


Figure 4-3 Combined View of Noise Zones and Peak Noise Contours





4.3 Noise Sensitive Areas and Noise Complaints

This technical report provides additional analysis on housing and school sensitive land uses within the peak noise contours. The housing estimates provided in Table 4-2 include the following:

- Areas within the 130 dB and greater Pk_{15} contour, where there is a high risk of noise complaints: a few housing units at the north ends of Kimberwick Lane and Toluca Road on Aquia Creek; portions of subdivisions to the southwest of Garrisonville Road near the Stafford County/Fauquier County line, and rural residential areas along Brent Town Road in Fauquier County. All of these areas are in proximity to the MCINCR-MCBQ boundary.
- Areas within the 115-130 Pk_{15} contour band, where there is a medium risk of noise complaints: the predominance of the housing is in the Garrisonville area.

Schools, medical facilities, and churches within the peak noise contours are depicted in Figure 4-4. Of the 16 schools located in the vicinity of MCINCR-MCBQ, only one (Anthony Burns Elementary) school is outside of the 115 dB Pk_{15} contour (Figure 4-4), where there is a low risk of noise complaints. The remaining schools are located within the 115-130 Pk_{15} area that has a medium risk of noise complaints. Schools nearest to the MCINCR-MCBQ boundary would likely experience greater impulsive noise impacts on occasion. The estimated Pk_{15} noise level at each of the schools is presented in Table 4-5. These results indicate that Kate Waller Barret Elementary has the greatest potential for a noise level of 126 dB Pk_{15}. This school is also located the closest to the 130 dB Pk_{15} contour. The proposed location for the Moncure Elementary School will also locate the new school closer to the 130 dB Pk_{15} contour. No schools are located within the 130 dB and greater Pk_{15} contour.

Table 4-5. Estimated Peak Noise Levels at Schools in Vicinity of MCINCR-MCBQ

ID	Name	Noise Level (Pk_{15})
1	A.G. Wright Middle	<122 dB
2	Anthony Burns Elementary	<115 dB
3	Garrisonville Elementary	<122 dB
4	H.H. Poole Middle	<118 dB
5	Hampton Oaks Elementary	<118 dB
6	Kate Waller Barret Elementary	<126 dB
7	Margaret Brent Elementary	<117 dB
8	Moncure Elementary	<122 dB
9	Mountain View High	<117 dB
10	North Stafford High	<121 dB
11	Park Ridge Elementary	<120 dB
12	Rockhill Elementary	<123 dB
13	Rodney E. Thompson Middle	<117 dB
14	Shirley C. Heim Middle	<122 dB
15	Widewater Elementary	<121 dB
16	Winding Creek Elementary	<116 dB

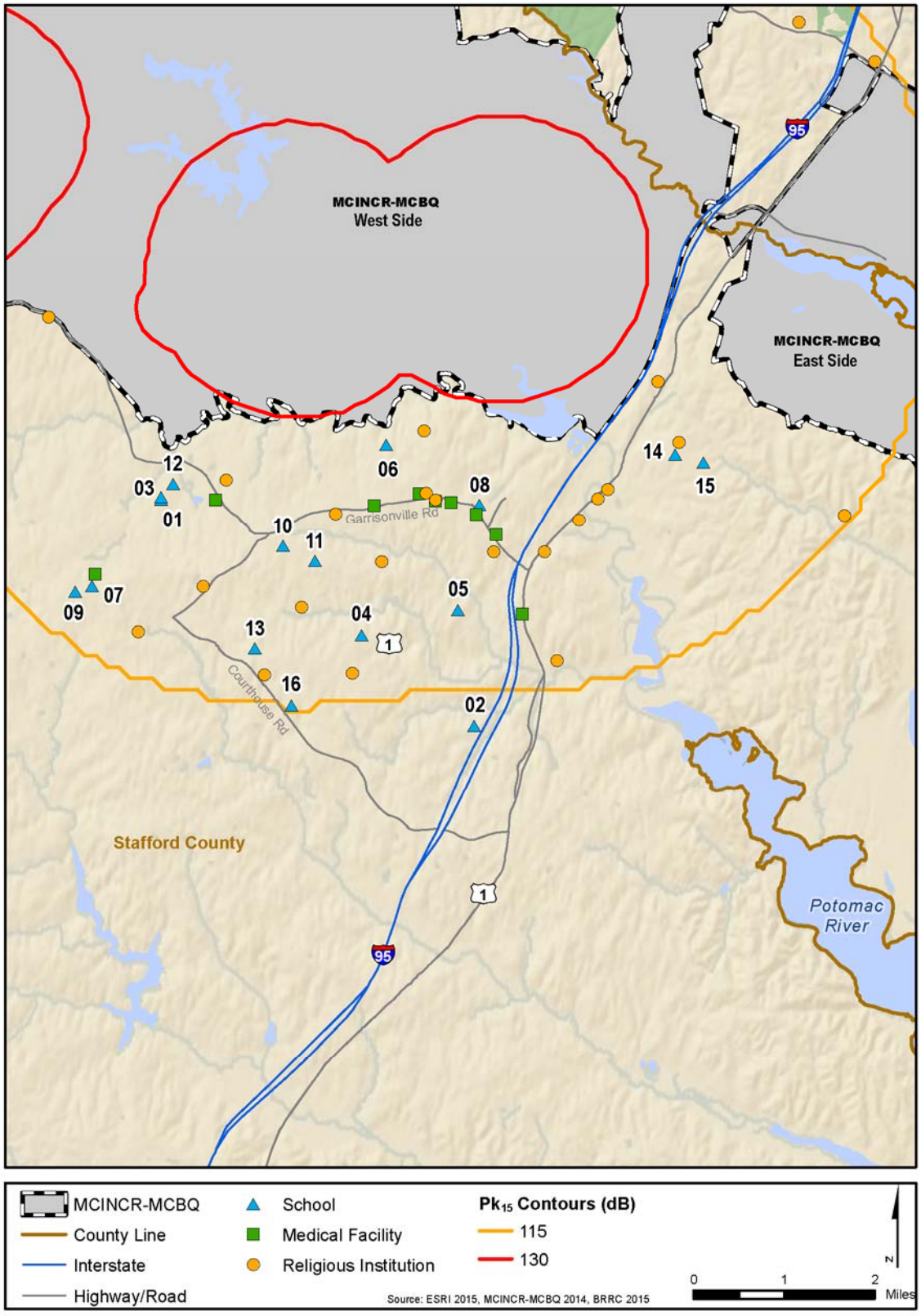
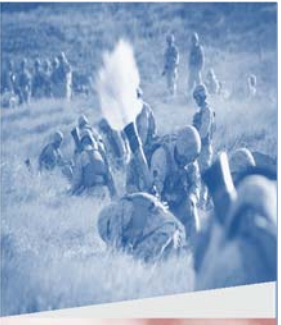
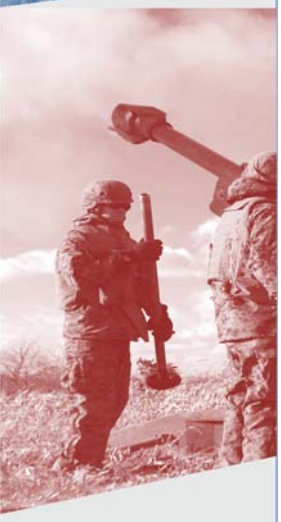


