Draft Environmental Assessment for Transition of HMM-774 to VMM-774

July 2015

Prepared by Department of Navy
In accordance with: Office of the Chief of Naval Operations Instruction (OPNAVINST) 5090.1, Chapter 10 (10 January 2014); Marine Corps Order P5090.2A, Change 3, Chapter 12 (26 August 2013); and United States Marine Corps National Environmental Policy Act Manual 2.0 (2011)
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Draft

Environmental Assessment for Transition of HMM-774 to VMM-774

July 2015

Lead Agencies:	United States (U.S.) Department of Navy, U.S. Marine Corps
Title of Proposed Action:	Transition of HMM-774 to VMM-774
Designation:	Environmental Assessment (EA)
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Abstract

This EA has been prepared to evaluate the potential environmental impacts associated with the transition of Marine Medium Helicopter Squadron 774 (HMM-774) to Marine Medium Tiltrotor Squadron 774 (VMM-774). The purpose of the proposed action is to replace the existing squadron of 12 CH-46E legacy aircraft assigned to the Marine Forces Reserve (MARFORRES) unit based at Naval Station (NS) Norfolk, Virginia with 12 MV-22B aircraft. The proposed action is needed to meet the requirements of the U.S. Marine Corps Aviation Plan to replace legacy aircraft and enhance the mission and combat capability of the medium-lift community.

The resource areas analyzed for potential impacts at NS Norfolk include airfield and airspace; noise; land use; air quality; socioeconomics and environmental justice; cultural resources; and public health and safety. This EA will be made available for public review before a Finding of No Significant Impact (FONSI) is signed. If a FONSI is not appropriate, an Environmental Impact Statement (EIS) will be prepared.

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EXECUTIVE SUMMARY

INTRODUCTION

This Environmental Assessment (EA) has been prepared to assess the potential environmental impacts associated with the transition of Marine Medium Helicopter Squadron 774 (HMM-774) to Marine Medium Tiltrotor Squadron 774 (VMM-774) at Naval Station (NS) Norfolk in Virginia. The proposed action is part of a Marine Corps wide process of replacing its aging fleet of medium-lift helicopters. These legacy aircraft are nearing the end of their lifecycle, cannot travel great distances, and are not well equipped for night or adverse weather operations.

This EA has been prepared in accordance with the requirements of the National Environmental Policy Act (NEPA) (42 U.S. Code §4321 et seq.); the Council on Environmental Quality regulations implementing NEPA (40 Code of Federal Regulations §1500 et seq.); Office of the Chief of Naval Operations Instruction 5090.1, Chapter 10, dated 10 January 2014; Marine Corps Order P5090.2A, Change 3; U.S. Marine Corps NEPA Manual 2.0 (2011); and all other applicable laws, regulations, Executive Orders, and instructions.

PROJECT PURPOSE AND NEED

The purpose of the proposed action is to transition HMM-774 to VMM-774 on NS Norfolk, Virginia. Replacing the legacy CH-46E aircraft with MV-22B aircraft would improve and modernize the medium-lift capability in the Mid-Atlantic region.

The transition of HMM-774 to VMM-774 is needed as part of the established U.S. Marine Corps Aviation Plan replacing CH-46E aircraft and enhancing the mission and combat capability of the medium-lift community. The CH-46E is at the end of its service life. Replacement of the CH-46E helicopters with the MV-22B is needed to improve operational capabilities, limit vulnerabilities in expected combat situations, and maintain combat and mission readiness.

PROPOSED ACTION

The proposed action is to transition HMM-774 to VMM-774. Transitioning the squadron includes more than just replacing its aircraft, it also includes renovating facilities to house and maintain the new system, as well as developing the skills needed to employ the new airframe within the squadron. Specifically, the proposed action involves: 1) replacing 12 CH-46E aircraft with 12 MV-22B aircraft; 2) increasing squadron personnel; 3) renovating airfield facilities to accommodate and maintain a squadron of 12 MV-22B aircraft; and 4) conducting MV-22B Training and Readiness airfield operations to attain and maintain proficiency in the operational employment of the MV-22B.

ALTERNATIVES CONSIDERED

This EA considers two action alternatives (Alternative 1 and Alternative 2) and the No Action Alternative. The action alternatives analyze two different hangars to house and maintain VMM-774. The predominant arrival, departure, and flight patterns associated with fixed-wing operations in the Landing Plane (LP) area of the airfield are the most consistent with and suitable for enduring MV-22B flight operations. HMM-774 is currently located in the Landing Field (LF) area of the airfield in Hangar LF-60; this area is predominately used for helicopter operations.

Under **Alternative 1 (Preferred)**, the 12 legacy CH-46E aircraft assigned to HMM-774 would be replaced with 12 MV-22B aircraft and the squadron would be redesignated as VMM-774. To support this transition, 30 additional permanent personnel would be assigned to the existing squadron for a total of 239 personnel. VMM-774 would move into an existing hangar (Hangar LP-167) with interior modifications. Two tenants located in LP-167 would relocate to LF-60 (Naval Air Systems Command and Stricken Aircraft Reclamation and Disposition Program); minor interior repairs would occur at LF-60. Parking apron improvements at LP-167 would include pavement repair and joint sealant replacement; restriping of the parking apron; installation of additional grounding points on the apron; repair or replacement of aircraft tie downs; and realignment of a segment of the perimeter fence. There is no net change in the total number of proposed MV-22B airfield operations compared to legacy CH-46E airfield operations; however, the type of operations would vary slightly. The MV-22B would have approximately 4,752 annual operations at NS Norfolk airfield.

Under **Alternative 2**, the 12 legacy CH-46E aircraft assigned to HMM-774 would be replaced with 12 MV-22B aircraft and the squadron would be redesignated as VMM-774. To support this transition, 30 additional permanent personnel would be assigned to the existing squadron for a total of 239 personnel. VMM-774 would move to an existing hangar (Hangar LP-27). The tenant located in LP-27 (a Navy MH-60 squadron) would relocate to Hangar LF-60. Relocating the MH-60 squadron to LF-60 would require a 2,000-square foot addition to Hangar LF-60. Hangar LP-27 does not provide adequate space to rotate the nacelle of the MV-22B. An addition to Hangar LP-27 is not feasible given the Inhabited Building Distance safety arc associated with the combat aircraft loading area on Taxiway G. Therefore, any maintenance procedures on the MV-22B requiring nacelle movement would require an operational workaround; the aircraft would have to be towed out of the hangar to rotate the nacelles, and then towed back into the hangar for required maintenance. Parking apron improvements at LP-27 would include pavement repair and joint sealant replacement; restriping of the parking apron; installation of additional grounding points on the apron; and repair or replacement of aircraft tie downs. There is no net change in the total number of proposed MV-22B airfield operations compared to legacy CH-46E operations; however, the type of operations would vary slightly. The MV-22B would have approximately 4,752 annual operations at NS Norfolk airfield.

Under the **No Action Alternative**, the squadron of CH-46E helicopters would be retired in 2015; personnel assigned to the squadron would be reassigned to another installation or released from the reserves. The No Action Alternative is not a viable alternative since it does not meet the purpose and need.

Table ES-1 shows the potential environmental impacts for both action alternatives and the No Action Alternative.

Table ES-1. Summary of Environmental Consequences

Resource Area	Alternative 1	Alternative 2	No Action Alternative
Airfield and Airspace	No net change in annual aircraft operations; however, MV-22B operations would occur primarily on Runway 10/28 instead of Runway 09/27. No significant impact to airfield operations or airspace management.	Same as Alternative 1.	Airfield operations reduced by 4,752 with retirement of CH-46E.

Table ES-1. Summary of Environmental Consequences			
Resource Area	**Alternative 1**	**Alternative 2**	**No Action Alternative**
Noise	Change to noise environment would be negligible and imperceptible to surrounding community. Acreage within existing noise contours would remain relatively unchanged. No significant direct, indirect, or cumulative impact to noise environment.	Same as Alternative 1.	Slight reduction in airfield operations would have a negligible change to the noise environment.
Land Use	No net change in annual aircraft operations. Noise Zones established in Air Installation Compatible Use Zone Study would not change. No significant direct, indirect, or cumulative impact to land use.	Same as Alternative 1.	Slight reduction in airfield operations would have a negligible change to the noise environment and Noise Zones would remain unchanged.
Air Quality	Emissions from MV-22B would be less than CH-46E for all criteria pollutants except for nitrogen oxides (NO_x). Small increase in NO_x emissions would occur, but would not exceed de minimis criteria. Emissions associated with construction would be minor and temporary. No significant direct, indirect, or cumulative impact to air quality.	Same as Alternative 1.	Air quality slightly improved with retirement of CH-46E and associated reduced airfield operations.
Socioeconomics and Environmental Justice	Additional 30 personnel required for MV-22 transition. Slight economic benefit associated with proposed renovations. No significant impact to socioeconomic conditions. No environmental justice concerns. No significant direct, indirect, or cumulative impact to socioeconomics or environmental justice.	Same as Alternative 1.	Loss of 102 fulltime personnel and 107 reservists at NS Norfolk with retirement of CH-46E.
Cultural Resources	No impact to any cultural resources. Consultation with State Historic Preservation Office would not be required in accordance with the Regional Programmatic Agreement. No significant direct, indirect, or cumulative impact to cultural resources.	Consultation with State Historic Preservation Office would be required to determine required minimization or mitigation measures for potential view shed impacts to historic districts at Hangar LF-60. No significant direct, indirect, or cumulative impact to cultural resources with implementation of mitigation measures.	No change to cultural resources.

Table ES-1. Summary of Environmental Consequences			
Resource Area	**Alternative 1**	**Alternative 2**	**No Action Alternative**
Public Health and Safety	Current airspace safety procedures, maintenance, training, and inspections would continue to be implemented, and MV-22B airfield flight operations would adhere to established safety procedures. No changes to established clear zones, accident potential zones, or other established airfield safety features would be required. No significant direct, indirect, or cumulative impact to public health and safety.	Same as Alternative 1.	Slight reduction in aircraft inventory and associated airfield operations would have negligible change to potential risk associated with aircraft mishaps.

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ACRONYMS AND ABBREVIATIONS

ACHP	Advisory Council on Historic Preservation
AICUZ	Air Installations Compatible Use Zones
AMC	Air Mobility Command
APZ	Accident Potential Zone
AQCR	Air Quality Control Region
BASH	Bird/Animal Aircraft Strike Hazard
BT	Bombing Target
CAA	Clean Air Act
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
CFTD	Containerized Flight Training Device
CO	Carbon Monoxide
CO_2	Carbon Dioxide
CPLO	Community Plans and Liaison Officer
dB	Decibel
DNL	Day-Night Average Sound Level
DOD	Department of Defense
EA	Environmental Assessment
EIS	Environmental Impact Statement
EO	Executive Order
^{o}F	Degrees Fahrenheit
FAA	Federal Aviation Administration
FCLP	Field Carrier Landing Practice
FONSI	Finding of No Significant Impact
FY	Fiscal Year
GCA	ground-controlled approach
GHG	Greenhouse Gas
HMM	Marine Medium Helicopter Squadron
JB	Joint Base
LF	Landing Field
L_{max}	Maximum Sound Level
LP	Landing Plane
LZ	Landing Zone
MARFORRES	Marine Forces Reserve
MCAF	Marine Corps Air Facility
MCAS	Marine Corps Air Station
MCB	Marine Corps Base
MCO	Marine Corps Order
mm	millimeter
MOA	Military Operations Area
mph	miles per hour
MSA	Metropolitan Statistical Area
MSL	Mean Sea Level
NA	not applicable
NAAQS	National Ambient Air Quality Standards
NAVAIR	Naval Air Systems Command
NC	North Carolina
NEPA	National Environmental Policy Act
NHPA	National Historic Preservation Act
NO_2	Nitrogen Dioxide
NO_x	Nitrogen Oxides
NRHP	National Register of Historic Places
NS	Naval Station
O_3	Ozone
OPNAVINST	Office of the Chief of Naval Operations Instruction
Pb	Lead
$PM_{2.5}$	Fine Particulate Matter Less Than or Equal to 2.5 Microns Aerodynamic Diameter
PM_{10}	Suspended Particulate Matter Less Than or Equal to 10 Microns Aerodynamic Diameter
POI	Point of Interest
ppb	parts per billion
ppm	parts per million
R-	Restricted Area
RPA	Regional Programmatic Agreement
SARDIP	Stricken Aircraft Reclamation and Disposition Program
SEL	Sound Exposure Level
SHPO	State Historic Preservation Office
SIP	State Implementation Plan
SO_2	Sulfur Dioxide
SP	Sea Plane
SUA	Special Use Airspace
TCP	Traditional Cultural Property
U.S.	United States
USCB	U.S. Census Bureau
USEPA	U.S. Environmental Protection Agency
VA	Virginia
VIP	Very Important Person
VMM	Marine Medium Tiltrotor Squadron
VOC	Volatile Organic Compound

VR	Visual Route
VTOL	Vertical Take-Off/Landing
W-	Warning Area
$\mu g/m^3$	micrograms per cubic meter

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CHAPTER 1 PURPOSE AND NEED

1.1 INTRODUCTION

The Department of the Navy has prepared this Environmental Assessment (EA) to assess the potential environmental impacts associated with transitioning from Marine Medium Helicopter Squadron 774 (HMM-774) to Marine Medium Tiltrotor Squadron 774 (VMM-774) at Naval Station (NS) Norfolk in Virginia (**Figure 1.1-1**). The proposed action is part of a Marine Corps wide process of replacing its aging fleet of medium-lift helicopters, such as the CH-46E, with modern compatible airframes such as the MV-22B. These legacy aircraft are nearing the end of their lifecycle, cannot travel great distances, and are not well equipped for night or adverse weather operations (U.S. Marine Corps 1999). Transitioning the squadron includes more than just replacing its aircraft, it also includes renovating facilities to house and maintain the new system, as well as developing the skills needed to employ the new airframe within the squadron.

This EA has been prepared in accordance with the requirements of the National Environmental Policy Act (NEPA) (42 United States [U.S.] Code §4321 et seq.); the Council on Environmental Quality (CEQ) regulations implementing NEPA (40 Code of Federal Regulations [CFR] §1500 et seq.); Office of the Chief of Naval Operations Instruction (OPNAVINST) 5090.1, Chapter 10, dated 10 January 2014; Marine Corps Order (MCO) P5090.2A, Change 3; U.S. Marine Corps NEPA Manual 2.0 (2011); and all other applicable laws, regulations, Executive Orders (EOs), and instructions. This EA will be made available for public review before a Finding of No Significant Impact (FONSI) is signed. If a FONSI is not appropriate, an Environmental Impact Statement (EIS) will be prepared.

1.2 BACKGROUND

Under a regionalization effort in 1998, Naval Air Station Norfolk was absorbed by NS Norfolk. NS Norfolk Chambers Field is a new entity created by a consolidation of several facilities and functions in Hampton Roads. Chambers Field consists of two heliports, six helipads, and an 8,400-foot runway and is home to C-2, C-9, C-12, and E-2 fixed-wing aircraft, and H-3, H-46, H-53, and H-60 helicopters. Chambers Field is divided into four operational areas designated as Landing Field (LF), V Pad, Sea Plane (SP), and Landing Plane (LP) (**Figure 1.2-1**).

HMM-774 is a Marine Forces Reserve (MARFORRES) squadron based at NS Norfolk (Chambers Field), Virginia. HMM-774 is a medium-lift helicopter squadron consisting of CH-46E Sea Knight transport helicopters. The reserve squadron has been continuously stationed aboard NS Norfolk since being activated in 1969 and is currently located in Hangar LF-60 in the LF area of the airfield (see **Figure 1.2-1**). The Mid-Atlantic region, primarily Virginia and North Carolina, is where the squadron has operated since its activation. HMM-774 falls under the command of Marine Aircraft Group 49 and the 4th Marine Aircraft Wing, with the mission of supporting the Marine Air-Ground Task Force.

CH-46E Sea Knight

Figure 1.1-1. NS Norfolk General Location

Figure 1.2-1. NS Norfolk Airfield Operational Areas

1.2.1 CH-46E Sea Knight

HMM-774 is the last Marine Corps squadron operating the CH-46E. First fielded in 1980, the Boeing CH-46E Sea Knight is a medium-lift transport helicopter used by the Marine Corps to provide assault transport of combat troops, supplies, and equipment. Assault support is its primary function, and the movement of supplies and equipment is secondary. Additional tasks include combat support, search and rescue, support for forward refueling and re-arming points, casualty evacuation, and tactical recovery of aircraft and personnel. It also provides humanitarian mission and disaster relief support.

The CH-46E has tandem counter-rotating rotors powered by two upgraded T58-GE-16 turboshaft engines, producing 1,870 horsepower each. The engines are coupled so that either could power both rotors in an emergency. The rotors each feature three fiberglass blades and can be folded for shipboard operations. The CH-46E has a cargo bay with a rear loading ramp that can be removed or left open in flight for extended cargo or for parachute drops. An internal winch is mounted in the forward cabin and can be used to pull external cargo on pallets into the aircraft via the ramp and rollers. A belly cargo hook can be attached for carrying external cargo.

The Sea Knight can accommodate a crew of five and a troop capacity of 24 combat-loaded Marines, or it can be outfitted to carry medical evacuation litters when responding to disasters (cargo weight up to 4,000 pounds). The CH-46E has a combat range of 75 nautical miles for an assault mission with 12 passengers at a cruise speed of 120 knots and a service ceiling of 17,000 feet. Armament includes two .50 caliber machine guns and a M240D 7.62 millimeter (mm) machine gun.

1.2.2 MV-22B Osprey

MV-22B Osprey

The MV-22B Osprey is a joint-service, multi-mission tiltrotor vertical/short take-off and landing transport aircraft with two wingtip-mounted proprotors[1]. The aircraft combines the vertical take-off and landing (VTOL) and hovering advantages of the helicopter with the high-speed, high altitude cruise capability of modern turboprop aircraft. Except for the actual take-off and landing, the MV-22B spends most of its flight time at higher speed and at higher altitudes (similar to fixed-wing aircraft) than the rotary-wing (helicopter) aircraft it is replacing. It is designed for combat, combat support, combat service support, and Special Operations missions worldwide. The MV-22B is powered by two Rolls-Royce Allison T406/AE1107C turbo shaft engines, producing 6,150 horsepower each.

The MV-22B is shipboard compatible (able to land and take-off from ships) with the world's first complete blade fold and storage system that allows aircraft to be easily accommodated aboard ships. It is able to operate off L-class amphibious ships, amphibious assault general purpose and multi-purpose class ships, and can also operate from and be stowed on nuclear aircraft carriers. The aft ramp is used for loading and unloading troops and cargo in the interior cargo compartment and the MV-22B can transport

[1] A proprotor is a spinning airfoil that is used as both an airplane-style propeller and a helicopter-style rotor during the same flight. Proprotors are typically used on tiltrotor aircraft.

external cargo using a tandem hook suspension system for high speed transport of loads, such as vehicles and equipment.

The MV-22B can carry a crew of four and up to 24 combat-loaded Marines, or 10,000 pounds (5 tons) of cargo, at a cruising speed in excess of 240 knots. It has a combat range of 430 nautical miles and a service ceiling of 25,000 feet. The MV-22B is armed with one 7.62 mm caliber M-240G machine gun, which can be mounted on either side of the ramp and can have an Interim Defense Weapons System, which consists of a weapon turret with a six barreled 7.62 mm GAU-17/A (installed in the aircraft's aft cargo hook bay) and an M-2 (.50 caliber machine gun). Combat support is enhanced by the MV-22B's ability to be operated at night, under adverse weather conditions, in confined or isolated areas, and with various internal and external loads. The MV-22B is designed to meet Marine Corps operational requirements well into the 21st century.

1.3 PURPOSE AND NEED FOR PROPOSED ACTION

The purpose of the proposed action is to transition the existing HMM-774 squadron to VMM-774. Replacing the legacy CH-46E aircraft with MV-22B aircraft would improve and modernize the medium-lift capability in the Mid-Atlantic region.

The transition of HMM-774 to VMM-774 is needed as part of the established U.S. Marine Corps Aviation Plan replacing CH-46E aircraft and enhancing the mission and combat capability of the medium-lift community (U.S. Marine Corps 2015). The CH-46E is at the end of its service life. Replacement of the CH-46E helicopters with the MV-22B is needed to improve operational capabilities, limit vulnerabilities in expected combat situations, and maintain combat and mission readiness.

1.4 THE ENVIRONMENTAL REVIEW PROCESS

1.4.1 The National Environmental Policy Act

NEPA of 1969 requires consideration of environmental issues in federal agency planning and decision making. Under NEPA, federal agencies must prepare an EA or an EIS for any federal action, except those actions that are determined to be "categorically excluded" from further analysis (40 CFR §1501.3 and §1501.4). An EA is a concise document that provides sufficient analysis for determining whether to prepare an EIS or a FONSI (40 CFR §1508.9).

1.4.2 Public Involvement

The public review process provides the opportunity for stakeholders (including government agencies, special interest groups, and citizens) to review and comment on the EA. The EA public comment period will begin with the publication of a Notice of Availability in the Virginian-Pilot (Norfolk, Virginia). The notice will indicate the availability of this EA for public review and comment (**Appendix C**). Comments will be accepted by mail, e-mail, or at the public meeting.

Copies of the EA will be available for review in the Mary D. Pretlow Anchor Branch Library in Norfolk. The EA will also be available on the Navy Region Mid-Atlantic website (www.cnic.navy.mil/cnrma). A public meeting will be held at Willoughby Elementary School in Norfolk to solicit comments on the Draft EA. See **Appendix C** for copies of public meeting materials.

1.5 ORGANIZATION OF THIS EA

Chapter 1 (this chapter) provides background information relevant to the proposed action and discusses its purpose and need. Chapter 2 presents the proposed action, alternatives development process, descriptions of the alternatives analyzed in this EA, and actions requiring consideration of cumulative effects. Chapter 3 includes the affected environment, environmental consequences, and the cumulative effects analysis for all resource areas. This chapter also includes an analysis of the No Action Alternative. Mitigation measures are included in Chapter 3. References are provided in Chapter 4, and Chapter 5 contains a list of the preparers of this document. Several technical appendices are also included to provide supporting information.

CHAPTER 2 PROPOSED ACTION AND ALTERNATIVES

2.1 DESCRIPTION OF THE PROPOSED ACTION

The proposed action is to transition HMM-774 to VMM-774. This proposed action includes the following components:

- Replace 12 CH-46E aircraft with 12 MV-22B aircraft;
- Increase squadron personnel;
- Renovate existing facilities to accommodate and maintain MV-22B aircraft; and
- Conduct approximately 4,752 annual MV-22B operations at NS Norfolk airfield.

Further descriptions of the proposed action components are provided in **Sections 2.1.1 through 2.1.5**.

2.1.1 Aircraft Transition

The MV-22B was procured to replace legacy medium-lift helicopters for both the active and the reserve components of the Marine Corps. The transition from CH-46E to MV-22B began in 2005, and HMM-774 is the last squadron in the Marine Corps to transition. Under the proposed action, HMM-774 would be redesignated as VMM-774. The existing 12 CH-46E aircraft assigned to the squadron would be retired in Fiscal Year (FY) 2015. There would be a period of training required to transition CH-46E personnel to MV-22B personnel. Once training is complete and all 12 MV-22B aircraft have arrived, VMM-774 would operate the MV-22B at NS Norfolk. The first MV-22B aircraft would arrive at NS Norfolk in FY 2016, and the squadron is expected to be fully operational by FY 2018.

2.1.2 Personnel

Staffing requirements to maintain and operate the MV-22B reserve squadron would be 239 personnel (109 full-time and 130 reservists). This would require a small increase in personnel (7 full-time and 23 reservists) from the current staffing levels. **Table 2.1-1** shows full-time and reserve personnel for HMM-774 versus VMM-774.

Table 2.1-1. Personnel Associated with HMM-774 and VMM-774

	Full-time (officer/enlisted)	Reservists (officer/enlisted)	Total
HMM-774 (CH-46E)	102 (8/94)	107 (25/82)	209
VMM-774 (MV-22B)	109 (8/101)	130 (27/103)	239
Proposed Change	**+7 (0/7)**	**+23 (2/21)**	**+30**

2.1.3 Facility Requirements

2.1.3.1 Runway

Department of Defense (DOD) runways are separated into two types, Class A and Class B. Class A runways are less than 8,000 feet long and are primarily intended for small, light aircraft; Class B runways are primarily intended for high-performance and large, heavy aircraft (DOD 2011). A Class A runway is required to support MV-22B operations. The runway to be used for MV-22B operations at NS Norfolk is

a Class B runway and would be capable of supporting operations without modification (U.S. Navy 2009a).

2.1.3.2 Hangar

VMM-774 would require a hangar with approximately 39,000 gross square feet available to support maintenance and provide assigned personnel office and shop space. Aircraft hangars include three distinct areas: (1) the hangar bay that provides weather protected shelter for inspection, servicing, maintenance, and emergency shelter for operational aircraft; (2) the shop/maintenance area that provides work center space for equipment and personnel in support of organizational level maintenance; and (3) squadron administrative and operations area that provides administrative office spaces for mission planning, including brief/debrief rooms, ready room, and personnel offices.

2.1.3.3 Aircraft Parking Area

VMM-774 would require a parking area with tie downs on the apron to accommodate up to 10 of the 12 assigned MV-22B aircraft, with the remaining 2 (or more as required for maintenance) housed in the hangar. The MV-22B can be parked flight-ready or in blade fold/wing stow position, so surface area required for parking varies depending on how planes are configured (**Table 2.1-2**). The blade fold/wing stow position allows more MV-22B aircraft to be parked in a smaller area, but adds the requirement to use a seven person aircraft tow crew to tow the aircraft to a parking spot large enough for the aircraft to become flight ready, and back to the blade fold/wing stow spot after operations and maintenance are completed. The proposed areas for parking would not require increasing the existing surface area of the apron, but would include asphalt repairs and restriping of the surface.

Table 2.1-2. MV-22B Aircraft Configurations (feet)

Configuration	Length	Width	Height
Flight Ready	57.3	84.6	22.1
Full Stow	63.0	18.4	18.2

Source: U.S. Navy 2013a.

2.1.3.4 Containerized Flight Training Device

VMM-774 would require two Containerized Flight Training Devices (CFTDs) to meet training requirements. CFTDs are flight simulators and have become integral in the proficiency training of pilots. The CFTD trains aircrews on basic aircraft familiarization and handling qualities. Training capabilities include systems/subsystems operation, communication, malfunctions, day and night flying, use of night-vision goggles, formation flying, aerial refueling, and landing on ships. The device is intended to train aircrews for any task that might be performed in the aircraft, while limiting the monetary and environmental costs of in-flight training. Two CFTDs are planned for installation adjacent to Hangar LP-49 (flight simulator) at NS Norfolk (U.S. Navy 2015a). VMM-774 would use these CFTDs and no modifications would be required.

2.1.4 Airfield Operations

The MV-22B would be operated in accordance with the *Naval Air Training and Operating Procedures Standardization Flight Manual* (U.S. Navy 2009b), which references aircraft systems, procedures, operating limitations, and the like. The types and frequency of training events provided below and elsewhere in the EA are based on the *MV-22B Training and Readiness Manual* (U.S. Marine Corps

2010). An operation represents a single movement or individual flight in the base airfield or airspace environment. For example, one aircraft departing and returning would represent two airfield flight operations.

As illustrated in **Table 2.1-3**, the proposed total MV-22B airfield operations would be the same as the current CH-46E airfield operations, but the types of operations and flight patterns would be slightly different. Actual operations can vary somewhat depending on specific training missions or need at any given time. For analysis purposes, a total of 4,752 annual airfield operations are expected with the MV-22B squadron (**Table 2.1-3**); approximately 360 of these operations would occur at night. The MV-22B squadron would execute the following types of airfield operations at NS Norfolk: arrival (landing); departure (take-off); touch-and-go; field carrier landing practice (FCLP); and ground-controlled approach (GCA). These types of operations more closely resemble operations currently performed by fixed-wing aircraft at the airfield. Each of these is described below.

Table 2.1-3. Annual Airfield Operations

Type of Operation	Current CH-46E Operations	Proposed MV-22B Operations	Proposed Change
Arrival	106	58	-48
Departure	106	58	-48
Touch-and-Go	162	200	+38
FCLP	0	44	+44
GCA	22	36	+14
Total Monthly Operations	**396**	**396**	**0**
Total Annual Operations	**4,752**	**4,752**	**0**

Arrival. This involves aircraft returning and landing from a local training area, landing zone (LZ), low-altitude route, or as part of a training maneuver. For the MV-22B, the aircraft would transition from airplane mode of flight to the VTOL mode in order to land. Such landings would occur on the runways or at helicopter pads at the airfield. The following defines the basic types of arrivals.

- *Straight-in/Full-Stop Arrival.* When performing this operation, an aircraft lines up 6-10 nautical miles from the airfield on the runway centerline, descends gradually, converts to VTOL mode, lands, and then taxis off the runway. This operation can involve vertical landings or roll-on landings, if the aircraft is in conversion mode. About ten straight-in/full-stop arrivals are anticipated per month for VMM-774 at NS Norfolk.
- *Overhead Break Arrival.* An expeditious arrival using visual flight rules. An aircraft approaches the runway 500 feet above the altitude of the landing pattern. Approximately halfway down the runway, the aircraft performs a 180-degree turn to enter the landing pattern. Once established in the landing pattern, the aircraft converts to VTOL mode, lowers landing gear, and performs a 180-degree descending turn to land vertically on the runway. Roll-on landings in conversion mode can be used. About 36 overhead break arrivals are anticipated per month for the squadron at NS Norfolk.
- *Instrument Arrival.* In this operation, air traffic controllers direct the MV-22B to a landing using instrument flight rules only (i.e., non-visual means). During the approach, the aircraft transitions to conversion mode, lowers the landing gear, then continues to transition to VTOL mode prior to executing a vertical landing. Roll-on landings can be made in conversion mode. About 12 instrument arrivals are anticipated per month at NS Norfolk.

Departure. This involves an aircraft taking off to a local training area, LZ, low-altitude route, a non-local training area, or as part of a training maneuver (i.e., touch-and-go). MV-22B take-offs are either vertical or after a short roll. About 58 departures are anticipated per month from NS Norfolk.

Touch-and-Go. An aircraft lands and takes off on a runway without coming to a full stop. After landing, the pilot executes another take-off with minimal delay without taxiing clear of the runway. The touch-and-go is counted as two operations because the landing is counted as one operation and the take-off is counted as another. During routine training, 100 touch-and-go operations are expected per month for the squadron (200 total operations).

FCLP. An aircraft practices simulated carrier landing. FCLPs are required training for all pilots before landing on an aircraft capable ship. The FCLP is counted as two operations because the landing is counted as one operation and the take-off is counted as another. An average of 22 FCLPs is expected monthly for this squadron (44 total operations).

GCA. In this training event, air traffic controllers guide aircraft to a landing to practice arrivals under adverse conditions. This event may involve a precision or non-precision approach. The GCA is counted as two operations because the landing is counted as one operation and the take-off is counted as another. Eighteen GCA patterns are anticipated per month for VMM-774 at NS Norfolk (36 total operations).

2.1.5 Other Training Requirements

MV-22B training requirements are defined in the *MV-22B Training and Readiness Manual* (U.S. Marine Corps 2010). Training would be conducted outside of the NS Norfolk airfield within existing DOD airspace and training ranges where other MV-22B aircraft and the current CH-46E squadron also conduct training. This proposed action does not establish new airspace or training ranges or change the manner in which these assets are used. Proposed VMM-774 usage of airspace and training ranges is described in **Sections 2.1.5.1 and 2.1.5.2**; however, training to occur at other DOD Installations has been previously analyzed in other NEPA documents and those documents are incorporated by reference to this EA in accordance with CEQ guidance (77 Federal Register 14473). VMM-774 would coordinate all training events with owners of the individual range(s) to ensure no scheduling conflicts would occur and that the planned training is consistent with the range's procedures and NEPA documentation. Evaluation of impacts from training of MV-22B aircraft in the Mid-Atlantic region is provided in the following documents:

- EA for Marine Corps Base (MCB) Camp Lejeune/Marine Corps Air Station (MCAS) New River Range Operations (U.S. Navy 2009c)
- EA for MCAS Cherry Point Range Operations (U.S. Navy 2009d)
- EIS/Overseas EIS for Atlantic Fleet Training and Testing (U.S. Navy 2013b)
- EA for Proposed Military Operations Areas in Eastern North Carolina (U.S. Navy 2003)
- EIS for Introduction of the V-22 to the Second Marine Aircraft Wing in Eastern North Carolina (U.S. Marine Corps 1999)

2.1.5.1 Airspace

VMM-774 training would occur within airspace currently used by other MV-22B squadrons (**Figure 2.1-1**), including:

- Restricted Area (R-6606). Airspace designated to support ground or flight activities that could be hazardous to non-participating aircraft. Entry into restricted areas without approval from the using or controlling agency is prohibited.
- Warning Area (W-50A/B/C, W-72A/B, and W-386). Airspace extending 3 nautical miles from the coast of the U.S., designated to contain activity that may be hazardous to non-participating aircraft. A warning area may be located over domestic waters, international waters, or both.
- Military Operations Area (Farmville MOA). Airspace established to separate or segregate certain non-hazardous military activities from instrument flight rules aircraft traffic and to identify visual flight rules aircraft traffic where these military activities are conducted.
- Military Training Route (visual routes [VR]: VR-042, VR-1755, VR-1046, and VR-707). A corridor of airspace used by the military, usually for the purpose of conducting low-altitude, high-speed training.
- Aerial Refueling Track (Farmville MOA and W-72A and W-386). A segment of defined airspace in which a tanker flies a racetrack pattern while refueling the receiver aircraft.

2.1.5.2 Training Ranges

Various DOD training ranges and facilities would be used during MV-22B training operations that are consistent with approved training activities at these locations. These training ranges include:

- Pennsylvania:
  - Muir Army Air Field at Fort Indiantown Gap
- New Jersey:
  - Joint Base (JB) McGuire-Dix-Lakehurst
- North Carolina:
  - Bombing Target (BT)-11 and BT-9 Ranges at MCAS Cherry Point
  - Dare County Bombing Range
  - Long Shoal Naval Ordnance Area (commonly referred to as Stumpy Point Bombing Range)
  - Marine Corps Outlying Landing Field Atlantic
- Virginia:
  - Blackstone Army Air Field at Fort Pickett
  - Felker Army Air Field at JB Langley-Eustis
  - Fort AP Hill
  - Marine Corps Air Facility (MCAF) Quantico
- West Virginia:
  - Camp Dawson

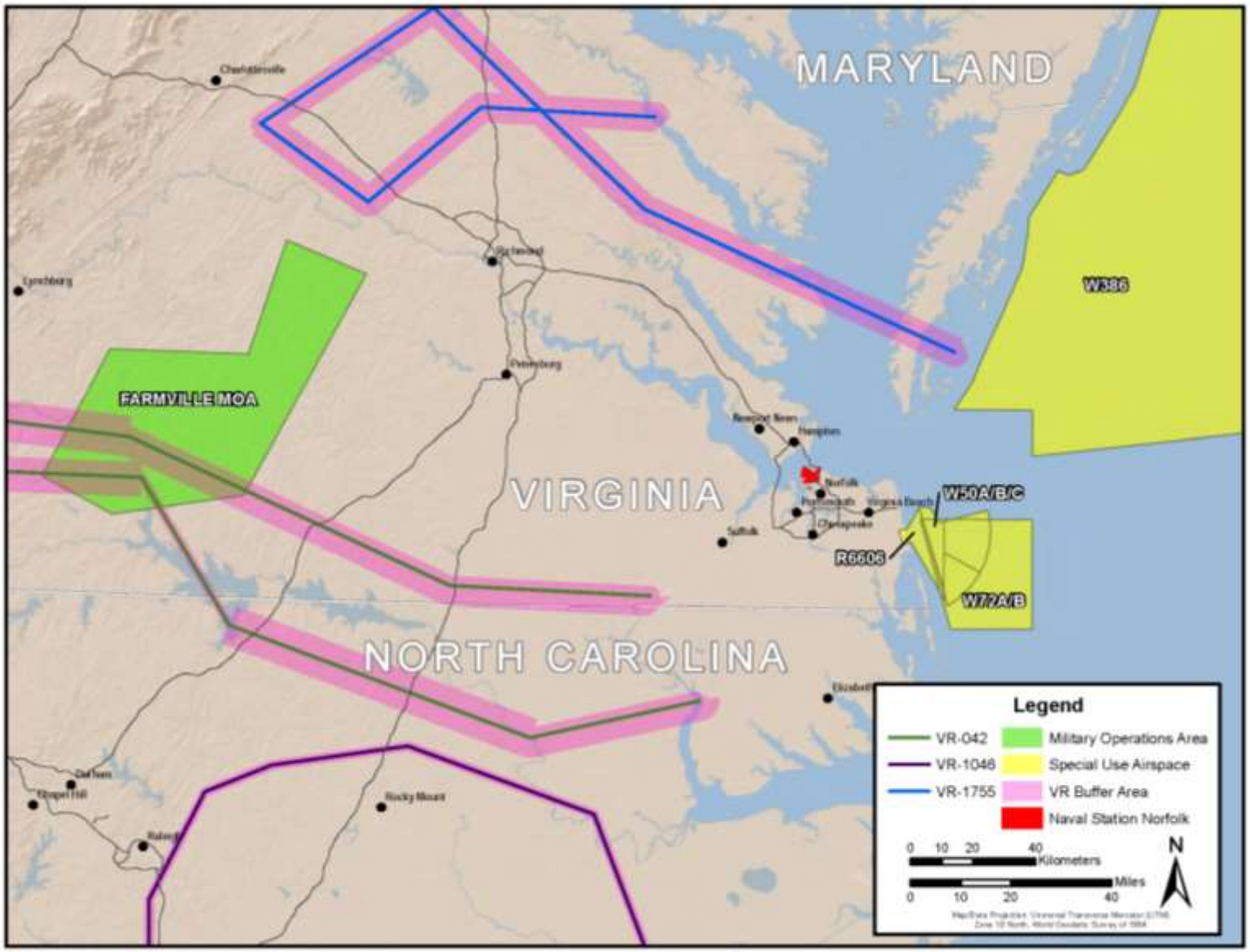

Figure 2.1-1. Airspace to be Used for MV-22B Training

In addition to training ranges, the MV-22B utilizes a variety of approved LZs located independently or within training ranges. Existing LZs currently authorized for use by MV-22B aircraft would be used to practice safely inserting and extracting cargo and personnel. Because of varying scenarios and the need to train for a variety of missions, the typical training operations at an LZ would normally consist of up to four MV-22B aircraft approaching, hovering/landing, taking off, flying patterns or repeat landings, and exiting.

VMM-774 would conduct aerial gunnery exercises. MV-22B onboard weapons include: M-240G (7.62 mm) and the M-2 (.50 caliber) machine-guns, along with expendables (decoy flares). **Table 2.1-4** lists proposed annual ordnance use. About three aircraft are expected to execute aerial gunnery training once per quarter to maintain training and readiness currency. The squadron would utilize the Dare County Bombing Range, Long Shoal Naval Ordnance Area (Stumpy Point Bombing Range), and BT-11 and BT-9 ranges (all in North Carolina) for aerial gunnery training.