Figure 4-4. Schools, Churches, and Medical Facilities in the Vicinity of MCINCR-MCBQ





There are no hospitals within the peak noise contours; however, nine medical facilities were identified within the 115-130 Pk_{15} contour band. There were 31 churches identified in the 115-130 Pk_{15} contour band and 1 church identified within the 130 Pk_{15} contour band.

The impulse noise exposure from training at MCINCR-MCBQ are short in duration, and for those people occupying spaces within the 115 dB Pk_{15} contour area, the noise event would be "occasionally" noticeable. Figure 4-5 shows recorded noise complaints surrounding MCINCR-MCBQ from 2011 to 2013, color-coded by year. Also note that school locations are all outside the Noise Zone II and Noise Zone III contours depicted in Figure 4-2 (based on the CDNL analysis from 2006 RCUZ). Noise complaints are tracked at MCINCR-MCBQ in order to determine where complaints originate, as well as to determine if there are any mitigation factors that can be applied to limit the amount of off-base impacts that occur. As shown, there is a cluster along the southwestern edge of the base boundary. These complaint locations are near where the 130 dB Pk_{15} extends off base, though no complaint data actually exists within the 130 dB Pk_{15} contour for these 3 years.

However, given the proximity to the 130 dB Pk_{15} contour, it would be expected that complaints may occur here. Noise complaints seem to appear to cluster to the south as well, where locations are within the 115 dB Pk_{15} noise contour. These areas would be considered to have a Medium risk of noise complaint.

4.4 Community-Enacted Peak Noise Land Use Compatibility Examples

Many community noise ordinances are aimed at controlling excessive noise, such as those from construction or transportation, so as not to be objectionable to community residents. Noise control ordinances typically outline noise-sensitive land uses and prohibits certain kinds of noise disturbances in particular areas or at particular times of day. Some community noise ordinances set limits on A-weighted and C-weighted noise to readings on a sound meter. For example, the town of Ogunquit, Maine uses both A- and C-weighted noise measurements to limit noise-inducing activities. Its noise ordinance limits daytime (7 a.m. to 10 p.m.) noise-generating activities to 72 dB in Business Districts and 67 dB in Other Districts; nighttime (10 p.m. to 7 a.m.) activities are limited to 62 dB in Business Districts and 67 dB in Other Districts. These noise levels may be exceeded by 10 dB for a single period, but for no longer than 15 minutes, in any one day (Town of Ogunquit 1999).

Many other communities have adopted local land use controls (e.g., zoning overlays) to promote compatible land use within the noise zones associated with military operations and training. Most of these communities have enacted land use compatibility controls via zoning and the regulations are principally associated with airfields and A-weighted noise. As such, many communities have adopted zoning overlays based upon Air Installations Compatible Use Zones noise and accident potential zones. Maricopa County, Arizona is one community of many that has adopted a military-impact overlay district that establishes specific regulations concerning density, noise reduction and disclosure, and heights of structures (Maricopa County 2015). The adopted overlay zone corresponds to the Air Installations Compatible Use Zones for Luke Air Force Base.

Few communities have adopted specific recommendations for CDNL Noise Zones II and III and peak noise exposure. Like the communities around MCINCR-MCBQ, several communities have acknowledged the presence of C-weighted or military operations-related impulse noise in