Table 2.1-4. Proposed Total Annual Ordnance Use

Ordnance	Annual Rounds
7.62 mm	21,000
.50 caliber	11,000
MJU-47 flares	480
SM-875 flares	480

2.2 ALTERNATIVES DEVELOPMENT

CEQ regulations (40 CFR §1508.9(b)) and the guidelines contained in Navy NEPA implementing regulations in 32 CFR part 775; OPNAVINST 5090.1, Chapter 10 (10 January 2014); and MCO P5090.2A, Change 3, Chapter 12 (26 August 2013), Environmental Compliance and Protection Manual, provide guidance on the consideration of project alternatives and promote the objective evaluation of all reasonable alternatives. Reasonable alternatives must meet the stated purpose and need for the proposed action (refer to **Section 1.3**), which is to transition HMM-774 to VMM-774.

2.2.1 Alternatives Eliminated from Further Analysis

The following alternatives were considered but eliminated from further analysis because they did not meet the purpose of and need for the proposed action. Reasonable alternatives include those that are practical or feasible from a technical and economic standpoint. **Sections 2.2.1.1 and 2.2.1.2** provide justification for the alternatives dismissed from further analysis for transitioning HMM-774 to VMM-774. These alternatives included off-base alternatives as well as alternatives within NS Norfolk.

2.2.1.1 Off-Base Alternatives

HMM-774 has been continuously stationed at NS Norfolk since 1969, and the desire of MARFORRES is to continue the presence at NS Norfolk due to the strategic location, which allows the squadron to support MCB Camp Lejeune and MCAF Quantico. At the initial planning stages for this action, NS Norfolk did not appear to be the most economically viable alternative for transitioning HMM-774 due to a number of facility deficiencies noted in a preliminary assessment for stationing MV-22B aircraft at the base. To support a fully-informed decision, a siting study to investigate the feasibility of relocating the reserve squadron to another installation was initiated (U.S. Navy 2013a). A screening analysis was performed to identify all possible locations (regardless of service area) using the following criteria:

- *Distance to supported elements*. VMM-774 is a logistics support squadron and must be able to fly within one airplane leg's distance (500 nautical miles) to MCB Camp Lejeune or MCAF Quantico.
- *Mission Compatibility*. Installations with existing rotary missions or both rotary- and fixed-wing missions would be the most compatible with the proposed MV-22B operations.
- *Recruitability*. As a reserve squadron, home basing in a location with a large pool of potential recruits is necessary to eliminate or avoid manpower complications.
- *Configuration*. Existing facilities and infrastructure were examined to determine which installations could best accommodate the MV-22B with the least infrastructure or construction requirements.

The siting study ultimately resulted in NS Norfolk and MCAS New River as potential installations for VMM-774 (U.S. Navy 2013a). However, since conclusion of the siting study, the situation at MCAS New River has changed. A newly constructed Type II hangar (AS-508) that was considered available during the siting study is no longer available due to the planned addition of a new operational MV-22B squadron at MCAS New River planned for FY 2019 (U.S. Marine Corps 2015). With this additional squadron, there is no longer available hangar space for the reserve squadron and no space to allow for new construction. In addition, after the siting study's completion, MARFORRES received notification from the Deputy Chief of Naval Operations supporting NS Norfolk as a viable location for transitioning HMM-774 to VMM-774 with proposed infrastructure modifications (U.S. Navy 2014). Based on this information, relocating the reserve squadron to MCAS New River was eliminated as an alternative for analysis in this EA.

2.2.1.2 NS Norfolk Alternatives

Alternatives for providing hangar and parking space for VMM-774 were assessed at NS Norfolk. Siting criteria for VMM-774 hangar space includes the following requirements:

- Available for arrival of first MV-22B aircraft (scheduled for FY 2016)
- Located in the LP area to allow aircraft to utilize Runway 10/28
- Sufficient size to support up to four aircraft at a time

<u>Hangar LF-60</u>

The predominant arrival, departure, and flight patterns associated with fixed-wing operations in the LP area are the most consistent with and suitable for enduring MV-22B flight operations. HMM-774 is currently located in the LF area of the airfield in Hangar LF-60; this area is predominately used for helicopter operations. As such, housing the squadron in LF-60 is not the most efficient or reasonable location. In addition, the size and configuration of LF-60 does not meet the criteria to support MV-22B hangar space. Extensive modifications to LF-60 would be required to meet the space and configuration requirements for MV-22B that could not be completed within the timeline for arrival of the first aircraft. Therefore, utilizing LF-60 for MV-22B was eliminated as an alternative for analysis in this EA.

<u>Build a New Hangar</u>

The arrival of the first MV-22B aircraft is scheduled for FY 2016. Given the time constraints, programming the funds, determining a location, and developing a facility design for a new hangar are not

feasible. Therefore, this alternative was eliminated from detailed analysis. Renovation of an existing facility is the only viable option at NS Norfolk.

2.2.2 Alternatives Carried Forward for Analysis

2.2.2.1 No Action Alternative

No action means that the proposed action would not take place. Analysis of the No Action Alternative provides a benchmark, enabling decision-makers to compare the magnitude of the environmental effects of the proposed action or alternatives versus the potential impacts if no action were implemented. In many projects, a No Action Alternative is the same as the description of the existing condition. However, in the case of this proposed action, the No Action Alternative would not be a static situation, but represents the conditions if HMM-774 does not transition to VMM-774.

Under the No Action Alternative, the existing 12 CH-46E assigned to HMM-774 would retire in FY 2015, and the squadron of 209 personnel would be reassigned to other installations or released from the reserves. No facility or parking apron improvements would occur. The No Action Alternative is not a viable alternative since it does not meet the purpose and need of the proposed action, but is carried forward as a baseline against which to compare the impacts of the action alternatives.

2.2.2.2 Alternative 1 (Preferred)

Under Alternative 1, HMM-774 would transition to VMM-774. The 12 legacy CH-46E aircraft assigned to HMM-774 would be replaced with 12 MV-22B aircraft. To support this transition, squadron staffing would increase to 239 personnel (an increase of 30 personnel from the current squadron, see **Table 2.1-1**).

VMM-774 would relocate to Hangar LP-167, which is located in the LP area of the airfield and encompasses just under 160,000 square feet. LP-167 is adjacent to Runway 10/28, allowing for easy taxiing to and from the runway. The hangar is currently occupied by NS Norfolk Air Operations, Air Mobility Command (AMC), Naval Air Systems Command (NAVAIR), and Stricken Aircraft Reclamation and Disposition Program (SARDIP) (**Figure 2.2-1**). SARDIP and NAVAIR would relocate to Hangar LF-60. The other tenants in Hangar LP-167 would remain in place and share the space with VMM-774. Minor interior repairs would occur at LF-60 to include paint, tile repair, and network improvements. NAVAIR would require hangar and shop space for two MH-60s and one MH-53 (all with blades folded). SARDIP would require hangar and shop space for one E-2C (wings folded) in addition to parking apron space for two E-2C aircraft. These units do not require routine access to the fixed-wing runway (10/28); consolidating all functions within the LF area for these units would improve operational efficiency.

Interior renovations of Hangar LP-167 would be required to accommodate the MV-22B; the footprint of LP-167 would not change and no ground disturbance is expected. Hangar LP-167 could support parking of three MV-22B aircraft in the spread configuration and one aircraft in the fold/wing stow configuration. Facility renovations include repair of the hangar bay doors; repair or replacement of lighting fixtures, windows, walls, ceiling tiles, and flooring in the hangar bay and administrative spaces, as needed; repair of the crane in the hangar; replacement of the electrical distribution system; replacement of the overhead sprinkler system to include aqueous film forming foam; replacement of the heating, ventilation, and air conditioning system; installation of additional grounding points in the hangar; interior and exterior painting; and repair or replacement of aircraft tie downs in the hangar.

Figure 2.2-1. Alternative 1 (Preferred)

The existing hazardous materials storage locker located at LF-60 would also be relocated to Hangar LP-167 to provide storage for maintenance petroleum, oils, and lubricants. The exact location for the locker has not been determined, but would not result in any ground disturbing activities.

VMM-774 aircraft would be parked in two locations on either side of Hangar LP-167: on the northwest apron (6 aircraft) and on the northeast apron (3 aircraft) (**Figure 2.2-1)**. MV-22B parking on the northwest apron would reduce AMC transient aircraft parking by two spaces. Parking on the northeast apron would require realignment of a segment of the perimeter fence south of the parking area (adjacent to LP-212) to comply with force protection standards. The northeast apron is currently used by NS Norfolk Air Operations for very important person (VIP)/transient parking. The squadron would work with NS Norfolk Air Operations to facilitate VIP parking as necessary. High temperature heat resistant concrete and joint sealant would be installed at each individual aircraft parking spot. Additional aircraft parking apron repairs include pavement repair and joint sealant replacement; restriping of the parking apron; installation of additional grounding points on the apron; and repair or replacement of aircraft tie downs.

Proposed MV-22B airfield operations would total 396 monthly operations (4,752 annual operations). Approximately 30 of the monthly operations would occur at night. Night and weekend operations are already supported at NS Norfolk. There is no net change in the total number of annual airfield operations under Alternative 1 compared to legacy CH-46E operations; however, the type of operations would vary slightly (refer to **Table 2.1-3**).

2.2.2.3 Alternative 2

Under Alternative 2, the HMM-774 would transition to VMM-774. The 12 legacy CH-46E aircraft assigned to HMM-774 would be replaced with 12 MV-22B aircraft and the squadron would be redesignated as VMM-774. As with Alternative 1, the squadron staffing would increase to 239 personnel (refer to **Table 2.1-1**).

Under Alternative 2, VMM-774 would trade hangars with a Navy MH-60 squadron located in Hangar LP-27. VMM-774 would relocate to Hangar LP-27 located in the LP area of the airfield (**Figure 2.2-2**). Interior renovations would be required at Hangar LP-27 to facilitate MV-22B maintenance (repair/replace electrical, structural, roofing and flooring, etc.). The existing hazardous materials storage locker located at LF-60 would also be relocated to Hangar LP-27 to provide storage for maintenance petroleum, oils, and lubricants. The exact location for the locker has not been determined, but would not result in any ground disturbing activities. Hangar LP-27 does not provide adequate vertical space to rotate the nacelles of the MV-22B. The nacelles are the outer casings of the aircraft's two engines. An addition to Hangar LP-27 is not feasible given the Inhabited Building Distance safety arc associated with the combat aircraft loading area on Taxiway G. Therefore, any maintenance procedures on the MV-22B requiring nacelle movement would require an operational workaround; the aircraft would have to be towed out of the hangar to rotate the nacelles, and then towed back into the hangar for required maintenance.

Dedicated VMM-774 aircraft parking would be as depicted in **Figure 2.2-2.** The aircraft parking area would require the same types of repairs noted in Alternative 1: heat resistant concrete and joint sealant; restriping; additional grounding points; and repair/replacement of aircraft tie downs.

Figure 2.2-2. Alternative 2

To accommodate the movement of the MH-60 squadron, interior modifications and renovations to Hangar LF-60 would be required, as well as a 2,000 square foot addition (**Figure 2.2-2**). Modifications and renovations would include: replacement of carpet, tile, and epoxy flooring where needed; interior and exterior painting; replacement of ceiling tiles; repair of aircraft grounding receptacles in the hangar and on the aircraft parking apron; and repair and repainting of the aircraft parking apron.

Proposed MV-22B airfield operations would total 396 monthly operations (4,752 annual operations). Approximately 30 of the monthly operations would occur at night. Night and weekend operations are already supported at NS Norfolk. There is no net change in the total number of annual airfield operations under Alternative 2 compared to legacy CH-46E operations; however, the type of operations would vary slightly (refer to **Table 2.1-3**).

2.2.3 Summary of Alternatives

Table 2.2-1 provides a summary of the proposed action components addressed under each alternative.

Table 2.2-1 Summary of Alternatives

Proposed Action Component	No Action Alternative	Alternative 1	Alternative 2
Aircraft Transition	• 12 CH-46E retired in FY 2015. • No replacement aircraft assigned.	• 12 CH-46E retired in FY 2015. • Replaced with 12 MV-22B aircraft.	• 12 CH-46E retired in FY 2015. • Replaced with 12 MV-22B aircraft.
Personnel	• Reduce personnel at NS Norfolk by 209.	• Increase personnel at NS Norfolk by 30.	• Increase personnel at NS Norfolk by 30.
Facility Requirements	• No facility construction or renovations.	• VMM-774 relocates to Hangar LP-167. • Current tenants of Hangar LP-167 (SARDIP and NAVAIR) relocate to Hangar LF-60. • Interior renovations to Hangar LP-167. • Interior renovations to LF-60. • Realign section of perimeter fence south of parking. • Improve pavement conditions on parking apron.	• VMM-774 relocates to Hangar LP-27. • Current tenants of Hangar LP-27 (Navy MH-60 squadron) relocate to Hangar LF-60. • Interior renovations to Hangar LP-27. • Interior renovations and 2,000 square foot addition to Hangar LF-60. • Improve pavement conditions on parking apron.
Airfield Operations	• Reduce CH-46E annual airfield operations by 4,752.	• Reduce CH-46E annual airfield operations by 4,752. • Increase MV-22B annual airfield operations by 4,752.	• Reduce CH-46E annual airfield operations by 4,752. • Increase MV-22B annual airfield operations by 4,752.

2.3 ACTIONS REQUIRING CONSIDERATION OF CUMULATIVE EFFECTS

NEPA regulations require an evaluation of those cumulative effects with the potential for significance. CEQ regulations implementing the procedural provisions of NEPA define cumulative impacts as: "*The impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (federal or non-federal) or person undertakes such other actions*" (40 CFR § 1508.7). The CEQ also provides guidance on cumulative impacts analysis in *Considering Cumulative Effects Under the National Environmental*

Policy Act (CEQ 1997) and *Guidance on the Consideration of Past Actions in Cumulative Effects Analysis* (CEQ 2005).

Table 2.3-1 provides the projects given consideration for potential cumulative effects to resources at NS Norfolk. The cumulative effects analysis focuses on the transition action, renovation activities, personnel increases, and airfield operations at NS Norfolk; cumulative effects of training at off-base locations are analyzed in the NEPA documents referenced in **Section 2.1.5**. Current and reasonably foreseeable future actions that may occur in the same location and/or at the same time as the proposed action were considered.

Table 2.3-1. Projects for Cumulative Effects Consideration

Project	Year	Description	Resources Impacted
Relocation of the Fleet Recreation Park ball fields[1]	2011	Relocated ball fields that were previously situated at the approach/departure surface at the west end of Chambers Field.	public health and safety
Airfield Obstruction Management Plan[2]	2012	Implements Airfield Obstruction Management Plan (formerly Clear Zone Management Plan) that provides recommendations for removing vegetation height obstructions to reduce safety risks.	public health and safety
I-564 Intermodal Connection[3]	2013	Grants Virginia Department of Transportation real property rights to extend I-564 to Norfolk International Terminal and make other highway improvements in the vicinity of NS Norfolk airfield.	airfield and airspace; air quality
Storage locker and oil tank relocation[4]	2015	Relocates a hazardous materials storage locker and used oil tank from the flightline to hangar LF-60.	airfield and airspace; public health and safety
Establish concrete pads for CFTDs[5]	2015	Constructs a concrete pad and electrical connections for two CFTDs adjacent to Hangar LP-49 simulator building.	public health and safety
Replace Navy C-2A with Navy V-22(N)[6]	2020	Proposal to replace Navy C-2A aircraft with Navy variant of V-22. East coast basing option includes NS Norfolk. Existing infrastructure and facilities would be used to the extent possible.	airfield and airspace; noise; land use; air quality

Sources: [1]Virginia Department of Transportation 2012; [2] U.S. Navy 2012; [3]U.S. Navy 2013c; [4]U.S. Navy 2013d; [5]U.S. Navy 2015a; [6]U.S. Navy 2015b.

CHAPTER 3 AFFECTED ENVIRONMENT AND ENVIRONMENTAL CONSEQUENCES

This chapter describes the affected environment and environmental consequences from the proposed transition of HMM-774 to VMM-774 at NS Norfolk. Two action alternatives and the No Action Alternative are analyzed. The following definitions are useful when reviewing this chapter:

- **Affected Environment or Baseline Conditions** – descriptions of the existing conditions by resource area at the time of preparation of this EA. The affected environment includes the operation of 12 CH-46E reserve aircraft, approximately 4,752 airfield operations annually. The HMM-774 squadron is currently housed in Hangar LF-60 and primarily utilizes the LF area of the airfield (Runway 09/27). There are 209 personnel currently assigned to the squadron.
- **No Action Alternative** – in this scenario, HMM-774 would not transition to VMM-774. The current CH-46E aircraft assigned to the squadron will retire in FY 2015. The current 209 personnel assigned to the squadron would be reassigned to other installations or released from the reserves. The squadron would vacate Hangar LF-60 and no facility or parking apron improvements would occur. This alternative is not viable nor does it meet the purpose and need. Descriptions of the impacts associated with the No Action Alternative are provided by resource area.
- **Action Alternatives** – two alternatives (Alternatives 1 and 2) are proposed for the transition of HMM-774 to VMM-774. The primary difference between the two alternatives is the hangar where the squadron would be housed. In both alternatives, the 12 CH-46E aircraft would be replaced with 12 MV-22B aircraft. There would be no net change in the total annual airfield operations between the current CH-46E operations and the proposed MV-22B operations; however, the MV-22B would have slightly different flight tracks and would primarily utilize the LP area of the airfield (Runway 10/28). In both action alternatives, an additional 30 personnel would be assigned to the squadron (for a total of 239). Descriptions of the impacts associated with each alternative are provided by resource area and compared against the existing conditions to provide a frame of reference.
- **Cumulative Effects** – a description of the proposed action's contribution to cumulative effects within the region of influence by resource area. A list of cumulative actions (past, present, and reasonably foreseeable) were provided in **Table 2.3-1**. Not all cumulative actions affect all resource areas; therefore, only those projects with the potential to contribute to cumulative effects of an individual resource are addressed (see **Table 2.3-1** for resources affected by each project).

Resource areas analyzed in this EA are airfield and airspace, noise, land use, air quality, socioeconomics and environmental justice, cultural resources, and public health and safety. Some resources were eliminated from detailed analysis in the EA in accordance with CEQ guidance because the proposed action would not affect these resources, or would have negligible or minor impacts not warranting detailed analysis (40 CFR §1501.7(a)(3) and *Federal Register* Volume 77 page 14475). The resources eliminated from detailed analysis include:

- **Biological Resources** – The proposed action would not impact any federally threatened or endangered species or critical habitat. Fence repairs and realignment under Alternative 1 would result in minimal to no disturbance to vegetation. The management of wildlife, specifically bird/animal aircraft strikes hazards (BASH) in the airfield environment, is evaluated in **Section 3.7**. Overall impacts to biological resources would be negligible.
- **Community/Emergency Services** – The proposed action would not substantially affect the current capacity of the community and emergency services available or within the surrounding municipalities. No impacts on community and emergency services would be expected.
- **Hazardous Wastes and Materials** – Minor amounts of hazardous materials would be used during facility renovations, construction, and operations. The hazardous materials storage locker at LF-60 would be relocated to the new VMM-774 hangar. All hazardous wastes and materials would be disposed of or dispensed at existing facilities in accordance with federal, state, and local regulations; therefore, no impacts from hazardous wastes and materials would be anticipated.
- **Recreation** – There are no recreational resources located within areas evaluated under the proposed action. The proposed action would not involve any activities that would alter recreational areas or impact recreational activities at or adjacent to NS Norfolk. No impacts to recreation resources would occur.
- **Soils and Topography** – Renovations would take place within existing hangars and on the parking apron. Minor soil disturbance is anticipated with the repair/realignment of a segment of the perimeter fence near Hangar LP-167. Overall, impacts to soils and topography would be negligible.
- **Utilities** – The proposed action would not substantially increase demand to current utility systems. Computer system wiring and new electric power connections may be required, but these needs would not interfere with utility load distribution or continuity of service. New utilities or upgrades to existing utilities would be run through existing duct banks. As such, no impacts to this resource would be expected.
- **Visual/Aesthetic Resources** – Renovation activities associated with the proposed action would result in facilities that would be consistent with the current characteristic features of the airfield, aesthetic qualities of the installation, and surrounding areas and view sheds at NS Norfolk. There would be no impacts to this resource.
- **Water Resources** – Minor ground-disturbing activities may occur in a limited area during repair and realignment of the perimeter fence near Hangar LP-167; no surface water or wetlands are in proximity to the perimeter fencing. No impacts to water resources would be anticipated.

3.1 AIRFIELD AND AIRSPACE

The safe, orderly, and compatible use of the nation's airspace is made possible through a system of flight rules and regulations, airspace management actions, and air traffic control procedures just as use of the nation's highway system is governed by traffic laws and rules for operating vehicles. The National Airspace System is designed and managed to protect aircraft operations around most airports and along air traffic routes connecting these airports, as well as within special areas where activities such as military flight training are conducted. The Federal Aviation Administration (FAA) has the overall responsibility

for managing the airspace system and accomplishes this through close coordination with state aviation and airport planners, military airspace managers, and other entities.

The affected environment for airfield and airspace encompasses the airfield that supports aircraft take-offs, landings, and pattern operations. It also includes airspace where aircraft operations occur over the installation and adjacent airspace where flight tracks are flown in association with the airfield.

3.1.1 Affected Environment

The airfield at NS Norfolk is called Chambers Field. The airfield consists of parking apron space and 15 aircraft hangars, along with a variety of weapons storage facilities, fuel storage areas, and general maintenance/storage warehouses. The airfield elevation is 15 feet above mean sea level (MSL), and there are taxiways throughout the airfield of varying widths.

Chambers Field has a single Class B runway configuration for fixed-wing operations, Runway 10/28. It is 8,369 feet long and 200 feet wide. Runways are numbered according to their magnetic heading for aircraft on approach or departure. For example, on Runway 10/28, the numbers 10 and 28 signify this runway is most closely aligned with a compass heading of 100 and 280 degrees, respectively. An additional Class A runway, Runway 09/27, is used for helicopter take-off and landing only (**Figure 3.1-1**). It is 1,600 feet long and 150 feet wide. HMM-774, the CH-46E reserve squadron, is housed in Hangar LF-60 in the LF area.

3.1.1.1 Airfield Operations

Aircraft that typically utilize Chambers Field can be broken down into two categories, fixed-wing aircraft and rotary-wing aircraft. Fixed-wing aircraft utilizing Chambers Field include the E-2, C-2, C-9, C-130, C-5, and F/A-18. Rotary-wing aircraft utilizing Chambers Field include the MH-60, SH-60/HH-60, MH-53, and CH-46E. Eleven rotary-wing squadrons of 137 aircraft and seven fixed-wing squadrons of 53 aircraft are homebased at Chambers Field, plus three tenant commands hosting transient aircraft.

The basic flight operations at Chambers Field are departures, straight in/full-stop arrivals, overhead arrivals, touch-and-go operations, low approaches, and GCAs. The airfield is operational 24 hours a day, 365 days a year.

Figure 3.1-1. NS Norfolk Chambers Field Airfield

3.1.1.2 Airspace

The use of airspace over Chambers Field is dictated by the FAA National Airspace System. This system is designed to ensure the safe, orderly, and efficient flow of commercial, private, and military aircraft. Chambers Field is located within Class D controlled airspace[2], which roughly encompasses an area within a 4.3-nautical mile radius of the center of NS Norfolk that extends upward to, but not including, 2,000 feet above MSL. Norfolk International Airport's Class C controlled airspace[3] overlies all of Chambers Field's Class D Airspace.

The main Air Traffic Control tower located to the south of Runway 10/28 (in LP area) at Chambers Field directs traffic within the Class D airspace entering, exiting, or taxiing at the airfield. In addition, a separate air traffic control tower is located in the LF area specifically for helicopter operations.

Chambers Field's operational areas include several Special Use Airspace (SUA) areas. SUA in the region primarily includes Restricted Areas and Warning Areas (see **Figure 2.1-1**). SUA proximate to Chambers Field include:

- Restricted Area R-6606. Located off shore to the east of Chambers Field.
- Warning Areas W-50A/B/C, W-72A/B, and W-386. Located off shore to the east of Chambers Field.

3.1.2 Environmental Consequences

3.1.2.1 No Action Alternative

Under the No Action Alternative, HMM-774 would not transition to VMM-774. The No Action Alternative would result in a slight reduction of helicopter operations in the airfield and associated airspace at NS Norfolk (approximately 4,752 annual operations). The reduction would have a negligible impact to the airfield and airspace at NS Norfolk.

3.1.2.2 Alternative 1: Hangar LP-167

Under Alternative 1, HMM-774 would transition to VMM-774 and relocate to Hangar LP-167. The CH-46E aircraft would be replaced on a one for one basis with MV-22B aircraft. Aircraft would be parked as depicted in **Figure 2.2-1**. Parking MV-22B aircraft on the northwest apron would decrease the AMC transient parking by two spaces. The proposed parking area on the northeast apron is currently used for VIP transient parking. The squadron would relocate MV-22B aircraft in the event of VIP arrivals. These transient spaces are not used on a permanent basis and alternative accommodations could be made to reduce these inconveniences. Therefore, significant direct or indirect impacts to the squadrons sharing the parking apron are not expected.

The proposed total operations for the MV-22B aircraft would be the same as the total operations for the CH-46E that they are replacing (4,752 annual airfield operations). The MV-22B operates slightly differently than the CH-46E aircraft and would mainly utilize Runway 10/28. The limited amount of annual operations would not significantly alter the current distribution of operations between the two

[2]Class "D" airspace generally surrounds airports with an operating control tower. Pilots must have two-way radio communication with the tower to enter the airspace.
[3]Class "C" airspace generally surrounds larger airports with an operating control tower and a radar approach control facility. Pilots must have two-way radio communication and mode C transponders to enter this airspace.

runways. There are slight variations in the number and types of operations between the MV-22B and the CH-46E they are replacing (see **Table 2.1-3**); however, the proposed MV-22B operations are not any different from the fixed-wing operations occurring in the airfield. In addition, the total airfield operations occurring at an airfield fluctuate due to deployments, training scenarios, and mission changes. The small number of operations addressed in this EA would be much less than the variation observed year to year at the airfield and not have a direct or indirect impact to airfield management. VMM-774 would continue to conduct flight operations in a manner consistent with current airfield procedures. Impacts to civilian aircraft and other users in the vicinity of NS Norfolk would not occur, as existing standard operating procedures and course rules would continue to apply. VMM-774 usage of associated airspace would be consistent with current operations, and there would be no direct or indirect impact to airspace.

3.1.2.3 Alternative 2: Hangar LP-27

Under Alternative 2, HMM-774 would transition to VMM-774 and relocate to Hangar LP-27. The CH-46E aircraft would be replaced on a one for one basis with MV-22B aircraft. Aircraft would be parked as depicted on **Figure 2.2-2**. There are no other aircraft parked in this location; therefore, there would be no impacts to other squadrons. The potential impacts to the airfield operations and associated airspace at NS Norfolk would be the same as described under Alternative 1.

3.1.3 Cumulative Effects

The storage locker and used oil tank relocation to occur at LF-60 removes these impediments from the flightline, which removes a potential hazard. The proposed I-564 Intermodal connector would be constructed in the vicinity of Runway 10/28, but would not affect airfield operations or management. The Navy's C-2A aircraft are tentatively scheduled to transition to the V-22 during the 2020-2025 timeframe. The proposal for replacing C-2A with V-22(N) is not defined well enough to discuss airfield impacts in detail; however, it is currently expected that this proposal would be accommodated with existing airfield facilities and would not substantially alter the aircraft inventory at NS Norfolk. The proposed action, in combination with other projects, is not expected to have a significant cumulative effect on airfields or airspace.

3.2 NOISE

Noise is defined as unwanted or annoying sound that interferes with or disrupts normal human activities; the primary human response to noise is annoyance. The response of different individuals to similar noise events is diverse and is influenced by the type of noise, the perceived importance of the noise, its appropriateness in the setting, the time of day, the type of activity during which the noise occurs, and the sensitivity of the individual to noise. See **Appendix A** for a general discussion of sound, noise metrics, and noise effects.

A noise study specific to NS Norfolk was performed to determine the potential change in the noise environment from transitioning HMM-774 to VMM-774. From the noise modeling perspective, this involves replacing the CH-46E aircraft with MV-22B aircraft and adjusting the airfield operations and flight tracks to account for proposed MV-22B operations. The study utilized DOD noise modeling software (NOISEMAP) to depict the noise exposure associated with existing conditions, the No Action Alternative, and the action alternatives. The software utilizes available data on the noise profile specific to an individual aircraft to model noise exposure within the airfield and surrounding environment. The

results of that study are summarized in this section. For additional details on methodology and detailed calculations refer to **Appendix B**.

Noise associated with construction activities is temporary, and is typically dominated by grading/earth-moving equipment and impact devices. Smaller equipment such as backhoes, concrete mixers, compressors, etc., would likely be the types of construction equipment used under the proposed action. Proposed construction activities would occur during typical work-day hours from 7 a.m. to 5 p.m., Monday – Friday. During operation, construction activities generate noise levels typically ranging from 70 to 90 decibels (dB) at a distance of 50 feet (Washington Department of Transportation 2014). The proposed construction activities at NS Norfolk would occur within the airfield, be temporary and minor, and would not affect the existing noise environment. Therefore, construction noise is not discussed further.

Other sources of noise, such as general vehicular traffic and other maintenance and landscaping activities, are common on-going occurrences at the installation. While these sources may contribute to the overall noise environment, they are temporary, localized, and relatively minor compared to the dominant aircraft-generated noise at and adjacent to NS Norfolk. For this reason, these other noise sources are not discussed further.

3.2.1 Affected Environment

The affected environment for noise is defined as NS Norfolk, the City of Norfolk, and those portions of the adjacent cities that may be affected by noise from aircraft operations (portions of Newport News and Hampton).

3.2.1.1 Aircraft Operations

Since aircraft operations at an active airfield fluctuate depending on missions, training activity, deployments, transient aircraft, etc., the annual operations presented in **Table 3.2-1** (and used in the modeling process) represent an average of annual flight operations over the most recent four year period with available data (2011 through 2014). These operations include all aircraft assigned to NS Norfolk and transient aircraft activity. This average is the best representation of the existing conditions with respect to aircraft operations and the noise environment. It should be noted that the annual operations presented here are different from those reported in the 2009 Air Installations Compatible Use Zones (AICUZ) Study. The AICUZ Program utilizes a higher level of operations to ensure compatible land use planning while accounting for annual fluctuations in operations and long term mission changes (see **Section 3.3** for additional information on the AICUZ Program).

Current airfield activity at NS Norfolk (determined by averaging data from 2011 through 2014) includes 67,317 flight operations per year, about 40 percent of which are fixed-wing (predominantly E-2 and C-2) and 60 percent rotary-wing (predominantly H-60). Fixed-wing aircraft (and some of the rotary-wing aircraft) use the main Runway 10/28, with about 49 percent in the 28 direction and 51 percent in the 10 direction. Additionally, rotary-wing aircraft use Runway 09/27 and a series of helicopter pads on the northern edge of the airfield (LF, V Pad, and SP areas). The frequency of use for each of the pads and the approach and departure tracks leading to/from each is derived from a review of historical data (2011 through 2014) and interviews with NS Norfolk staff (Cardno 2015).

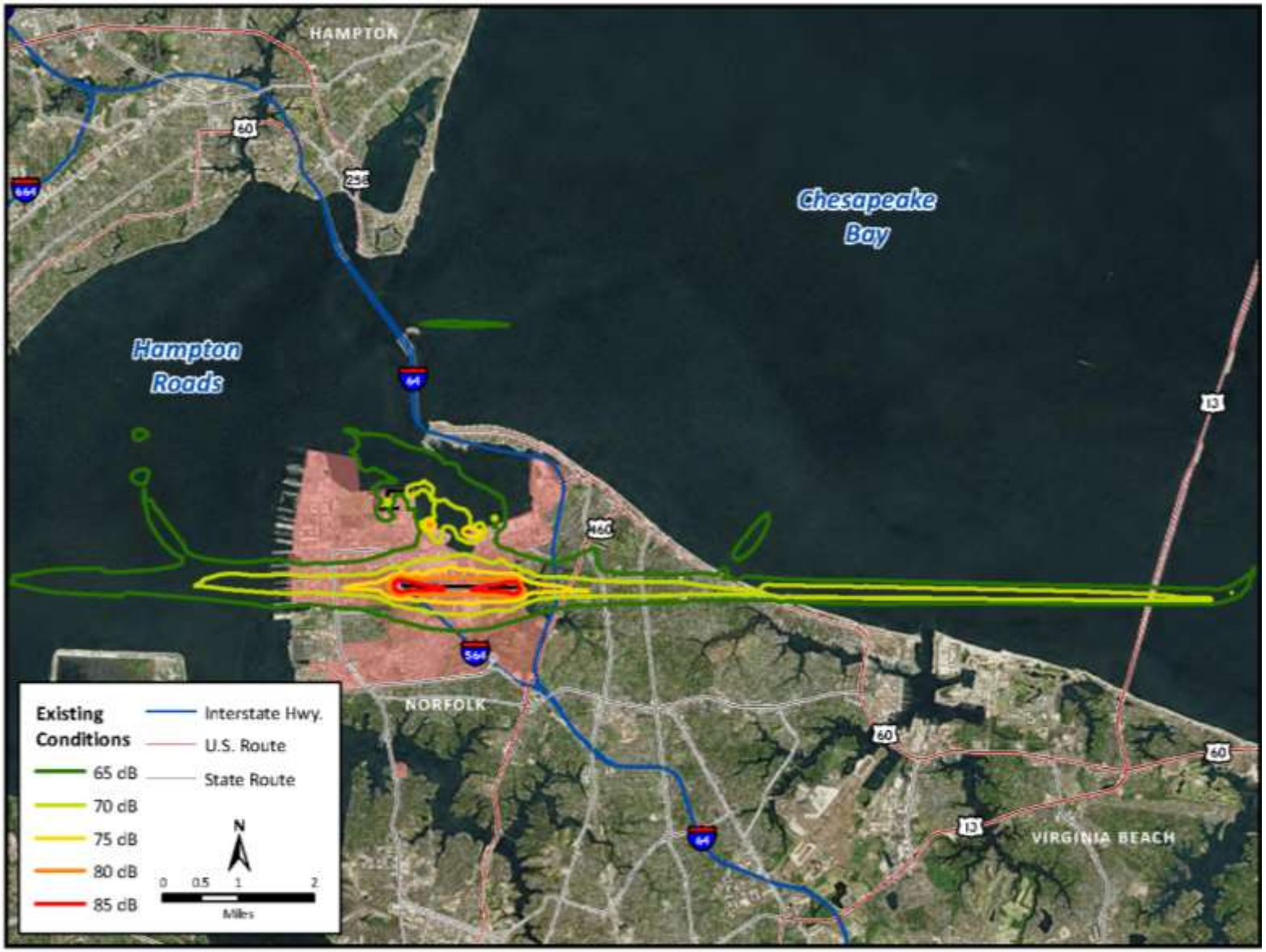

Figure 3.2-1. Noise Exposure under Existing Conditions

Table 3.2-1. Annual Operations at NS Norfolk under Existing Conditions			
Operation Type	**Acoustic Day (7 a.m. to 10 p.m.)**	**Acoustic Night (10 p.m. to 7 a.m.)**	**Total**
Arrival	13,802	4,524	18,326
Departure	13,811	4,515	18,326
Closed Patterns[1]	23,222	7,443	30,665
Total	**50,835**	**16,482**	**67,317**

Note: [1] Closed patterns include touch-and-go and GCA. See **Section 2.1.4** for further descriptions of airfield operations.

3.2.1.2 Noise Exposure

In order to determine noise exposure under existing conditions, the aircraft operations shown above were modeled using the latest DOD approved aircraft noise modeling software. Day-night average sound level (DNL) is the relevant noise metric for this analysis and is based on annual average daily aircraft operations. DNL is the U.S. Government standard for modeling the cumulative noise exposure and assessing community noise impacts (see **Appendices A and B** for additional information). The resulting noise contours generated from the modeling process are shown in **Figure 3.2-1**.

Table 3.2-2 shows the acreages under each noise contour for both on- and off-base areas, excluding large bodies of water. Large bodies of water are excluded from this analysis to get a more accurate characterization of the potential for human annoyance. A total of 941 acres off-base experience noise levels above 65 dB DNL. The greatest off-base impacts occur in the 65-70 dB DNL contour, with 568 acres. No off-base acreage experiences noise exposures above 80 dB DNL.

Table 3.2-2. Noise Exposure under Existing Conditions			
Contour (dB DNL)	**On-Base (acres)**	**Off-Base (acres)**	**Total (acres)**
65-70	834	568	1,402
70-75	519	343	862
75-80	232	30	262
80-85	171	--	171
85+	74	--	74
Total	**1,830**	**941**	**2,771**

Generally in noise analyses, points of interest (POIs) are chosen to determine noise exposure at a known location or reference point. These are usually schools, churches, hospitals, or other locations with noise sensitive uses. Because of the large number of possible POIs in the Norfolk area that might include individual schools, hospitals, churches, etc., the surrounding area was broken into U.S. Census Bureau (USCB) census tracts, and smaller tracts combined into representative geographic areas. This allows for a diverse sample of points which are spread out relatively evenly by population, such that they are a good surrogate for having hundreds of closely-spaced points representing individual churches, hospitals, schools, and neighborhoods. The noise is calculated for a point in the center of each area, as shown on **Figure 3.2-2**. The DNL value throughout the area would not be exactly the same, but the point value is representative of the noise exposure within the area as a whole. The 18 POIs and the estimated noise exposure in DNL under existing conditions are listed in **Table 3.2-3**.