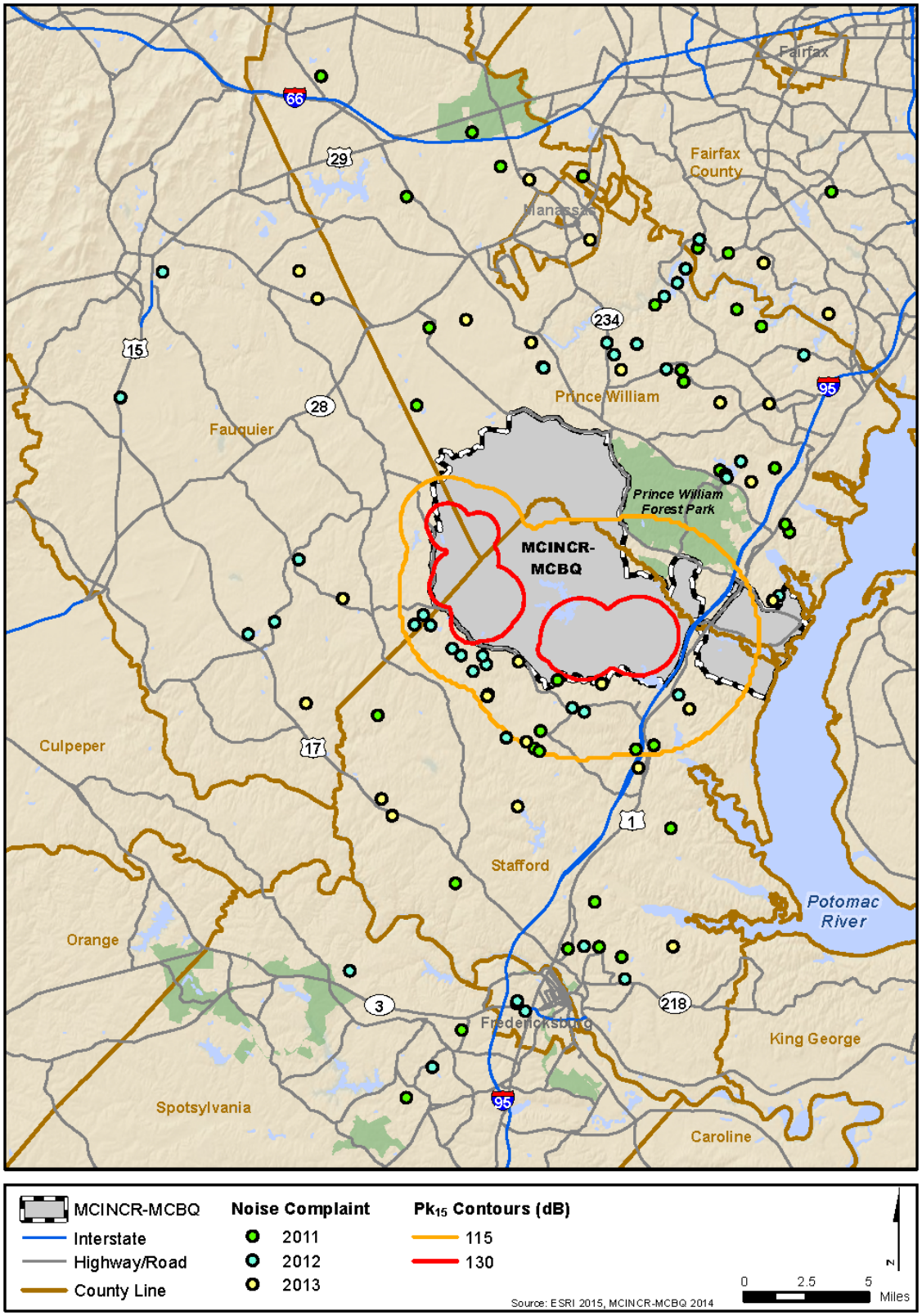
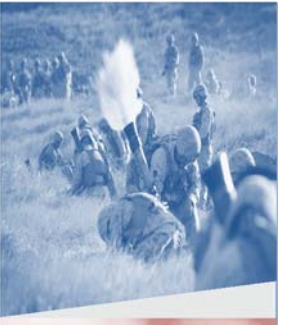
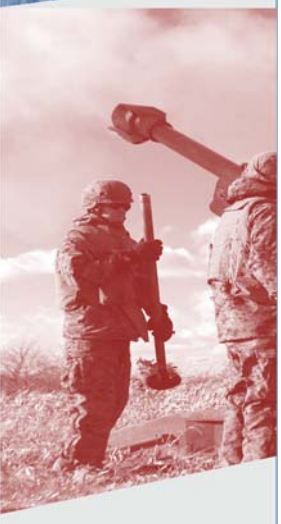


Figure 4-5. Noise Complaints Recorded for MCINCR-MCBQ from 2011 to 2013





comprehensive plans or advisory notices. However, very few have put zoning regulations in place to regulate the types of activities and land uses allowed in areas affected by C-weighted noise. That is, only a few communities have used Army noise regulations (i.e., Chapter 14, AR 200-1) to drive community-based land use compatibility policies. Although both Stafford County and Fauquier County considers the MCINCR-MCBQ RCUZ in their comprehensive plans, neither county has adopted zoning or regulations addressing land use density, noise reduction and disclosure, etc. Below are several examples of how communities have addressed or otherwise considered C-weighted noise in their land use decision making processes.

4.4.1 Clay County, Florida

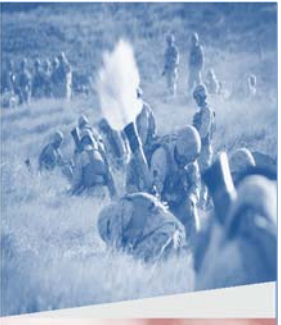
Clay County, Florida adopted an amendment to its comprehensive plan that sets forth policies regulating land use within areas impacted by military activities conducted at Camp Blanding Joint Military Training Center. The amendment also incorporates an Impact Area Map, which is a composite of the areas shown as the Land Use Planning Zone and the "Potential Peak Noise Area" in related noise management plans for Camp Blanding, into the county's Future Land Use Map. The Impact Area Map takes into account C-weighted noise associated with military operations. The policies limit allowable uses within the Land Use Planning Zone to those that are acceptable according to Chapter 14 of Army Regulation 200-1 and require notification of any proposed development within the zone. The notification requirement also extends to the potential peak noise area. All proposed comprehensive plan amendments, proposed land development regulation text amendments, applications for planned unit developments, developments of regional impact, rezoning requests, and similar applications within the Land Use Planning Zone and potential peak noise area are required to be submitted to Camp Blanding for review and comment prior to final action by Clay County (Clay County 2009). While the comprehensive plan amendments and the incorporation of an Impact Area map into the future land use plan establishes policies to encourage land use compatibility, Clay County has not adopted a zoning overlay or other land use regulation to codify its compatibility policies.

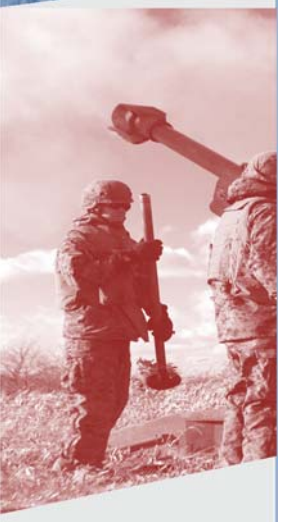
4.4.2 Fairbanks North Star Borough, Alaska

Fairbanks North Star Borough, Alaska has adopted an advisory overlay zone corresponding to the Land Use Planning Zone surrounding Fort Wainwright, to include areas that fall within the 57 CDNL and greater noise contour. The Military Noise Overlay is advisory in nature and simply notifies the public that affected properties *may* be affected by military-related noise. There are no land use regulations associated with the overlay zone (Fairbanks North Star Borough 2015).

4.4.3 Riley County, Kansas

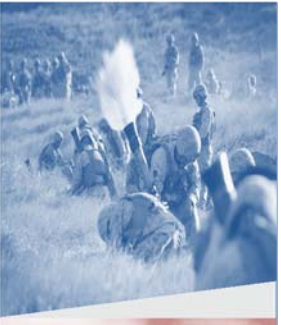
The Fort Riley JLUS resulted in a noise zone map that shows average and peak noise levels, using a C-weighted noise metric to measure the blast noise associated with operations at Fort Riley. While Riley County has not yet adopted a specific overlay zone to regulate land use within the areas affected by the noise zones, the noise zone map is posted on the county's planning department website to advise residents and potential residents of the presence of noise-generating activities. The map also describes the land uses compatible within each of the noise zones as defined by the U.S. Army Environmental Noise Program (Riley County 2011).

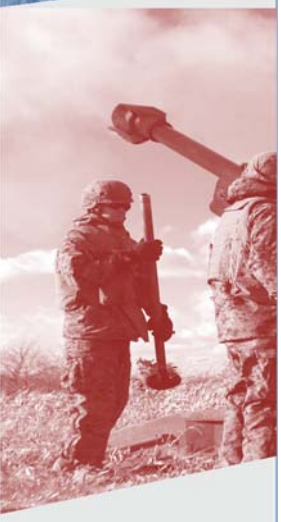




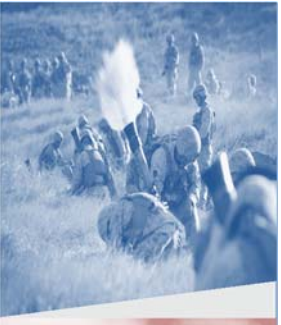
4.4.4 City of Fayetteville, North Carolina

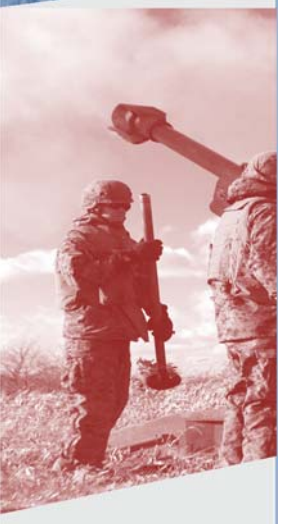
Fayetteville, North Carolina adopted a Noise-Accident Potential Overlay District in its Unified Development Ordinance (2013) that establishes land regulations in areas where people would be exposed to higher than average noise levels and potential for aircraft accidents associated with proximity to airports and Fort Bragg. Peak noise levels are also considered. Residential uses are not permitted unless there is a strong reason presented to allow for residential properties. Uses within the overlay district are considered compatible if they do not result in a gathering of individuals in an area that would result in an average density of greater than 25 persons per acre per hour during a 24-hour period, not to exceed 50 persons per acre at any time (City of Fayetteville 2013).





(This page intentionally left blank)





5.0 CONCLUSION AND RECOMMENDATIONS

MCINCR-MCBQ is an installation with an important military mission that involves an active RTA. The activities that occur at the MCINCR-MCBQ RTA are inherently loud and may impact local communities well outside the installation boundary. Having the necessary predictive tools to anticipate potential problems before they occur within the surrounding communities is essential to promote good relations with these communities and prevent unnecessary conflict.

This report is centered on the July 2015 noise modeling results related to the Pk_{15} metric (for impulsive noise). This metric is utilized for determining the potential for noise complaints based on the weapon systems used within the RTA. The Pk_{15} contours provide one more tool for the installation to use to give the public an estimation of the impacts that could occur from range activities that generate impulse noise. However, this metric is not used to develop land use recommendations in the way that CDNL contours are typically used.

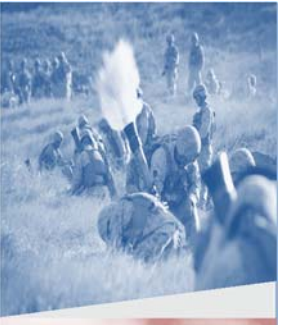
The use of CDNL to develop land use and zoning regulations will continue, as the CDNL contours represent cumulative noise impacts to an area. Cumulative noise impacts to areas have generally been seen as adverse, because they are ongoing. The Pk_{15} metric can be used in addition to the CDNL metric for developing planning recommendations, but is inherently different because it is not a cumulative noise metric. Therefore, results from the Pk_{15} noise modeling are not used to analyze repeated sound energy or noise exposure impacts. Community noise exposure guidelines based on the Pk_{15} noise metric do not exist. However, the potential for the surrounding community to be startled by noise events (130 dB Pk_{15} and greater), and the potential to occasionally notice the noise (115 dB Pk_{15} to 129 dB Pk_{15}) are important to those people living in the vicinity of the base.

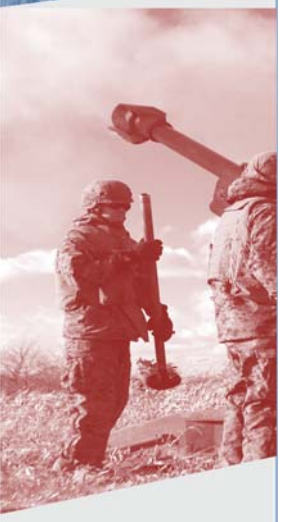
Ultimately, the Pk_{15} noise contours provide another useful tool in communicating noise impacts in a simplified manner to those living and/or working near an active range. MCINCR-MCBQ should continue to work with the community on implementing proactive planning initiatives, which could include:

- Real estate disclosure statements can reduce the likelihood of noise-sensitive people moving into an area impacted by impulse noise.
- Encroachment planning, including partnering with interested stakeholders on restrictive use easements on conservation, open, working lands, etc. to place such lands in a protective status that would preclude their development as noise sensitive land uses.
- Adoption of land use planning or controls to limit or preclude noise sensitive land uses within the PK_{15} 115 decibels (dB) and 130 dB noise contours.