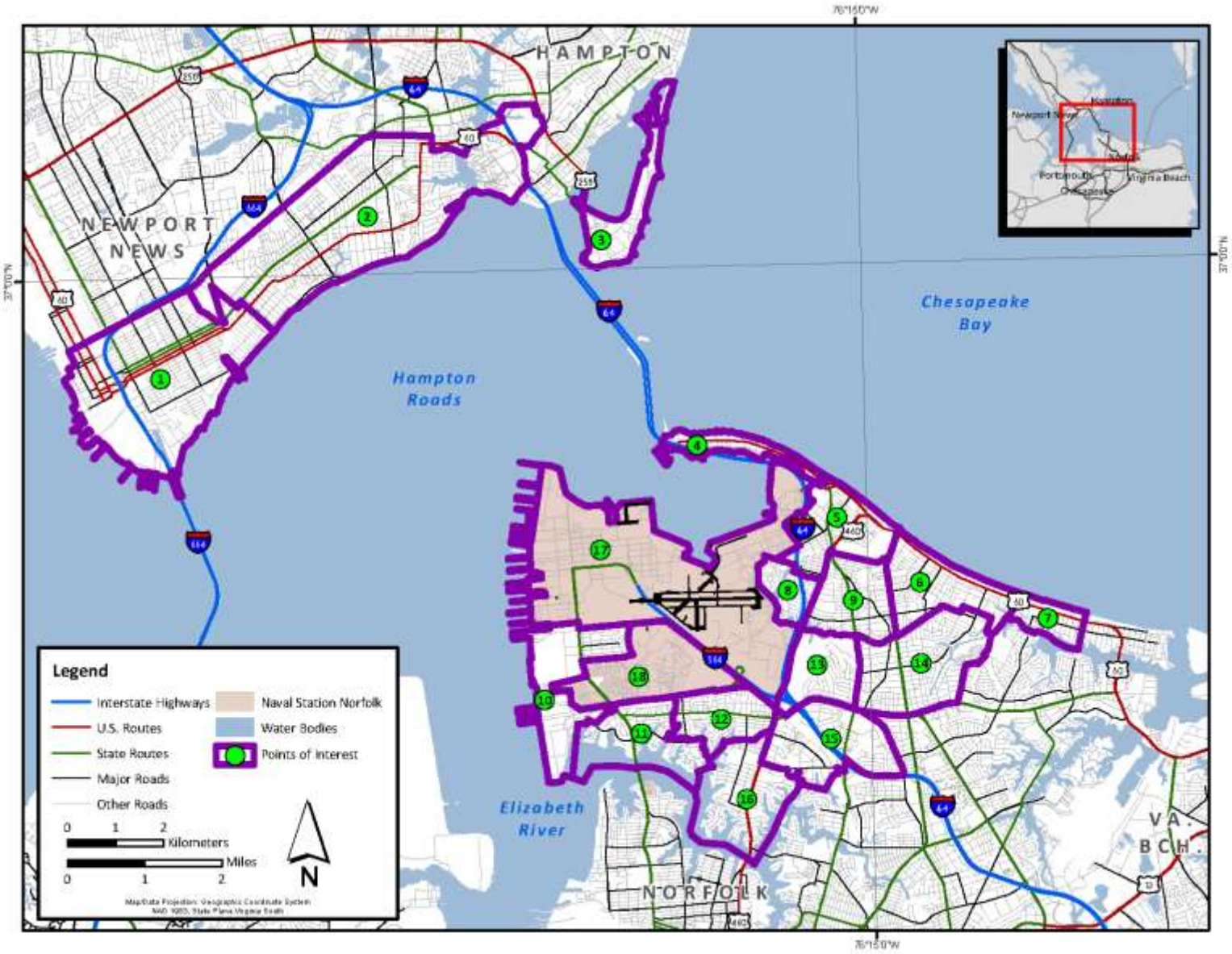

Figure 3.2-2. POIs in Vicinity of NS Norfolk

Table 3.2-3. Noise Exposure at POIs under Existing Conditions		
ID	**Description**	**dB DNL**
1	Newport News	50.6
2	Hampton	45.1
3	Fort Monroe	51.2
4	Willoughby	62.1
5	West Ocean View	60.3
6	East Ocean View	65.9
7	Little Creek	56.4
8	North Granby	72.3
9	Northside	72.3
10	Terminal	54.8
11	Meadowbrook	52.6
12	Wards Corner	54.5
13	Central Granby	56.2
14	Brentwood	51.3
15	Suburban Park	48.8
16	South Granby	46.3
17	Naval Station	60.6
18	Camp Allen	58.1

3.2.2 Environmental Consequences

3.2.2.1 No Action Alternative

Under the No Action Alternative, HMM-774 would not transition to VMM-774. The No Action Alternative would result in a reduction of helicopter operations at NS Norfolk Chambers Field by approximately 4,752 operations annually. The reduction would represent approximately 7 percent of the total operations when compared to existing conditions shown in **Table 3.2-1**. The reduction would result in a negligible change to the noise exposure within any of the noise contours either on- or off-base and would remain the same or similar to **Table 3.2-2**. Changes to annual average noise levels would be imperceptible to the surrounding community and the POIs.

3.2.2.2 Alternative 1: Hangar LP-167

Under Alternative 1, HMM-774 would transition to VMM-774 and relocate to Hangar LP-167. The MV-22B would replace the CH-46E one for one, with regard to aircraft operations. There would be no net change in annual operations at NS Norfolk; however, the flight tracks would be slightly different for the MV-22B. The results of modeling the noise exposure for the aircraft replacement and changes to the flight tracks are shown in **Figure 3.2-3**. The change from existing conditions is almost indistinguishable. There would be no direct or indirect impacts to the existing noise environment.

Table 3.2-4 provides the modeled noise exposure on- and off-base for the defined noise contours under Alternative 1. The acreage provided excludes large water bodies. Noise exposure within the contours is almost identical to existing conditions (refer to **Table 3.2-2**). Overall, implementation of Alternative 1 would result in 5 less acres exposed to noise levels above 65 dB DNL. This corresponds to less than a 1 percent change in land area exposed to 65 dB DNL or greater. The off-base exposure remains the same with the exception of a 1-acre decrease within the 65-70 dB DNL contour.

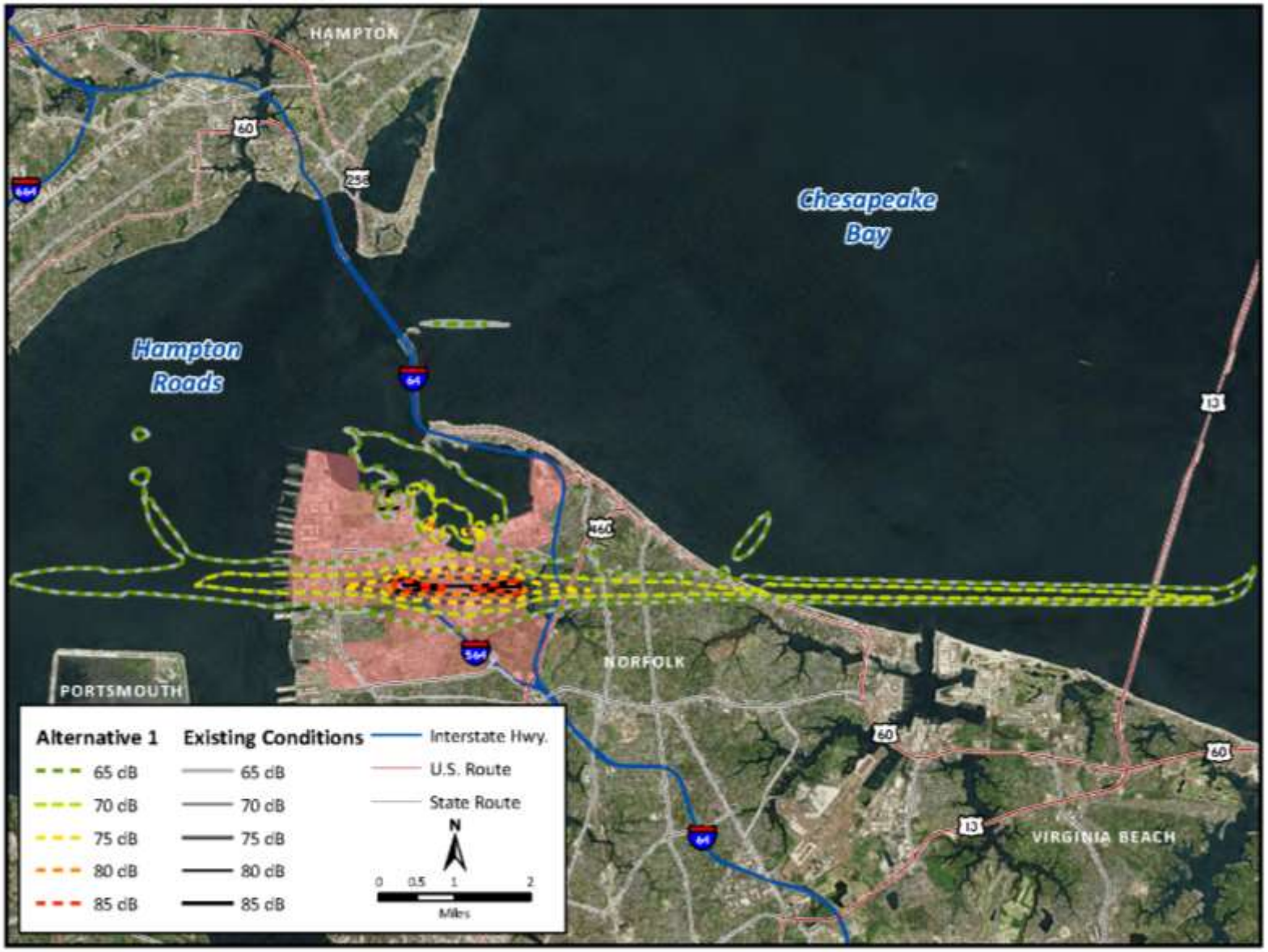

Figure 3.2-3. Alternative 1 Noise Exposure Compared to Existing Conditions

Table 3.2-4. Noise Exposure under Alternative 1				
Contour (dB DNL)	**On-base (acres)**	**Off-Base (acres)**	**Total (acres)**	**Total Change from Existing Conditions (+/-) (acres)**
65-70	827	569	1,396	-6
70-75	518	343	861	-1
75-80	233	31	264	+2
80-85	171	--	171	--
85+	74	--	74	--
Total	**1,823**	**943**	**2,766**	**-5**

Table 3.2-5 shows the DNL values calculated for the 18 POIs. DNL values at the various POIs are almost identical, with the highest change being 0.1 dB DNL. Typically, DNL values are reported rounded to the nearest whole number, but for this case, the values are shown in tenths of a dB to illustrate the minor differences and to avoid exaggerating the potential impact by rounding. A difference of 0.1 dB DNL would be imperceptible to the human ear. Implementation of Alternative 1 would have negligible impacts with regard to noise exposure in the vicinity of NS Norfolk.

Table 3.2-5. Noise Exposure at POIs under Alternative 1 Compared to Existing Conditions			
ID	**Description**	**dB DNL**	**Change from Existing Conditions (+/-)**
1	Newport News	50.5	-0.1
2	Hampton	45.1	0.0
3	Fort Monroe	51.2	0.0
4	Willoughby	62.1	0.1
5	West Ocean View	60.3	0.0
6	East Ocean View	65.9	0.0
7	Little Creek	56.4	0.0
8	North Granby	72.3	0.0
9	Northside	72.3	0.0
10	Terminal	54.8	0.0
11	Meadowbrook	52.6	0.0
12	Wards Corner	54.5	0.1
13	Central Granby	56.3	0.0
14	Brentwood	51.3	0.0
15	Suburban Park	48.9	0.1
16	South Granby	46.4	0.0
17	Naval Station	60.7	0.1
18	Camp Allen	58.2	0.0

Two metrics are typically used to characterize the noise during single events (i.e, an aircraft operation): maximum sound level (L_{max}) and Sound Exposure Level (SEL). L_{max} is the maximum level that occurs over a fraction of a second and is important in judging if a sound event would interfere with conversation, TV watching, or other activities. SEL represents the total sound energy in an event and includes the maximum and all lower noise levels produced as part of the event. It does not represent the sound heard at any given time during the event, but rather the sound of the entire event. SEL provides a better measure of an aircraft flyover noise exposure than L_{max} alone. Both L_{max} and SEL are discussed in more detail in **Appendix A**.

Single event noise modeling was performed to provide a comparison of the expected noise exposure for three representative airfield operations: a GCA Box pattern at Runway 10, a departure from Runway 10, and a touch-and-go pattern at Runway 09. As stated previously, the MV-22B operates differently than the

CH-46E it is replacing; therefore, the flight profile used during the modeling scenario for each of these operations was specific to the aircraft and the way each aircraft would fly that event. Values for L_{max} and SEL were calculated for selected POIs (those closest to the flight track with the greatest potential for effect) for each of these representative airfield operations. This method allows the reader to compare the noise experience as it is expected to occur in the real world, vice modeling both aircraft with the same generic flight profile. The single event results are described for each representative airfield operation in the following sections.

GCA Box Pattern

Figure 3.2-4 depicts the flight tracks used for the two aircraft flying a GCA Box pattern to Runway 10 at NS Norfolk. Also depicted on the figure are the four representative POIs, those closest to the flight tracks, for which L_{max} and SEL are calculated. The metric results are shown in **Table 3.2-6**. For the representative GCA Box comparison, the calculated metrics at the sample POIs show that the observer would experience lower SEL and L_{max} for the MV-22B pattern than would be experienced for the CH-46E pattern at POIs 3, 5, and 9. At POI 10, the MV-22 pattern results in higher SEL and L_{max} values.

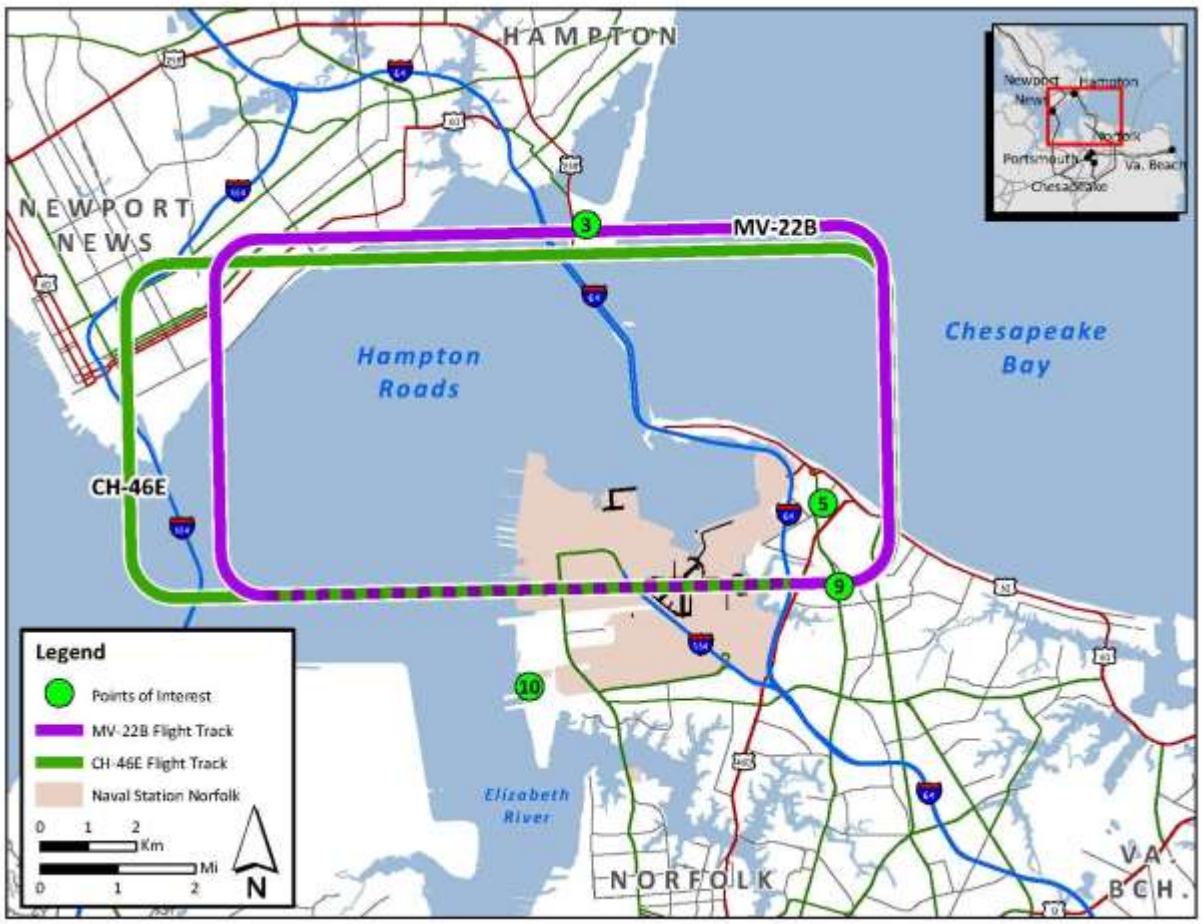

Figure 3.2-4 Representative GCA Box Pattern Flight Tracks

Table 3.2-6. Single Event Metrics for Representative GCA Box Pattern				
	CH-46E		MV-22B	
POI	SEL	L_{max}	SEL	L_{max}
3	82.2	67.9	78.0	65.6
5	77.1	65.2	74.1	54.7
9	97.8	90.4	93.9	84.5
10	69.2	51.6	73.5	58.95

Departure from Runway 10

Figure 3.2-5 depicts the departure flight track used for the two aircraft flying a normal departure from Runway 10 at NS Norfolk. Note that in this case, the flight tracks (path over the ground) are the same, although the profiles (power settings, speeds, etc) are still different for the two aircraft. Also depicted on the figure are the four representative POIs, those closest to the flight track, for which SEL and L_{max} are calculated. The metric results are shown in **Table 3.2-7**. For the representative departure comparison, all of the points show that the observer would experience lower SEL and L_{max} for the MV-22B departure than would be experienced for the CH-46E departure. The decreases are expected to be noticeable; L_{max} decreases between 6 and 11 dB and SEL decreases between 7 and 11 dB, depending on the POI. This is largely due to the fact that the CH-46E flies slower and lower, while the MV-22B accelerates and climbs much more like a fixed-wing aircraft. Increased altitude tends to reduce the noise experienced directly below or near the flight track.

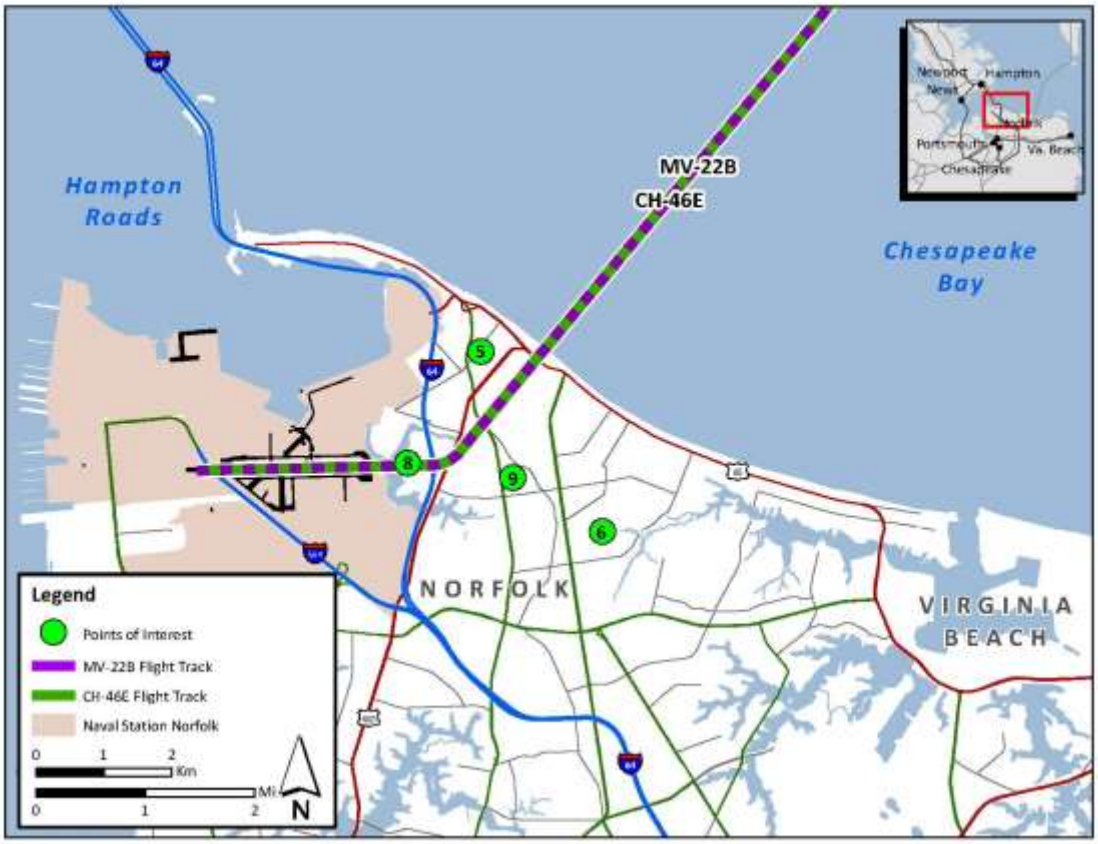

Figure 3.2-5 Representative Departure Flight Tracks

Table 3.2-7. Single Event Metrics for Representative Departure from Runway 10				
	CH-46E		MV-22B	
POI	SEL	L_{max}	SEL	L_{max}
5	79.4	65.9	72.3	59.7
6	73.4	58.6	62.6	47.8
8	92.5	82.9	82.5	74.1
9	78.8	66.7	69.4	57.1

Touch-and-Go Pattern

Figure 3.2-6 depicts a Touch-and-Go Pattern at Runway 09 for both aircraft at NS Norfolk. Also depicted on the figure are the four representative POIs, those closest to the flight tracks, for which SEL and L_{max} are calculated. The metric results are shown in **Table 3.2-8**. For the touch-and-go pattern comparison, all of the points show that the observer would experience greater SEL and L_{max} for the MV-22B than would be experienced for the CH-46E. The low altitude of the CH-46E tends to mean that less of that noise can propagate across the greater ground distance and thus the noise experienced at points further from the track is less. At POIs 5 and 8, the increases in L_{max}, while numerically large, may or may not be particularly noticeable in an active airfield environment. At POI 4, the SEL and L_{max} changes of 4-5 dB may be noticeable on a single event basis. At the more distant POI 10, there is also a difference, but the resulting SEL and L_{max} values are small enough that they may not be noticeable in an airfield environment.