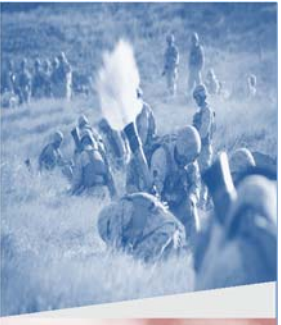
This would be executed through a continuation of stakeholder engagement to better inform the community on peak noise and the peak noise analysis provided in this report. These recommendations are consistent with those of the 2014 MCB Quantico JLUS.

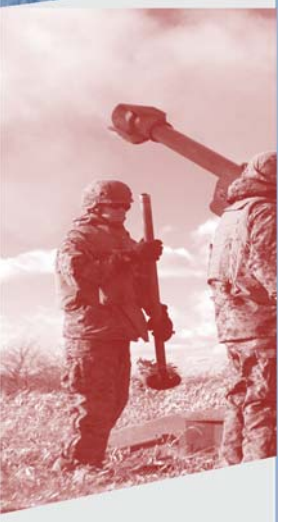
To facilitate the stakeholder engagement, companion products to this report have been provided under separate cover in the form of a community brochure and a PowerPoint presentation.





(This page intentionally left blank)



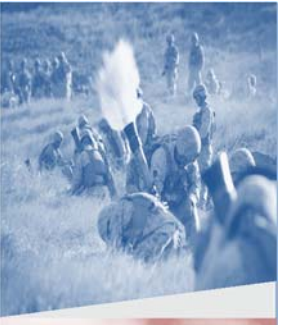


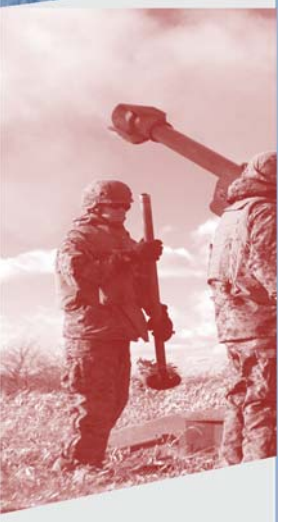
6.0 REFERENCES

Army Public Health Command. 2005. Operational Noise Manual, An Orientation for Department of Defense Facilities, November.

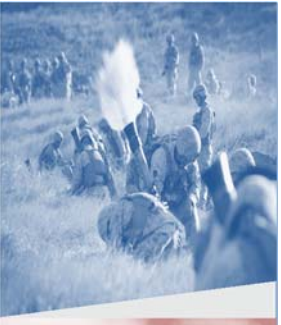
Blue Ridge Research and Consulting. 2015. Peak Noise Levels for Large Caliber Munitions at MCB Quantico, VA. Technical Note. Report No. BRRC 15-06. June.

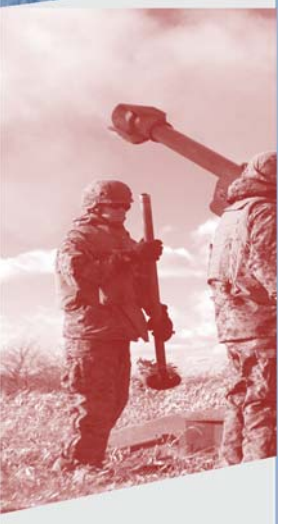
City of Fayetteville. 2013. City of Fayetteville, NC Unified Development Ordinance, Section 30-3.H.5 Noise-Accident Potential Overlay (NPO) District





http://www.cityoffayetteville.org/vic/default.htm?turl=Documents%2F303hoverlayzoningdi





s.htm. November.

Clay County 2009. Ordinance No. 2009-065. An Ordinance of the Board of County Commissioners of Clay County, Florida, Amending the Clay County 2015 Comprehensive Plan Initially Adopted Pursuant to Clay County Ordinance No. 92-03.

Department of the Army. 2007. Army Regulation 200-1, Environmental Quality, Environmental Protection and Enhancement. Headquarters Department of the Army. 13 December.

Department of Defense (DOD). 2011. DOD Instruction 4165.57, Air Installations Compatible Use Zones (AICUZ). 2 May.

DOD Noise Working Group. 2013a. Technical Bulletin, An Overview of Blast Noise: Characteristics, Assessment and Mitigation. December.

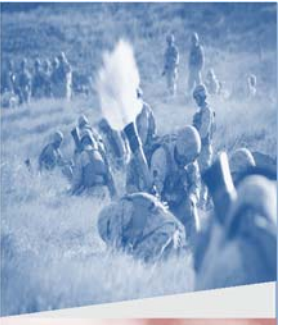
_____. 2013b. Technical Bulletin, Non-Auditory Health Effects of Aircraft Noise. December.

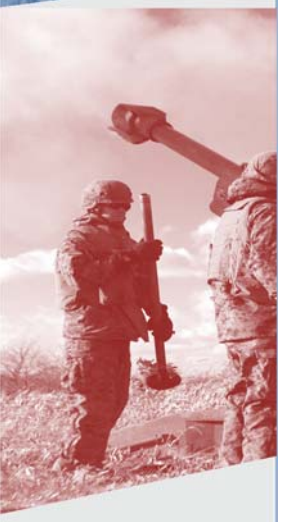
_____. 2009. Improving Aviation Noise Planning, Analysis, and Public Communication with Supplemental Metrics. Guide to Using Supplemental Metrics. December.

Department of the Navy. 2008. Marine Corps Order 11010.16. Air Installations Compatible Use Zones (AICUZ) Program. 9 October.

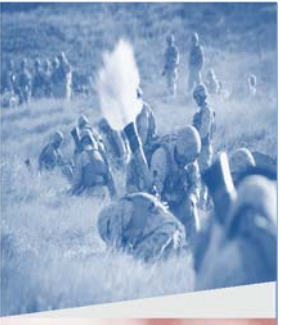
Fairbanks North Star Borough. 2015. Memorandum from Mellissa Kellner, Planner, to Fairbanks North Star Borough Planning Commission regarding “Ordinance No. 2015-49 (OC2015-006) Military noise Overlay. 15 October.