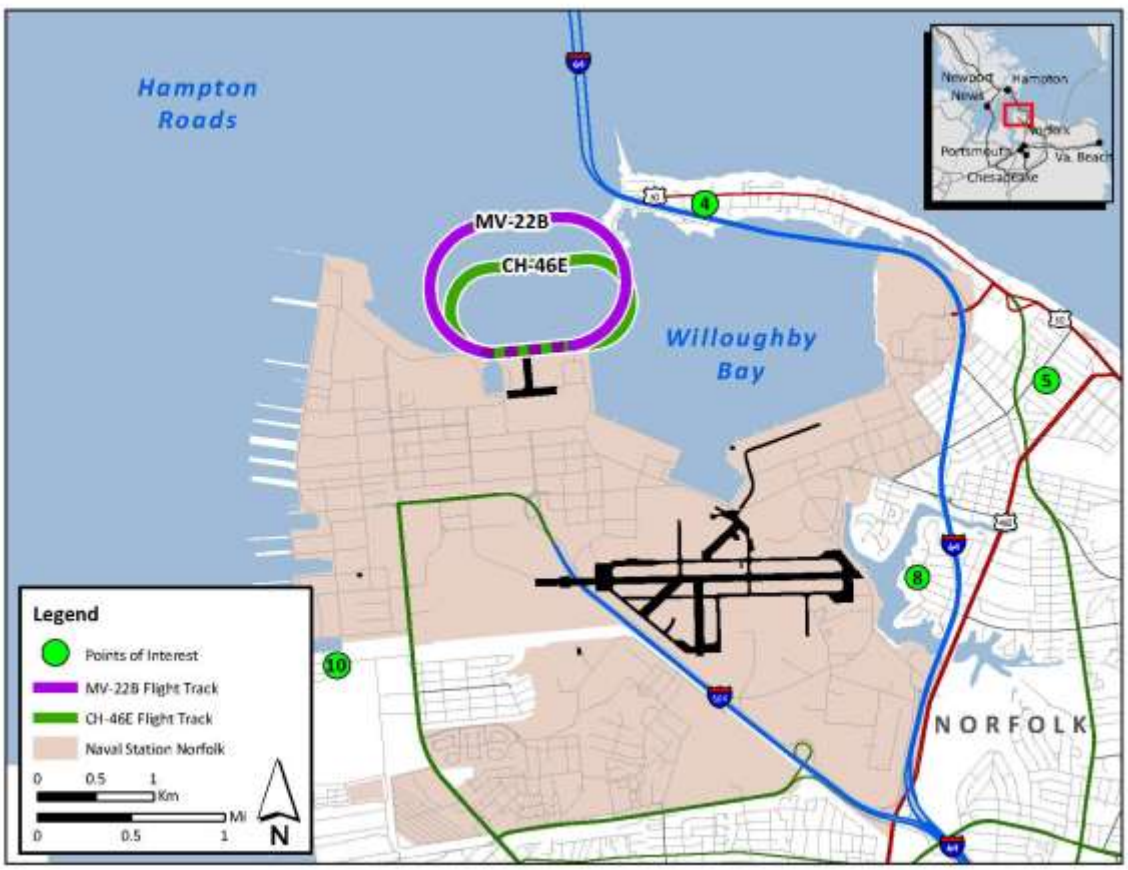

Figure 3.2-6 Representative Touch-and-Go Pattern Flight Tracks

Table 3.2-8. Single Event Metrics for Representative Touch-and Go Pattern				
	CH-46E		MV-22B	
POI	SEL	L_{max}	SEL	L_{max}
4	73.7	61.0	77.4	66.3
5	49.4	34.5	60.3	50.7
8	52.1	36.1	61.8	51.0
10	48.8	32.6	54.7	42.1

Single event metrics such as SEL and L_{max} are useful tools when properly applied. These examples show that there is not a simple answer to the question of "which aircraft is louder". As shown in this section, it depends on what each aircraft is doing and the location of the observer. The overall contribution to the noise environment from the proposed MV-22B operations would still be dwarfed by the jet traffic at NS Norfolk, which is why the small changes in CH-46E and MV-22B traffic don't make much difference in the noise exposure at the airfield (see **Figure 3.2-3**). For comparative purposes, a C-5 overflight on take-off (1,000 feet overhead) produces an SEL of 113.5 dB and an L_{max} of 106.3 dB directly below the flight track.

The DoD-accepted metric for determining overall impacts of a proposed action is DNL, which was shown to be relatively unchanged for Alternative 1. The SEL and L_{max} calculations were performed to provide additional information to help further characterize the changes to the noise environment that may be experienced outside the airfield from the aircraft transition. The fact that SEL and L_{max} values for various overflight patterns increase in some cases and decrease in others further indicate that the overall noise impact of Alternative 1 would be negligible.

3.2.2.3 Alternative 2: Hangar LP-27

Under Alternative 2, HMM-774 would transition to VMM-774 and relocate to Hangar LP-27. The proposed air operations for the MV-22B would be the same as those described under Alternative 1. Therefore, the noise impacts from implementation of Alternative 2 would be the same as those described for Alternative 1.

3.2.3 Cumulative Effects

The Navy's C-2A aircraft are tentatively scheduled to transition to the V-22 during the 2020-2025 timeframe. The potential direct impacts resulting from noise associated with the proposal to replace C-2A with the V-22(N) are not known at this time. A comprehensive noise analysis for that proposed action would occur during development of the EA and would include the MV-22B operations addressed in this EA. It is likely that an update to the 2009 AICUZ Study would occur prior to that action (aircraft transition is anticipated to occur in 2020) that would account for any changes to the noise environment that would have implications to the land use recommendations surrounding the base. The minor incremental increase in noise from the proposed action, in combination with the future transition from C-2A to the V-22(N), is not likely to contribute to a significant cumulative effect to the noise environment.

3.3 LAND USE

Land use often refers to human modification of land for residential or economic purposes. Land uses are frequently regulated by management plans, land use plans, comprehensive plans, and local zoning and ordinances. These plans and regulations assist in identifying where future development can occur so it is

compatible with surrounding land uses and protects specially designated or environmentally sensitive uses.

Land use is interrelated with other resource areas including noise, socioeconomics, biological resources, and cultural resources. The impact analysis in this EA for land use focuses on those areas affected by airfield operations within Chambers Field. This analysis relies not only on zoning designations, but also on Accident Potential Zones (APZs) and noise zones as defined by the AICUZ Program.

The AICUZ Program was established in the early 1970s by the DOD to balance the need for aircraft operations with community concerns over aircraft noise and accident potential. The Program goals are to protect the safety, welfare, and health of those who live and work near military airfields while preserving the military flying mission. To accomplish these goals, the AICUZ Program analyzes accident potential, aircraft noise, operational procedures, and land use compatibility. The results of the AICUZ Program provide comprehensive recommendations for compatible development near installations such as NS Norfolk. Airfield safety footprints are identified (per AICUZ Program parameters) and are categorized into APZs. Refer to **Section 3.7** for more information on APZs.

Noise zones are critical for the establishment of land use compatibility, as residential land uses are normally not compatible at levels above 65 dB DNL. For land-use planning purposes, three noise zones are defined:

- **Noise Zone 1 (64 dB DNL and below)** is generally considered an area of low or no noise impact.
- **Noise Zone 2 (65 to 74 dB DNL)** is an area of moderate impact, where some land use controls are required.
- **Noise Zone 3 (75 dB DNL and greater**) is the most severely impacted area and requires the greatest degree of land use control.

3.3.1 Affected Environment

The affected environment for evaluation of land use is NS Norfolk's Chambers Field. Land use surrounding Chambers Field includes residential (both single- and multi-family), hotels, restaurants, professional offices, light industrial and technology parks, and retail stores (U.S. Navy 2009a). Chambers Field is located at the confluence of the James and Elizabeth Rivers. A mix of industrial uses, along with low-, medium-, and high-density residential development is located to the south. Immediately to the east of Chambers Field is a cemetery along with low- and medium-density residential development.

Table 3.3-1 presents the existing land use types within the Chambers Field noise zones 2 and 3 defined in the AICUZ Program.

Table 3.3-1. Existing Land Use Types (acres[1]) at NS Norfolk Chambers Field

Land Use Type	Noise Zone 2	Noise Zone 3	Total
Commercial	48.4	0	48.4
Industrial	243.8	2.5	246.3
Institutional	269.4	1.8	271.2
Residential Low Density	913.9	83.4	997.3
Residential Medium/High Density	251.5	34.6	286.1
Total	**1727.0**	**122.3**	**1849.3**

Note: [1]Does not include on-station acreage or any area over water.
Source: U.S. Navy 2009a.

3.3.2 Environmental Consequences

3.3.2.1 No Action Alternative

Under the No Action Alternative, HMM-774 would not transition to VMM-774. The No Action Alternative would result in a slight reduction of helicopter operations at NS Norfolk Chambers Field. The reduction would have a negligible change within acreage of any of the noise zones. Off-base land use planning would remain unchanged.

3.3.2.2 Alternative 1: Hangar LP-167

Under Alternative 1, HMM-774 would transition to VMM-774 and relocate to Hangar LP-167. The proposed total operations for the MV-22B aircraft would be the same as the total airfield operations for the CH-46E that they are replacing (4,752 annual operations). While the MV-22B operates slightly differently than the CH-46E, the direct and indirect impacts to the noise environment would be negligible (see **Section 3.2**). Therefore, there would be no change to existing noise zones and land use recommendations established under the 2009 AICUZ Study.

3.3.2.3 Alternative 2: Hangar LP-27

Under Alternative 2, HMM-774 would transition to VMM-774 and relocate to Hangar LP-27. Potential impacts to land use under Alternative 2 would be the same as those described under Alternative 1.

3.3.3 Cumulative Effects

The potential impacts to noise zones associated with the proposal to replace C-2A with V-22(N) are not known at this time; however, it is likely that an update to the 2009 AICUZ Study would occur prior to this action (anticipated to occur in 2020). The revised AICUZ would account for any projected changes to the airfield operations and the associated noise zones. The minor incremental increase in noise from the proposed action, in combination with the future transition from C-2A to the V-22(N), is not likely to contribute to a significant cumulative effect to the noise environment or land use planning.

3.4 AIR QUALITY

<u>National Air Quality Standards</u>

The U.S. Environmental Protection Agency (USEPA) regulates “criteria pollutants” in accordance with the Clean Air Act (CAA). These criteria pollutants are regulated due to the risks they create for human health and welfare when present in excessive amounts in the ambient air. The pollutants include ground-level ozone (O_3), carbon monoxide (CO), sulfur dioxide (SO_2), nitrogen dioxide (NO_2), lead (Pb), suspended particulate matter less than or equal to 10 microns aerodynamic diameter (PM_{10}), and fine particulate matter less than or equal to 2.5 microns aerodynamic diameter ($PM_{2.5}$). O_3 is not emitted directly, but results from the chemical interaction in the atmosphere of two precursor pollutants: volatile organic compounds (VOCs) and nitrogen oxides (NO_x).

The USEPA regulates criteria pollutants by setting standards, or permitted levels, for the amount of each pollutant that air may contain. These are known as National Ambient Air Quality Standards (NAAQS). There are two sets of NAAQS: the primary standards, which set limits to protect public health, including the health of sensitive populations such as asthmatics, children, and the elderly; and the secondary standards, which set limits to protect public welfare, including the prevention of visibility impairment,

damage to animals, crops, vegetation, and buildings. The CAA requires periodic review of the science upon which the standards are based and of the standards themselves. **Table 3.4-1** provides the current NAAQS.

NAAQS Attainment Status

The USEPA has designated areas – air quality control regions (AQCRs) – within which the NAAQS must be achieved or maintained. NS Norfolk is located within Virginia's Hampton Roads Intrastate AQCR (40 CFR §81.93).

The USEPA designates an area as nonattainment generally based upon air quality monitoring data or modeling studies that show the area violates, or contributes to violations, of the national standard. Where the data do not make such a showing, USEPA designates the area as attainment or unclassifiable. After a nonattainment area's air quality improves so that it is no longer violating or contributing to violations of the standard, and the state or tribe adopts a USEPA-approved plan to maintain the standard, USEPA can redesignate the area as attainment. These areas are known as maintenance areas. Maintenance areas retain that classification for 20 years after they are designated as attainment. The CAA and USEPA regulations impose special requirements to help improve and maintain the air quality of nonattainment and maintenance areas.

Table 3.4-1. National Ambient Air Quality Standards

Pollutant	Primary or Secondary	Averaging Time	Level[1]	Form
CO	Primary	8-hour	9 ppm	Not to be exceeded more than once per year
		1-hour	35 ppm	
NO_2	Primary	1-hour	100 ppb	98th percentile of 1-hour daily maximum, averaged over three years
	Both	Annual	53 ppb	Annual Mean
O_3	Both	8-hour	0.075 ppm	Annual fourth-highest daily maximum 8-hour concentration, averaged over three years
$PM_{2.5}$	Primary	Annual	12 $\mu g/m^3$	Annual mean, averaged over three years
	Secondary	Annual	15 $\mu g/m^3$	Annual mean, averaged over three years
	Both	24-hour	35 $\mu g/m^3$	98th percentile, averaged over three years
PM_{10}	Both	24-hour	150 $\mu g/m^3$	Not to be exceeded more than once per year on average over three years
Pb	Both	Rolling 3-month average	0.15 $\mu g/m^3$	Not to be exceeded
SO_2	Primary	1-hour	75 ppb	99th percentile of 1-hour daily maximum concentrations, averaged over three years
	Secondary	3-hour	0.5 ppm	Not to be exceeded more than once per year

Notes: [1]ppm = parts per million; ppb = parts per billion; $\mu g/m^3$ = micrograms per cubic meter.
Source: USEPA 2014.

The CAA mandates that states with areas in nonattainment adopt one or more state implementation plans (SIP) with the objective of eliminating or reducing the severity and number of violations of the NAAQS. A maintenance area has an approved maintenance plan under Section 175 of the CAA.

CAA General Conformity

The CAA Amendments of 1990 expand the scope and content of the act's conformity provisions in terms of their relationship to a SIP. Under Section 176(c), a project is in conformity if it corresponds to the plan's purpose of eliminating or reducing the severity and number of violations of the NAAQS and achieving their expeditious attainment.

General conformity further requires that such activities would not:

- Cause or contribute to any new violations of any standards in any area.
- Increase the frequency or severity of any existing violation of any standards in any area.
- Delay the timely attainment of any standard or any required interim emission reductions or other milestones in any area.

USEPA published the original general conformity rules (40 CFR Parts 51 and 93) in the *Federal Register* in 1993 and revised them in 2010. The rules apply to specified federal actions in nonattainment or maintenance areas for any of the criteria pollutants. The rules establish *de minimis* (threshold) emission levels by applicable pollutant to determine the relevancy of conformity requirements for a project. Actions that generate annual emissions of the applicable pollutant(s) below the applicable *de minimis* levels do not require a formal general conformity analysis and are considered to have no significant impact on air quality under NEPA for those pollutants.

For the purposes of general conformity applicability analysis, project emissions of VOCs and NO_x associated with the MV-22B aircraft are analyzed. VOCs and NO_x are specifically evaluated against the *de minimis* thresholds because in the ambient air they act as precursors to the formation of O_3. The Hampton Roads Intrastate AQCR is a designated maintenance area for O_3.

Greenhouse Gas (GHG) Emissions

GHGs are compounds that contribute to the greenhouse effect. The greenhouse effect is a natural phenomenon caused by gases trapping heat within the surface-troposphere (lowest portion of the earth's atmosphere) system, heating the surface of the earth. The primary GHG generated by human activities are carbon dioxide (CO_2), methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride.

The heating effect from GHGs is considered to be the probable cause of global warming observed over the last 50 years. Global warming and climate change can affect many aspects of the environment. The USEPA Administrator recognized potential risks to public health or welfare and signed an endangerment finding regarding GHGs under Section 202(a) of the CAA on December 15, 2009. The finding recognized that the current and projected concentrations of the six key well-mixed gases listed above threaten the public health and welfare of current and future generations.

On a national scale, federal agencies are addressing emissions of GHGs by reductions mandated in federal laws and EOs. Most recently, EO 13693, *Planning for Federal Sustainability in the Next Decade*, was enacted to address GHGs, including GHG emissions inventory, reduction, and reporting. This EA

addresses GHG emissions consistent with the CEQ's *Revised Draft Guidance for Federal Departments and Agencies on Consideration of Greenhouse Gas Emissions and the Effects of Climate Change in NEPA Reviews* (CEQ 2014). Because the dominant GHG emitted from fossil fuel combustion is CO_2 (85.4 percent of emissions), the analysis estimate considers CO_2 as the primary source of project-related GHG emissions.

3.4.1 Affected Environment

The affected environment for the air quality analysis is NS Norfolk in the Hampton Roads Intrastate AQCR. The area has a warm, humid, and temperate climate with hot summers and no dry seasons. Over the course of a year, the temperature typically varies from 33 degrees Fahrenheit (ºF) to 88°F and is rarely below 22°F or above 95°F. The annual average precipitation in Norfolk is around 47 inches. Rainfall in the summer season is the highest. The typical wind speeds vary from 0 miles per hour (mph) to 19 mph, rarely exceeding 26 mph as strong breeze. The wind is most often out of the southwest, northeast, south, north, and west.

NS Norfolk operates stationary sources that are regulated by the CAA. These stationary sources are covered by a Title V permit, which was most recently issued on December 22, 2014 and which also includes some state specific requirements. Stationary sources covered under this permit include but are not limited to fuel burning equipment, surface coating operations, abrasive blasting, woodworking, gasoline pumps, and degreasing. **Table 3.4-2** presents the annual stationary source emissions reported by NS Norfolk for calendar year 2014.

Table 3.4-2. 2014 Permitted Stationary Source Emissions at NS Norfolk

Tons Per Year					
VOCs	**CO**	**NO_x**	**SO_2**	**PM_{10}**	**$PM_{2.5}$**
72	74	117	26	17	0

Source: NS Norfolk 2014.

The primary air quality issue associated with the proposed action is mobile source emissions associated with aircraft operations (mobile sources are not included in the Title V permit). NS Norfolk airfield operations consist of operations conducted annually by both based and transient aircraft, which include both fixed-wing and rotary-wing aircraft. Because the proposed action involves the replacement of a specific rotary-wing model, the CH-46E, the current aircraft operations of this aircraft have been modeled to provide a comparison to the proposed operations of the MV-22B aircraft. All other aircraft operations are presumed to remain the same and are therefore not included in the model. In addition to aircraft operations, the current emissions analysis includes on-ground maintenance run-ups. **Table 3.4-3** presents the modeled annual emissions for CH-46E aircraft operations. See **Appendix D** for assumptions used and detailed calculations.