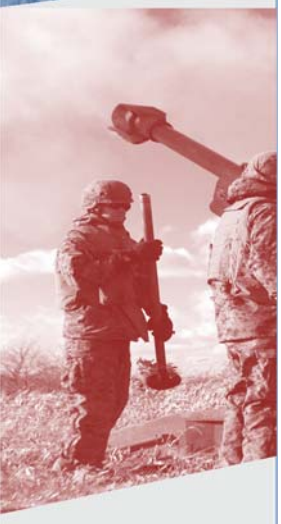
Maricopa County. 2015. Maricopa County, AZ, Zoning Ordinance, Chapter 10, Section 1010 Military Airport and Ancillary Military Facility Overlay Zone.





https://www.maricopa.gov/planning/Resources/Ordinances/pdf/reform_ordinance/Zoning





%20Ordinance.pdf. June.

Marine Corps Installations National Capital Region-Marine Corps Base Quantico (MCINCR-MCBQ). 2015. Marine Corps Base Quantico, Noise Complaint Log, 2010-2013.

Marine Corps Base Quantico. 2006. Range Compatibility Use Zone (RCUZ) Study. November.

Environmental Systems Research Institute. 2015. Imagery, roads, and county data sets. Redlands, California.

Riley County. 2011. Riley County, KS, Fort Riley Noise Contour Map http://gis.rileycountyks.gov/publicimages/FtRileyNoise.pdf. October.

Stafford County, Prince William County, Fauquier County, and Marine Corps Base Quantico. 2014. Quantico Joint Land Use Study. Final. June.

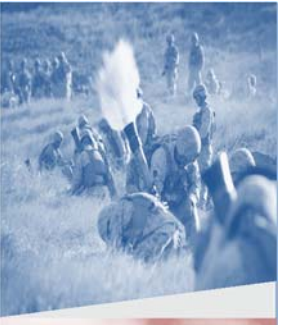
Town of Ogunquit. 1999. Ogunquit Zoning Ordinance. Article 8, General Standards, Section 8.9, Noise Abatement, Adopted April 4, 1998 and Amended April 5, 1999.

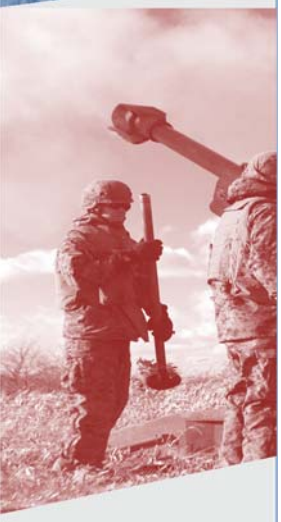
U.S. Army Public Health Command. 2014. Readiness through Hearing Loss Prevention. Technical Guide 250.

U.S. Census Bureau. 2010. 2010 Census Summary. Available at: www.census.gov.

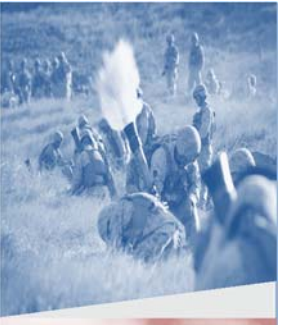
U.S. Marine Corps (USMC). 2008. Marine Corps Order 3550.11. Range Air Installations Compatible Use Zones (RAICUZ) Program. January.

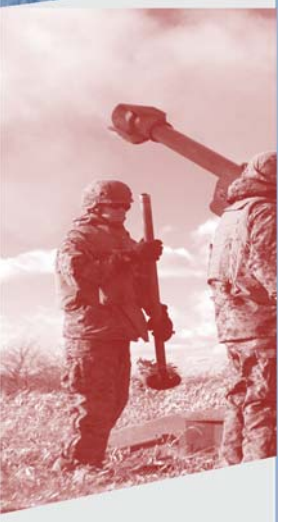
Wyle. 2006. Wyle Laboratories, Arlington, Virginia, Wyle Report 05-11, Final Noise Study for Marine Corps Base Quantico Range Complex, Virginia. January.



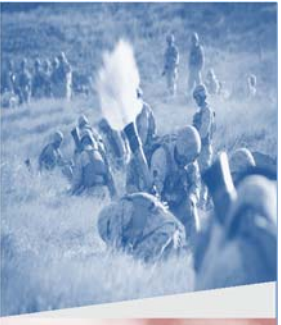


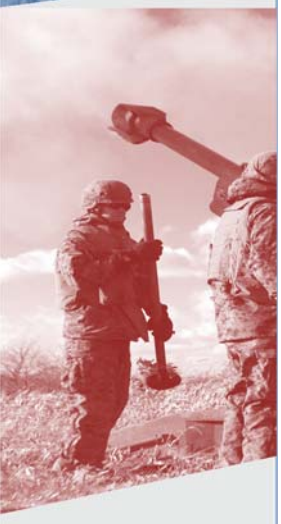
APPENDIX A
ACRONYMS AND ABBREVIATIONS





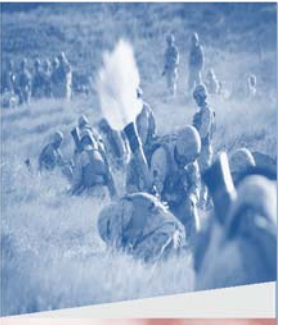
(This page intentionally left blank)

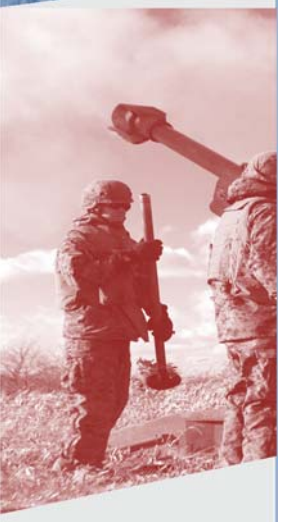




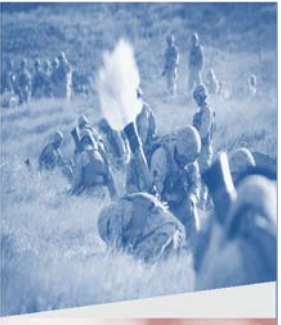
ACRONYMS AND ABBREVIATIONS

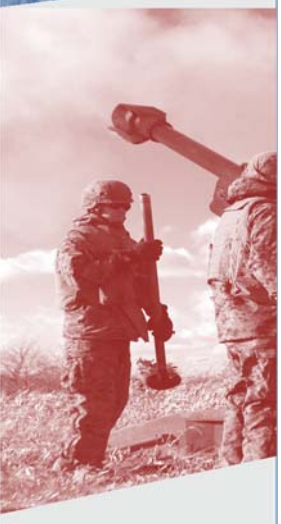
BNoise2	Blast Noise Version 2 Noise Modeling Software
CDNL	C-weighted Day-Night Average Sound Level
dB	decibel
DNL	Day-Night Average Sound Level
DOD	Department of Defense
JLUS	Joint Land Use Study
Lpk	Peak Sound Level
mm	millimeter
MCINCR-MCBQ	Marine Corps Installations National Capital Region-Marine Corps Base Quantico
NPO	Noise-Accident Potential Overlay
Pk_{15}	Peak Sound Level Exceeded15 Percent of the Time
RCUZ	Range Compatible Use Zones
RFMSS	Range Facility Management Support System
RTA	Range Training Area
U.S.	United States
USMC	United States Marine Corps



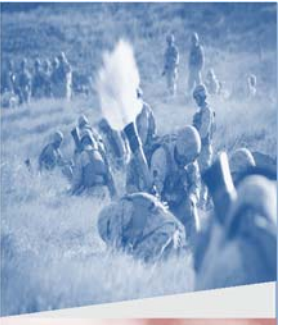


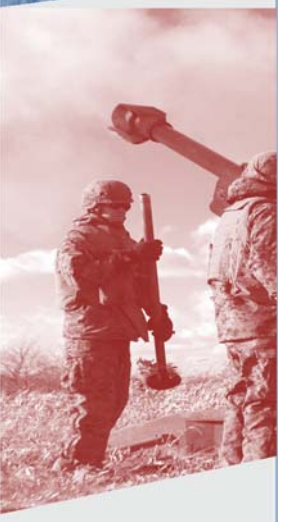
(This page intentionally left blank)



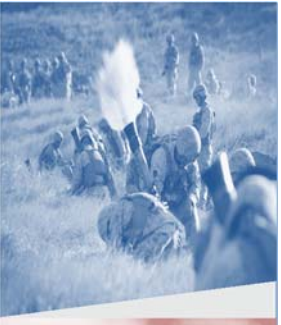


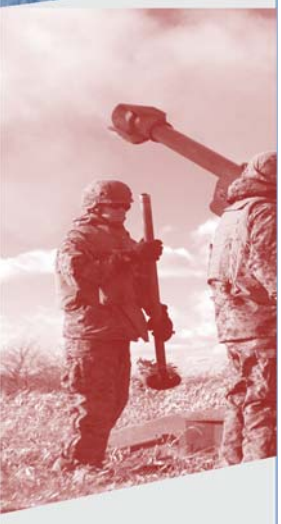
APPENDIX B
RANGE FACILITY MANAGEMENT SUPPORT SYSTEM DATA





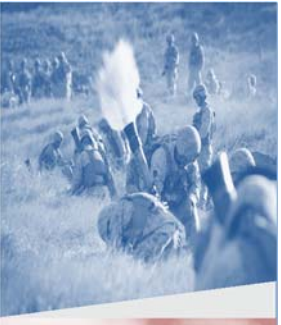
(This page intentionally left blank)