Table 3.4-3. CH-46E Emissions at NS Norfolk

	Tons Per Year					
	VOCs	**CO**	**NO_x**	**SO_2**	**PM_{10}**	**$PM_{2.5}$**
Airfield	4.80	14.64	0.96	0.66	0.99	0.99
Maintenance Run-ups	0.60	1.94	0.13	0.09	0.12	0.12
Total	**5.40**	**16.58**	**1.00**	**0.75**	**1.10**	**1.10**

3.4.2 Environmental Consequences

3.4.2.1 No Action Alternative

Under the No Action Alternative, HMM-774 would not transition to VMM-774. The aircraft operation reductions at NS Norfolk would have a corresponding reduction in emissions. The No Action Alternative would have a negligible impact on air quality in the Hampton Roads AQCR since current emissions associated with the CH-46E are minimal (see **Table 3.4-3**).

3.4.2.2 Alternative 1: Hangar LP-167

Under Alternative 1, HMM-774 would transition to VMM-774 and relocate to Hangar LP-167. Multiple interior renovation projects for LP-167 and LF-60 would be required (refer to **Section 2.2.2.2**); however, no significant air emissions would be created by these activities, resulting in no significant impact on regional air quality. **Table 3.4-4** presents the proposed airfield operations, as well as the additional commuter emissions (30 personnel), associated with the MV-22B. See **Appendix D** for assumptions used and detailed calculations.

Table 3.4-4. Proposed MV-22B Emissions at NS Norfolk

Alternative 1	Tons Per Year					
	VOCs	**CO**	**NO_x**	**SO_2**	**PM_{10}**	**$PM_{2.5}$**
Airfield	0.04	2.24	6.86	1.67	1.07	1.07
Maintenance Run-ups	0.03	1.78	3.15	0.81	0.52	0.52
Commuters	0.02	2.34	0.11	0.00	0.01	0.01
Total	**0.08**	**6.35**	**10.12**	**2.48**	**1.61**	**1.60**
Change from CH-46E	-5.32	-10.23	9.03	1.73	0.50	0.50
de minimis	100	NA	100	NA	NA	NA
Exceedance?	**No**	**NA**	**No**	**NA**	**NA**	**NA**

Note: NA=Not Applicable.

The change in emissions from transitioning from CH-46E aircraft to MV-22B aircraft is provided in **Table 3.4-4**. MV-22B emissions of VOCs and CO would be less than those from CH-46E operations, while emissions of NO_x, SO_2, PM_{10}, and $PM_{2.5}$ would be slightly more than the CH-46E. There would be no significant direct or indirect impacts to air quality for any of the criteria pollutants as a result of the transition from HMM-774 to VMM-774. As shown in **Table 3.4-4,** the results indicate that there would be no exceedance of a General Conformity *de minimis* threshold of 100 tons per year, and no further evaluation of conformity is required.

3.4.2.3 Alternative 2: Hangar LP-27

Under Alternative 2, HMM-774 would transition to VMM-774 and relocate to Hangar LP-27. The impacts to air quality would be similar to those described under Alternative 1. Interior hangar modification and apron repairs would be required for two hangars: LP-27 and LF-60 (see **Section 2.2.2.3**). The small exterior addition at LF-60 would create minor, temporary emissions during the construction phase. This short duration activity would not significantly impact local air quality. Proposed MV-22B emissions would be the same as those described under Alternative 1 (see **Table 3.4-4**); no significant impact to air quality would occur.

3.4.3 Cumulative Effects

The Navy's C-2A aircraft are tentatively scheduled to transition to the V-22 during the 2020-2025 timeframe. Wherever possible, the existing infrastructure used for C-2A operations would be maintained with minimal changes to accommodate the V-22(N). The force structure under the transition would remain similar to the current structure. The I-564 Intermodal connector would result in temporary, minor emissions within the airfield environment (below *de minimis* levels). As stated in **Section 3.4.2**, there are small emission increases anticipated for some criteria pollutants; however, any increases are considered to be minor adverse impacts. As a result, this cumulative impacts analysis focuses on GHGs.

Emission sources evaluated in this EA are exclusively associated with airspace operations and are limited to aircraft flight, maintenance testing of aircraft engines, and additional squadron staff commuting in highway vehicles. Transits to training areas and aircraft training activities in these areas (represented as touch-and-go) are evaluated as connected actions for inclusion in the cumulative analysis. The primary GHG emission associated with these sources is CO_2. Emissions of this GHG have been quantified and carried forward in the cumulative analysis because CO_2 emission factor information for vehicles and aircraft are published and readily available.

The cumulative effects for GHG emissions were evaluated for the proposed operation activities and compared to existing emissions to assess the net contribution of the proposed action. **Table 3.4-5** compares the GHG emissions associated with the proposed operations to the baseline operations. An increase in GHG emissions would occur as a result of the transition to MV-22B aircraft. Detailed calculations and assumptions can be found in **Appendix D**. For comparison purposes, the total GHG emissions in the U.S. in 2013 were 6,673 million metric tons (USEPA 2015). The increase in emissions from transition to MV-22B would represent 0.000006 percent of the total U.S. GHG emissions.

Table 3.4-5. GHG Emissions Estimated for Proposed Airfield Operations and Connected Actions at NS Norfolk

CH-46E	**CO_2 (metric tons per year)**
Airfield Activities	953
Connected Actions	5,226
Total	6,179
Proposed MV-22B	**CO_2**
Airfield Activities	3,416
Connected Actions	6,731
Total	10,147
Net Change	**3,968**

Individual sources of anthropogenic GHG emissions are not large enough to have an appreciable effect on climate change. For this reason, emissions of GHGs from the proposed action alone would not cause appreciable global warming that would lead to climate change. The emissions of MV-22B aircraft, as tactical vehicles, are exempt from the requirements of EOs and other mandates for GHG reductions, as specific training operation levels are required in order to maintain the core competency of the military. However, non-tactical aspects of military activities do fall under these mandates and are actively revised, evaluated, and reported as part of the federal government's initiatives to address GHG reductions and climate change. The Department of the Navy (and DOD) has committed to a 34 percent reduction in GHG emissions by 2020. As a result, the increase in GHG emissions that would result from transition to the

MV-22B aircraft would be offset by the large scale reduction in emissions generated by other Department of Navy activities.

3.5 SOCIOECONOMICS AND ENVIRONMENTAL JUSTICE

Socioeconomics describes the basic attributes and resources associated with the human environment, particularly population and economic activity. Economic activity typically encompasses employment, personal income, and industrial growth. The project area for socioeconomics is defined as the area in which the principal effects arising from implementation of the proposed action are likely to occur. The proposed action has the potential to cause a socioeconomic impact to the communities around NS Norfolk through changes or relocation of personnel.

When considering socioeconomic impacts, the Department of the Navy also considers Environmental Justice, specifically two EOs:

1. EO 12898, *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations*, mandates that federal agencies identify and address, as appropriate, disproportionately high and adverse human health or environmental effects of its programs on minority and low-income populations.
2. EO 13045, *Protection of Children from Environmental Health Risks and Safety Risks*, mandates that federal agencies identify and assess environmental health and safety risks that may disproportionately affect children as a result of the implementation of federal policies, programs, activities, and standards.

3.5.1 Affected Environment

Norfolk is in the Virginia Beach-Norfolk-Newport News, Virginia (VA)-North Carolina (NC) Metropolitan Statistical Area (MSA). In 2010, the MSA consisted of these locations: Currituck County (North Carolina); Gloucester County, Isle of Wight County, James City County, Mathews County, Surry County, York County, City of Chesapeake, City of Hampton, City of Newport News, City of Norfolk, City of Poquoson, City of Portsmouth, City of Suffolk, City of Virginia Beach, and City of Williamsburg (Virginia). For comparison purposes, data is provided for the entire MSA as well as the City of Norfolk specifically.

3.5.1.1 Demographics

Demographic data for the Virginia Beach-Norfolk-Newport News, VA-NC MSA and the City of Norfolk are provided in **Table 3.5-1**. The Virginia Beach-Norfolk-Newport News, VA-NC MSA encompasses approximately 2,600 square miles of land area, while the City of Norfolk encompasses approximately 54 square miles of land area (World Media Group 2014). The population is predominately white within the MSA, but within the City of Norfolk the population is more evenly split between white and black (47.1% and 43.1%, respectively). Key industries of employment within the region include government (local, state, federal), military, tourism, and health care. The number of people living below the poverty level is higher in the City of Norfolk than it is within the MSA (19.2% and 11%, respectively) and the median household income is also less than within the MSA (USCB 2011, 2013).

Table 3.5-1 Region of Influence Demographics		
	Virginia Beach-Norfolk-Newport News, VA-NC MSA	**City of Norfolk**
Total Population	1,648,136	242,803
White	59.2	47.1
Black	31.6	43.1
Other Minority	5.7	6.2
Average Household Size	2.5	2.3
Median Age	35.3	29.7
Under Age 18	24%	20.8%
Per Capita Income	$28,954	$24,659
Median Household Income	$59,293	$44,747
Below Poverty Level	11%	19.2%

***Sources**:* USCB 2011, 2013.

3.5.1.2 Military Role in Regional Economics

The Department of the Navy economic impact has been quantified for the Hampton Roads region, which is smaller than the Virginia Beach-Norfolk-Newport News, VA-NC MSA. Total economic impact on the Hampton Roads region from Department of the Navy installations is $9.2 billion. The installations provide 113,674 total jobs in the region, and NS Norfolk provides 62,084 jobs. The annual military and civilian payroll expenditures for work associated with the installations are $7.8 billion. The annual procurement for goods and services is $1.3 billion (Norfolk Department of Development 2014).

Although ship operations are the primary activity at NS Norfolk, jobs associated with supporting the mission at Chambers Field also contribute to local employment and economic benefits to the Virginia Beach-Norfolk-Newport News, VA-NC MSA.

3.5.2 Environmental Consequences

3.5.2.1 No Action Alternative

Under the No Action Alternative, HMM-774 would not transition to VMM-774. The existing staff of 209 personnel would be reassigned to other installations or released from the reserves. Given the scale of the local economy, the loss of these jobs would not have a significant direct or indirect impact on local socioeconomics. The 209 personnel represent 0.3 percent of the jobs at NS Norfolk. The No Action Alternative would not disproportionately affect low income or minority populations or children, and there would be no environmental justice concern.

3.5.2.2 Alternative 1: Hangar LP-167

Under Alternative 1, HMM-774 would transition to VMM-774 and relocate to Hangar LP-167. The 30 additional personnel required for the transition would likely be drawn from the existing pool of local area reservists or from reservists traveling to the area to participate in weekend drills. Proposed renovation activities would have a very slight, temporary benefit to the local economy. As discussed in **Sections 3.3.2** and **3.7.2**, noise zones defined in the AICUZ Program and APZs would not be affected; therefore, home values would be unaffected as a result of transitioning to an MV-22B reserve squadron at Chambers Field. Likewise, no perceptible change to the existing noise environment at any of the POIs in the community (or any off-base areas) would occur under Alternative 1. The transition of HMM-774 to VMM-774 would be seamless to the community and would not disproportionately affect low income or

minority populations or children; there would be no environmental justice concerns. There would be no significant direct or indirect impacts to socioeconomics.

3.5.2.3 Alternative 2: Hangar LP-27

Under Alternative 2, HMM-774 would transition to VMM-774 and relocate to Hangar LP-27. The socioeconomic impacts under this alternative would be the same as those described under Alternative 1. Alternative 2 would have no significant direct or indirect impact to socioeconomics; the squadron transition would be seamless to the community and would not disproportionately affect low income or minority populations or children. There would be no environmental justice concerns.

3.5.3 Cumulative Effects

No projects under consideration have overlapping effects on socioeconomics or environmental justice.

3.6 CULTURAL RESOURCES

The Navy is required to comply with the provisions of Section 106 of the National Historic Preservation Act (NHPA), including its implementing regulations codified in 36 CFR Part 800. To comply with Section 106, the Navy is required to identify historic properties within an area of potential effect; to consider the effects of a proposed action on these properties in consultation with appropriate consulting parties (e.g. Advisory Council on Historic Preservation [ACHP], State Historic Preservation Office [SHPO], Indian tribes, and interested parties); and avoid, minimize, or mitigate any adverse effects on these properties in consultation with appropriate consulting parties. The implementing regulations for Section 106 define historic properties as any prehistoric or historic district, site, building, structure, or object included in or eligible for inclusion in the National Register of Historic Places (NRHP) as outlined in 36 CFR 60.4 (NRHP, Criteria for Evaluation). Also included are any artifacts, records, and remains (surface or subsurface) that are related to and located within historic properties and any properties of traditional religious or cultural importance to Indian tribes (including Alaska Natives or Native Hawaiian Organizations). Section 110 of the NHPA requires all federal agencies to establish, in conjunction with the Secretary of the Interior, their own historic preservation programs for the identification, evaluation, and protection of historic properties.

Under 36 CFR Part 800, the ACHP allows federal agencies to tailor the Section 106 process to meet their needs through the development of program alternatives as governed by 36 CFR 800.14. Programmatic Agreements are the most commonly used program alternative. The agreements allow federal agencies to govern the implementation of a particular agency program or multiple undertakings similar in nature through negotiation of an agreement between the agency and the ACHP. The Navy utilizes a program alternative for the management of its historic buildings and districts in the Hampton Roads region of Virginia, which includes NS Norfolk. The Navy executed a Regional Programmatic Agreement (RPA) for the Navy's Historic Buildings in Hampton Roads in 1999 with the ACHP and Virginia Department of Historic Resources (also known as the SHPO) to streamline the Section 106 process. The agreement is still in use.

3.6.1 Affected Environment

Under Sections 106 and 110 of the NHPA, the Navy has conducted numerous cultural resources surveys to identify historic properties and determine their significance at NS Norfolk.

3.6.1.1 Architectural Resources

The first evaluation at NS Norfolk involved the NRHP nomination for the Jamestown Exposition Site Historic District. The historic district was formally listed in the NRHP in 1975. In 1996, R. Christopher Goodwin & Associates Inc. conducted an intensive architectural survey of the installation and identified three additional NRHP-eligible historic districts: Naval Air Station Historic District, Naval Administration/Recruit Training Historic District, and the Naval Supply Depot Historic District. The RPA includes the four historic districts and their contributing resources at NS Norfolk and outlines the management and treatment of the contributing resources within the historic districts. The RPA was recently updated in August 2010 to include the revised boundaries of the Naval Supply Depot Historic District and the Naval Air Station Historic District.

The Navy is currently performing a Phase 1 survey of resources constructed between 1948 and 1962 as part of the Cold War Assessment for the Hampton Roads area. In 2011, Dutton & Associates performed an initial assessment to identify resources that required further evaluation. The assessment did not identify any potential Cold War era resources from 1948 and 1962 at NS Norfolk and determined the resources constructed from 1948 to 1962 are not eligible for inclusion in the NRHP. The Virginia Department of Historic Resources reviewed the results of the windshield survey and did not provide comments.

There are three historic districts in the vicinity of the proposed action: Jamestown Exposition Site, Naval Administration/Recruit Training Station, and Naval Air Station Historic District (U.S. Navy 2013e). The Naval Supply Depot Historic District is not located within the vicinity or view shed of the proposed action. None of the facilities included in the proposed action (e.g. Building LP-167 and LF-60) are located within any of the historic districts, considered contributing resources of the historic districts, or considered a part of any of the historic districts (**Figure 3.6-1**). Additionally Building LP-167 was constructed in 1971 and LF-60 was constructed in 1976. The buildings are not currently 50 years old and therefore do not require evaluation for their eligibility for inclusion in the NRHP.

<u>Jamestown Exposition Site Historic District</u>

Listed in the NRHP in 1975, the Jamestown Exposition Site Historic District includes buildings constructed for the 1907 Jamestown Exposition, as well as other quarters and support buildings either acquired or built by the Navy when it established Naval Operating Base Norfolk in 1917 (U.S. Navy 2013e) (**Figure 3.6-1**). The Jamestown Exposition was a fair commemorating the 300th anniversary of the founding of Jamestown in the Virginia Colony. The district is eligible because of its historical and architectural significance. The most significant buildings in the district are the flag officers' quarters along the south side of Dillingham Avenue, which present "an impressive Naval Station parade of large-scale Colonial Revival quarters," several of which have monumental porticos. Most of the district's other structures also date to the 1907 Jamestown Exposition, although the present character of the neighborhood has been altered by the Navy over time to adapt to changing mission requirements (U.S. Navy 2013e).

<u>Naval Administration/Recruit Training Station Historic District</u>

Determined eligible under National Register Criteria A (Event) and C (Design/Construction) with a period of significance of 1917-1946, the Naval Administration/Recruit Training Station Historic District is associated with the evolution of naval recruit training (U.S. Navy 2013e) (**Figure 3.6-1**). The district illustrates the characteristics of permanent military construction spanning the period of World War I

through World War II. The district encompasses a variety of building types, including administration and school buildings, barracks, mess hall, and recreation and personnel support buildings. The district overlies the site design created for the 1907 Jamestown Exposition, and retains the original street grid developed by Warren H. Manning. Buildings subsequently built by the Navy reinforced the original Beaux Arts-inspired plan, emphasizing formality through axial relationships, linearity, clear edge-conditions, and building placement. The consistent use of similar building materials and their mid-rise scale gives the core of the base its distinct character (U.S. Navy 2013e).

Retention of the historic street grid and the consistent use of classical design principles in the siting and massing of the Navy's subsequent buildings make this a valued resource. The careful siting, mass, and scale of these buildings are critical components of the district's "campus-like" character.

Naval Air Station Historic District

Determined eligible under National Register Criteria A (Event) and C (Design/Construction) with a period of significance of 1917-1948, the Naval Air Station Historic District illustrates the evolution of naval aviation from World War I through World War II, when the aircraft carrier assumed equal importance with the battleship (U.S. Navy 2013e) (**Figure 3.6-1**). At the outset of World War II, NS Norfolk became the command center for naval air operations in the Atlantic. With the onset of World War II and the Navy's massive investment in air power, the small Hampton Roads air station was transformed by the addition of hangars, associated technical-support structures, and vast apron and taxiway spaces.

The district's buildings embody the distinctive character of military construction for naval air stations, and include a variety of resources types, including maintenance and storage buildings, administration buildings, barracks, officers' housing, and recreational facilities, all of which retain sufficient integrity to convey their association with the naval air station. The district comprises four noncontiguous elements, which define their different functions.

3.6.1.2 Archaeological Resources

The Navy utilizes the "Archaeological Resource Assessment and Predictive Model, Norfolk Naval Base Norfolk Virginia" prepared by Christopher Goodwin and Associates, Inc., in 2002 as the primary document for determining the need for archaeological survey at NS Norfolk. The Virginia SHPO concurred with the determinations of the report regarding low, moderate, and high potential areas. In addition, the Navy has performed numerous Phase 1 archaeological surveys at the installation over the years. There are five identified archaeological sites of which only one was determined to be potentially eligible for the NRHP (U.S. Navy 2013e).

There are no identified archaeological sites within the vicinity of the proposed action. Additionally, the 2002 predictive model considered the project areas as previously disturbed with low potential and did not recommend further archaeological investigations in these areas.

3.6.1.3 Other Cultural Resources

There are no federally-recognized Indian tribes in the Commonwealth of Virginia. There are two Indian tribes, the Catawba Indian Nation and the United Keetoowah Band of Cherokee Indians in Oklahoma, which have interests in the Hampton Roads areas of Virginia. However at this time, no traditional cultural properties (TCPs) or sacred sites have been identified at NS Norfolk.

Figure 3.6-1. NS Norfolk Historic Districts

3.6.2 Environmental Consequences

3.6.2.1 No Action Alternative

Under the No Action Alternative, HMM-774 would not transition to VMM-774. No hangar modifications or parking apron improvements would occur. There would be no changes within the view shed of the historic districts; therefore, no impact on the historic districts and their contributing resources would occur. Additionally no ground disturbing activities would occur as a result of this alternative, and there would be no impact to archaeological resources or other historic properties.