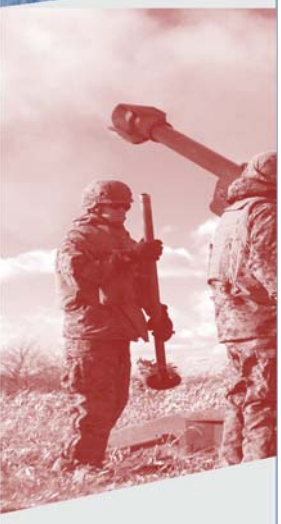




Modeling Parameters as Developed from the 2014 MCINCR-MCBQ RFMSS Data

RFMSS (Firing Points) MGRS Position	RFMSS DODIC	Yellowbook NEW TNT (Kg)	BNoise2 (Firing Point) Surrogate Munition	RFMSS (Target Points) MGRS Position	BNoise2 (Target Point) Surrogate Munition
18STH7668469259	CA45	4.8262	120-MM Mortar Zone 3	18STH7981667939	120-MM MORTAR / HE
	CA45	4.8262	120-MM Mortar Zone 3	18STH7994867725	120-MM MORTAR / HE
	CA45	4.8262	120-MM Mortar Zone 3	18STH7965567345	120-MM MORTAR / HE
	CA45	4.8262	120-MM Mortar Zone 3	18STH7950267433	120-MM MORTAR / HE
18STH7764168850	C995	0.8348	AT4 Rocket Zone 1	18STH7813469025	AT4 Rocket HE
	C995	0.8348	AT4 Rocket Zone 1	18STH7824868907	AT4 Rocket HE
	C995	0.8348	AT4 Rocket Zone 1	18STH7795468884	AT4 Rocket HE
	C995	0.8348	AT4 Rocket Zone 1	18STH7813568844	AT4 Rocket HE
18STH7766671244	C869	1.0676	81-MM Mortar Zone 2	18STH7930770580	81-MM MORTAR / HE
	C869	1.0676	81-MM Mortar Zone 2	18STH7923370425	81-MM MORTAR / HE
	C869	1.0676	81-MM Mortar Zone 2	18STH7910470663	81-MM MORTAR / HE
	C869	1.0676	81-MM Mortar Zone 2	18STH7904070530	81-MM MORTAR / HE
18STH7789869694	HX05	1.5074	AT4 Rocket Zone 1	18STH7823869826	AT4 Rocket HE
	HX05	1.5074	AT4 Rocket Zone 1	18STH7812369645	AT4 Rocket HE
	G881	0.1876	40-MM GREN LN M203 Zone 1	18STH7823869826	HAND GRENADE M67 / Zone 1
	G881	0.1876	40-MM GREN LN M203 Zone 1	18STH7812369645	HAND GRENADE M67 / Zone 1
18STH7898966633	CA43	1.0622	81-MM Mortar Zone 2	18STH7980967931	81-MM MORTAR / HE
	CA43	1.0622	81-MM Mortar Zone 2	18STH7996567491	81-MM MORTAR / HE
	CA43	1.0622	81-MM Mortar Zone 2	18STH7948467364	81-MM MORTAR / HE
	CA43	1.0622	81-MM Mortar Zone 2	18STH7976567266	81-MM MORTAR / HE
	HX05	1.5074	AT4 Rocket Zone 1	18STH7980967931	AT4 Rocket HE
	HX05	1.5074	AT4 Rocket Zone 1	18STH7996567491	AT4 Rocket HE
	HX05	1.5074	AT4 Rocket Zone 1	18STH7948467364	AT4 Rocket HE
	HX05	1.5074	AT4 Rocket Zone 1	18STH7976567266	AT4 Rocket HE
18STH7906671042	B643	0.4078	60-MM Mortar Zone 1	18STH7926370447	60-MM MORTAR / HE
	B643	0.4078	60-MM Mortar Zone 1	18STH7911270417	60-MM MORTAR / HE
	B643	0.4078	60-MM Mortar Zone 1	18STH7918670679	60-MM MORTAR / HE
	B643	0.4078	60-MM Mortar Zone 1	18STH7909470660	60-MM MORTAR / HE
18STH8382464770	D529	10.9316	155-MM HOW M109 Zone 2	18STH7946567454	155-MM HOWITZER M109 / HE
	D529	10.9316	155-MM HOW M109 Zone 2	18STH8005568233	155-MM HOWITZER M109 / HE
	D529	10.9316	155-MM HOW M109 Zone 2	18STH7974267284	155-MM HOWITZER M109 / HE
	D529	10.9316	155-MM HOW M109 Zone 2	18STH8029468014	155-MM HOWITZER M109 / HE
18STH8552564802	B546	0.0457	40-MM GREN LN M203 Zone 1	18STH8532864886	Projectile 40-MM Gun HE
	B546	0.0457	40-MM GREN LN M203 Zone 1	18STH8535764949	Projectile 40-MM Gun HE
18STH8601564577	G881	0.1876	HAND GRENADE M67 / Zone 1	18STH8597064592	HAND GRENADE M67 / Zone 1
18STH7912171095	B643	0.4078	60-MM Mortar Zone 1	18STH7926370447	60-MM MORTAR / HE
	B643	0.4078	60-MM Mortar Zone 1	18STH7911270417	60-MM MORTAR / HE
	B643	0.4078	60-MM Mortar Zone 1	18STH7918670679	60-MM MORTAR / HE
	B643	0.4078	60-MM Mortar Zone 1	18STH7909470660	60-MM MORTAR / HE
	EWAF	N/A	Demolition Charge Sheet 0.50 Kg		
18STH8608265320	M039	18.3387	Demolition Crater Charge 40 Lbs		
18STH8941965576	M591	0.1769	Dynamite, MILITARY / M1		
18STH8957165575	M039	18.3387	Demolition Crater Charge 40 Lbs		
18STH8958865647	M039	18.3387	Demolition Crater Charge 40 Lbs		
18STH8962365572	M591	0.1769	Dynamite, MILITARY / M1		
18STH8973765630	M039	18.3387	Demolition Crater Charge 40 Lbs		
18STH7724072889	M023	0.5670	C4 / M112 1.25 LBS		
18STH7744272411	M023	0.5670	C4 / M112 1.25 LBS		
18STH7749672848	M023	0.5670	C4 / M112 1.25 LBS		
18STH7754372441	M023	0.5670	C4 / M112 1.25 LBS		
18STH7932972297	M023	0.5670	C4 / M112 1.25 LBS		
18STH7967767386	M023	0.5670	C4 / M112 1.25 LBS		
18STH8583665434	M039	18.3387	Demolition Crater Charge 40 Lbs		
18STH8589765537	M039	18.3387	Demolition Crater Charge 40 Lbs		
18STH8596565331	M039	18.3387	Demolition Crater Charge 40 Lbs		





2014 Large Arms Munitions with Expenditure Frequencies Greater than Once Per Day

AMMO NOMENCLATURE	QUANTITY
CORD DETONATING REINFORCED PLIOFILM WRAPPED WTRPRF	36,751
CTG 40MM HEDP M430 W/FUZE M549 W/M16A2 LINKS	**31,578**
FUSE BLASTING TIME M700	6,387
CHG, DEMO SHEET ROLL 38 FT	5,692
CTG 81MM HE M889 IUK W/M935 PD FUZE	**4,772**
CTG 60MM HE M888 W/FZ PD M935	**4,245**
CTG 40MM HEDP M433 W/FUZE PIBD M550 F/GRENADE LAUN	**3,831**
GRENADE HAND FRAG M67 W/FUZE M213 W/SAFETY CLIP	**2,410**
SHOCK TUBE LEAD,PYROTECHNIC	2,000
PROJ 155MM HE M795	**1,735**
CHG, DEMO SHEET ROLL 25 FT	1,682
CTG 81MM HE M821 W/MO FUZE (IUK)	**1,552**
CHARGE, DEMOLITION	1,267
IGNITER TIME BLASTING FUSE M81 W/SHOCK TUBE CAPABI	1,060
CHARGE DEMOLITION BLOCK COMP C-4 1 1/4 LB M112	**1,039**
CHARGE DEMOLITION BLOCK 1/4 LB TNT	**1,027**
CTG, 81MM HE M889A2 W/ PD FUZE	**736**
CAP BLASTING ELECTRIC M6 SPECIAL	694
DETONATOR, NON-ELECTRIC, DUAL MK 154 MOD 0	629
CTG 81MM PRACTICE M879 W/FUZE PD M751	600
CTG 25MM TP-T M793	540
CAP BLASTING NON-ELECTRIC M7 SPECIAL	464
25MM TARGET PRACTICE DISCARDING SABOT WITH TRACER (TPDS-T)	451
AT4 LTWT MULTI-PURPOSE WPN	**423**
Grand Total	**111,565**