3.6.2.2 Alternative 1: Hangar LP-167

Under Alternative 1, HMM-774 would transition to VMM-774 and relocate to Hangar LP-167. Hangar LP-167 is not located within the view shed of any of the historic districts (refer to **Figure 3.6-1**). The proposed modifications to Hangar LF-60 would be interior and would not directly or indirectly affect the view shed of the Jamestown Exposition Site or the Naval Administration/Recruit Training Station Historic District. In accordance with the RPA, the Navy does not need to consult with SHPO, ACHP, and other interested parties on actions that only involve non-historic buildings or would not directly or indirectly affect historic districts. In addition, the proposed action would have no ground disturbance associated with the modifications to Hangar LP-167 and LF-60, as these buildings are located within areas of low archaeological potential. Minor soil disturbance would be anticipated from the repair/realignment of a segment of the perimeter fence near Hangar LP-167. There would be no impact to archaeological resources. At this time, there are no identified TCPs or sacred sites at NS Norfolk, and the proposed action would have no impact on TCPs or sacred sites. As such, selection of this alternative would not result in direct or indirect impacts to historic properties at NS Norfolk.

3.6.2.3 Alternative 2: Hangar LP-27

Under Alternative 2, HMM-774 would transition to VMM-774 and relocate to Hangar LP-27. To implement this alternative, exterior modifications and an addition to Hangar LF-60 would be required. Hangar LF-60 is within the view shed of the Jamestown Exposition Site and Naval Administration/Recruit Training Station historic districts (refer to **Figure 3.6-1**). In accordance with the RPA, all new construction, including additions, within or adjacent to historic districts require consultation with SHPO pursuant to the Section 106 process. If Alternative 2 is implemented, the Navy would consult with the SHPO regarding the direct and indirect effects of Alternative 2 on historic properties pursuant to Section 106 of the NHPA, and would develop measures to avoid or minimize the visual effect to the historic districts. No other cultural resources would be impacted by implementation of Alternative 2, as the area is considered to have low archaeological potential and there are no identified TCPs or sacred sites at NS Norfolk.

3.6.3 Cumulative Effects

The storage locker and used oil tank relocation scheduled at LF-60 is situated as to not be in the view shed of either historic district and the location is within an area determined to have low archaeological potential. As such, there is no potential effect to historic properties. No adverse cumulative effect from the proposed action, when considered together with the storage locker and used oil tank relocation, would occur.

3.7 PUBLIC HEALTH AND SAFETY

The Navy and Marine Corps practice Operational Risk Management as outlined in OPNAVINST 3500.39A and MCO 3500.27A. Requirements outlined in these documents provide for a process to maintain readiness in peacetime and achieve success in combat, while safeguarding people and resources. The public health and safety analysis addresses issues related to the health and well-being of both military personnel and civilians living on or in the vicinity of NS Norfolk. Specifically, this section provides information on hazards associated with aircraft mishaps, APZs, and BASH.

3.7.1 Affected Environment

3.7.1.1 Flight Safety

The FAA is responsible for ensuring safe and efficient use of U.S. airspace by military and civilian aircraft and for supporting national defense requirements. To fulfill these requirements, the FAA has established safety regulations, airspace management guidelines, a civil-military common system, and cooperative activities with the DOD.

The primary concern with regard to military training flights is the potential for aircraft mishaps (i.e., crashes) to occur, which could be caused by mid-air collisions with other aircraft or objects, weather difficulties, mechanical failures, pilot error, or BASH events.

Aircraft mishaps are classified in OPNAVINST 3750.6S as A, B, C, or D, with Class A mishaps being the most severe, with total property damage of $2 million or more (threshold was $1 million prior to 2010), total aircraft loss, or a fatality and/or permanent total disability. Combat losses are excluded from these mishap statistics. Class B mishaps are those with total property damage of $500,000 or more, but less than $2 million, or results in permanent partial disability or three or more personnel are hospitalized for in-patient care. Class C mishaps are those with total property damage of $50,000 or more, but less than $500,000, or a non-fatal injury that results in at least one day away from work. Class D is the least severe with total property damage $20,000 or more, but less than $50,000, or a recordable injury or illness occurs.

NS Norfolk maintains detailed emergency and mishap response plans to react to an aircraft accident, should one occur. These plans assign agency responsibilities and prescribe functional activities necessary to react to major mishaps, whether on- or off-base. Response would normally occur in two phases. The initial response focuses on rescue, evacuation, fire suppression, safety, elimination of explosive devices, ensuring security of the area, and other actions immediately necessary to prevent loss of life or further property damage. The initial response element usually consists of the Fire Chief, who would normally be the first on-scene Commander, fire-fighting and crash-rescue personnel, medical personnel, security police, and crash-recovery personnel. The second phase is the mishap investigation, which is comprised of an array of organizations whose participation would be governed by the circumstances associated with the mishap and actions required to be performed.

To complement flight training, all pilots use state-of-the-art simulators extensively. Simulator training includes all facets of flight operations and comprehensive emergency procedures, which minimizes risk associated with mishaps due to pilot error. Additionally, highly trained maintenance crews perform routine inspections on each aircraft in accordance with Navy and Marine Corps regulations, and maintenance activities are monitored by senior technicians to ensure the aircraft are equipped to withstand the rigors of operational and training events safely.

3.7.1.2 APZ Configurations

Most aircraft mishaps occur on or near the runway or along the centerline of the runway, diminishing in likelihood with distance from the airfield. Clear zones and APZs are areas in the vicinity of airfield runways where an aircraft mishap is most likely to occur, if one were to occur. While the likelihood of a mishap is remote, land uses within APZs should be low-density to ensure the maximum protection of public health and property. APZ configurations vary based on aircraft, but a general description and figure of the clear zones and APZs designated at NS Norfolk is below and illustrated in **Figure 3.7-1**.

- **Clear Zone**. The clear zone is a trapezoidal area lying immediately beyond the end of the runway
- **APZ I**. A rectangular area beyond the clear zone
- **APZ II**. A rectangular area beyond APZ I (or the clear zone if APZ I is not used)

An accident is more probable within APZ I than APZ II, and is more probable in the clear zone than in APZ I or APZ II.

3.7.1.3 BASH

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

Design modifications to the airfield also can be used to reduce the attractiveness of these types of land uses to birds and other wildlife, such as lawn height maintenance and decreasing desirable habitat like standing water. Chambers Field has an active BASH program. The airfield safety officer is the acting BASH coordinator, and they have a cooperative working relationship with the Naval Air Station Oceana (Virginia Beach, Virginia) safety officer and their wildlife experts to aid in managing the program. Personnel implement measures such as bird activity monitoring, dispersal scare tactics, lawn maintenance, and storm water drainage configurations to reduce bird and wildlife presence and BASH risk.

3.7.2 Environmental Consequences

3.7.2.1 No Action Alternative

Under the No Action Alternative, HMM-774 would not transition to VMM-774. The slight reduction in aircraft inventory and associated reduction in airfield operations at NS Norfolk would have a negligible change to potential risk associated with airfield activity. Current public health and safety procedures and programs would continue as they do currently.

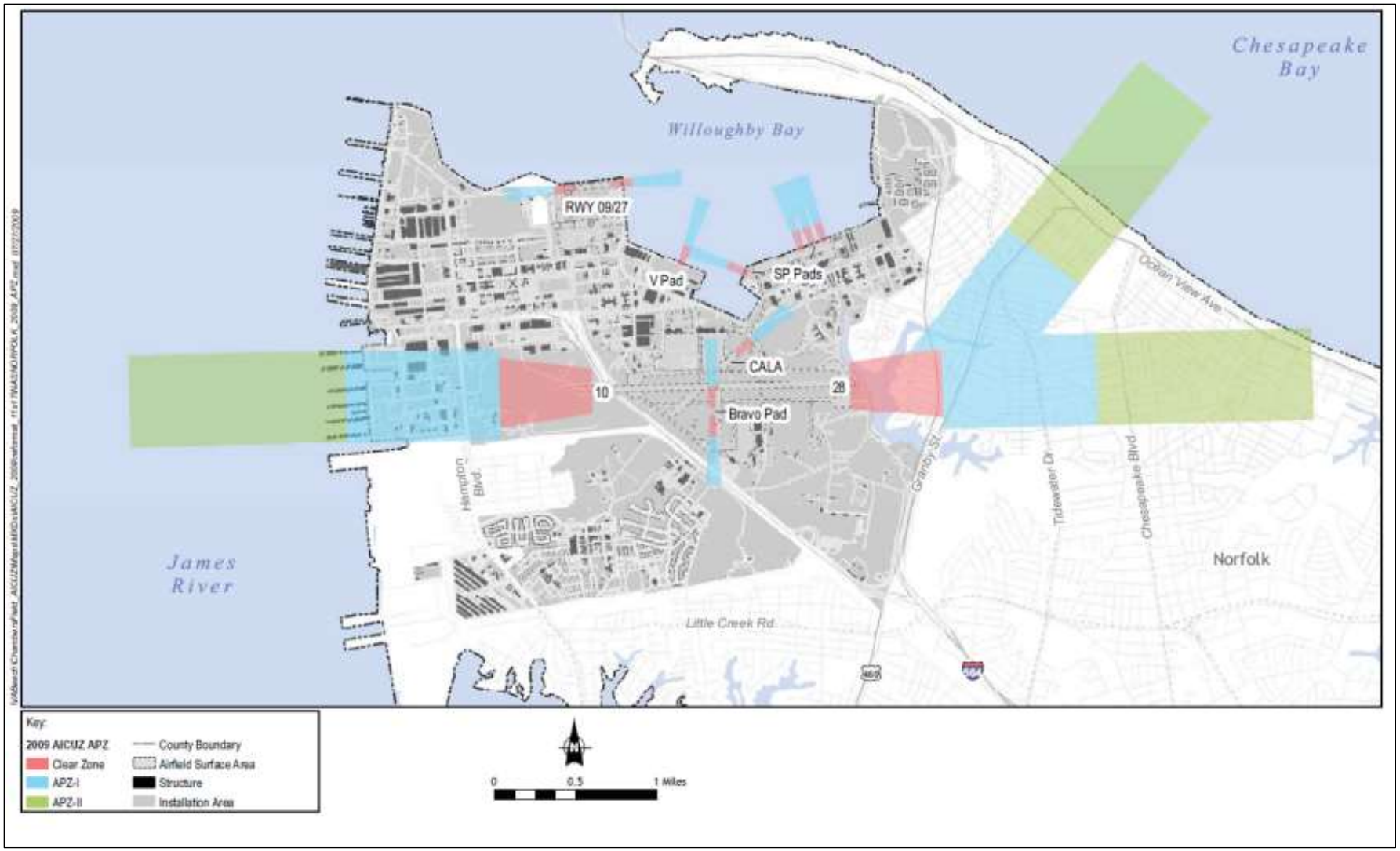

Figure 3.7-1. Clear Zones and APZs at Chambers Field

3.7.2.2 Alternative 1: Hangar LP-167

Under Alternative 1, HMM-774 would transition to VMM-774 and relocate to Hangar LP-167. Implementation of Alternative 1 would not measurably affect airfield safety at Chambers Field. The MV-22B replacement and total annual operations would occur on a one for one basis and there would be no change to total aircraft inventory or flight operations. The current Class A flight mishap rate for the MV-22B is 3.32 (rate of mishaps per 100,000 flight hours) (Naval Safety Center 2015). **Table 3.7-1** provides an account of Class A mishaps since 1997 for the MV-22B. For comparison, the CH-46E has flown over 1.8 million hours and currently has a Class A mishap rate of 2.45 (Naval Safety Center 2015). Current airspace safety procedures, maintenance, training, and inspections would continue to be implemented, and MV-22B airfield flight operations would adhere to established safety procedures. The existing APZs have been established for fixed-wing aircraft, and are therefore more expansive than what is required for a rotary-wing aircraft. As such, no changes to established clear zones, APZs, or other established airfield safety features would be required.

Alternative 1 would not change the potential for public health or safety impacts, including those related to aviation safety. All training regulations and procedures would reflect MV-22B specific rules, and pilots would adhere to the *MV-22B Training and Readiness Manual* (U.S. Marine Corps 2010). The airfield would update the emergency and mishap response plans specific to the MV-22B if changes are required.

Alternative 1 does not alter the potential for BASH events. BASH Program recommendations are primarily based on airfield habitat and its attractiveness to birds and other wildlife, not types of aircraft operating at the airfield. The operation of the MV-22B is not expected to change the BASH Program. Aircrews operating in Chambers Field airspace would be required to follow applicable procedures outlined in the Chambers Field BASH Program. Special briefings are provided to all pilots whenever the potential exists for greater bird-strike events within the airspace and operations are restricted if necessary. MV-22B pilots would be subject to these same procedures. Therefore, no significant BASH related impacts would be anticipated. Following safety protocols, no significant direct or indirect impacts to public health and safety would be associated with Alternative 1.

3.7.2.3 Alternative 2: Hangar LP-27

Under Alternative 2, HMM-774 would transition to VMM-774 and relocate to Hangar LP-27. The impacts under this alternative would be the same as those described under Alternative 1. The emergency and mishap response plans specific to the MV-22B would be updated if changes are required. Selection of Alternative 2 would not significantly alter the potential for BASH related impacts, as all applicable procedures for operating in the Chambers airfield environment would continue to be adhered. Following safety protocols, no significant direct or indirect impacts to public health and safety would be associated with Alternative 2.

Table 3.7-1 Class A Mishaps for MV-22B			
Year	**Flight Hours**	**Class A Mishaps**	**Class A Mishap Rate per 100,000 Hours**
FY 1997[1]	61	0	0
FY1998[1]	444	0	0
FY 1999[1]	416	0	0
FY 2000[1]	221	1	452.49
FY 2001[1]	470	1	212.77
FY 2002[2]	0	0	0
FY 2003[2]	0	0	0
FY 2004	1,986	0	0
FY 2005	3,866	0	0
FY 2006	5,984	0	0
FY 2007	9,713	0	0
FY 2008	14,425	1	6.93
FY 2009	13,540	0	0
FY 2010	16,891	0	0
FY 2011	24,688	0	0
FY 2012	29,937	1	3.34
FY 2013	32,118	2	6.23
FY 2014	35,880	0	0
FY 2015	19,927	1	5.02
TOTAL	**210,567**	**7**	**3.32**

Notes: [1] Hours flown from FY 1997 to FY 2001 were developmental and operational test hours.
[2] From January 2001 through mid-2002 the aircraft was grounded and received design changes. It returned to flight status in FY 2004.
Source: Naval Safety Center 2015.

3.7.3 Cumulative Effects

The previous relocation of the Fleet Recreation Park ball fields from the west of Chambers Field removed a land use conflict, which improved public health and safety in the vicinity of the airfield. The relocation of the hazardous material storage locker and used oil tank from the flightline to Hangar LF-60 removed a potential hazard from the flightline, which improved safety at the airfield. Implementing the recommendations in the Airfield Obstruction Management Plan (U.S. Navy 2012) improves airfield safety by reducing obstructions (vegetation) that present a risk to aircraft operating in the airfield. The use of CFTDs and other types of simulators for pilot training reduces cost and improves safety while still meeting the training mission (refer to **Section 2.1.3.4**). These positive effects on public health and safety, when considered in combination with the no significant impacts to public health and safety from the proposed action, would cumulatively have no significant impacts.

3.8 MITIGATION MEASURES

The purpose of mitigation is to eliminate potential negative impacts of an action on affected resources or to reduce an impact to less than significant. CEQ regulations (40 CFR 1508.20) state that mitigation includes:

- Avoiding the impact altogether by not taking a certain action or parts of an action.
- Minimizing impacts by limiting the degree or magnitude of the action and its implementation.
- Rectifying the impact by repairing, rehabilitating, or restoring the affected environment.
- Reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action.
- Compensating for the impact by replacing or providing substitute resources or environments.

There are no anticipated significant environmental impacts associated with Alternative 1 (Preferred Alternative) as described in **Sections 3.1 through 3.7** and no mitigation measures are required. If Alternative 2 is selected for implementation, Section 106 consultation with the SHPO would occur prior to any action on this proposal. All mitigation measures identified during that consultation would be followed.

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APPENDIX A
DISCUSSION OF NOISE AND ITS EFFECT ON THE ENVIRONMENT

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

FINAL

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

FINAL

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

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Acronyms & Abbreviations

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

(Continued on next page)

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

Appendix A

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

A.1 Basics of Sound

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

A.1.1 Sound Waves and Decibels

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

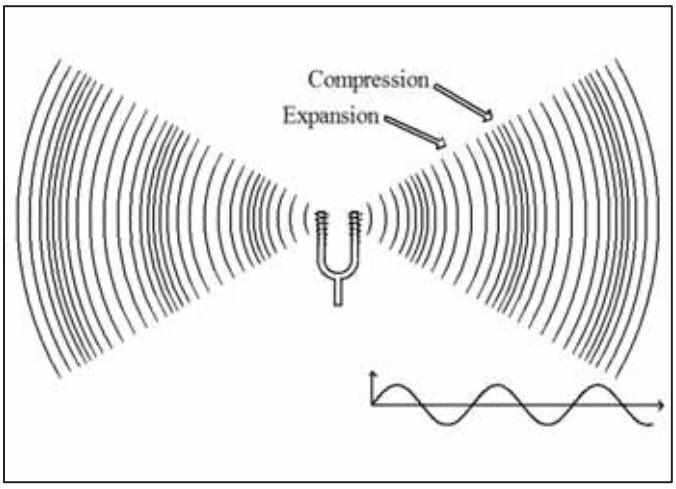


Figure A-1. Sound Waves from a Vibrating Tuning Fork

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

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

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

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

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

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

60 dB + 60 dB = 63 dB, and

80 dB + 80 dB = 83 dB.

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

60.0 dB + 70.0 dB = 70.4 dB.

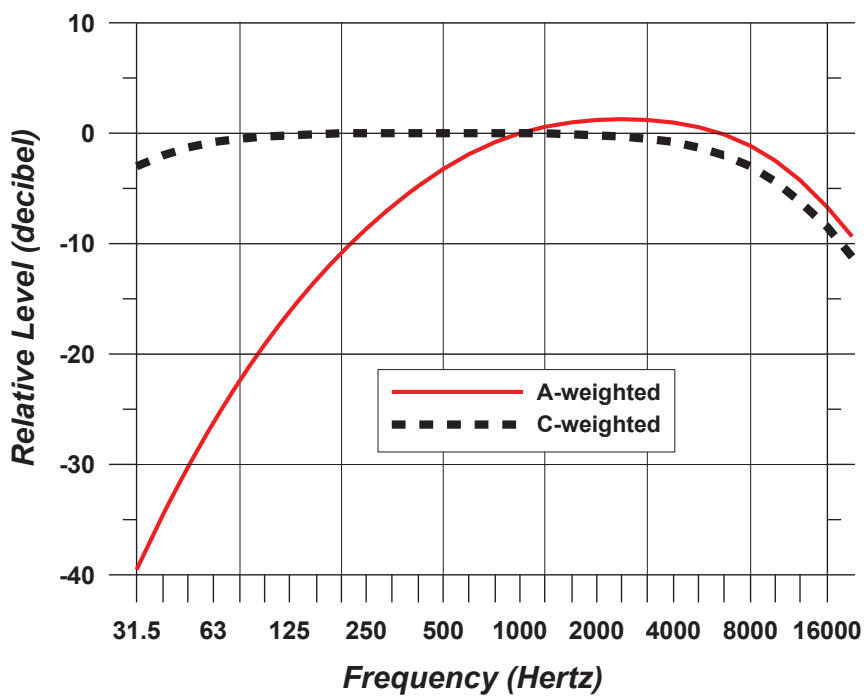
Because the addition of sound levels is different than that of ordinary numbers, this process is often referred to as "decibel addition."

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

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

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

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



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

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

A.1.2 Sound Levels and Types of Sounds

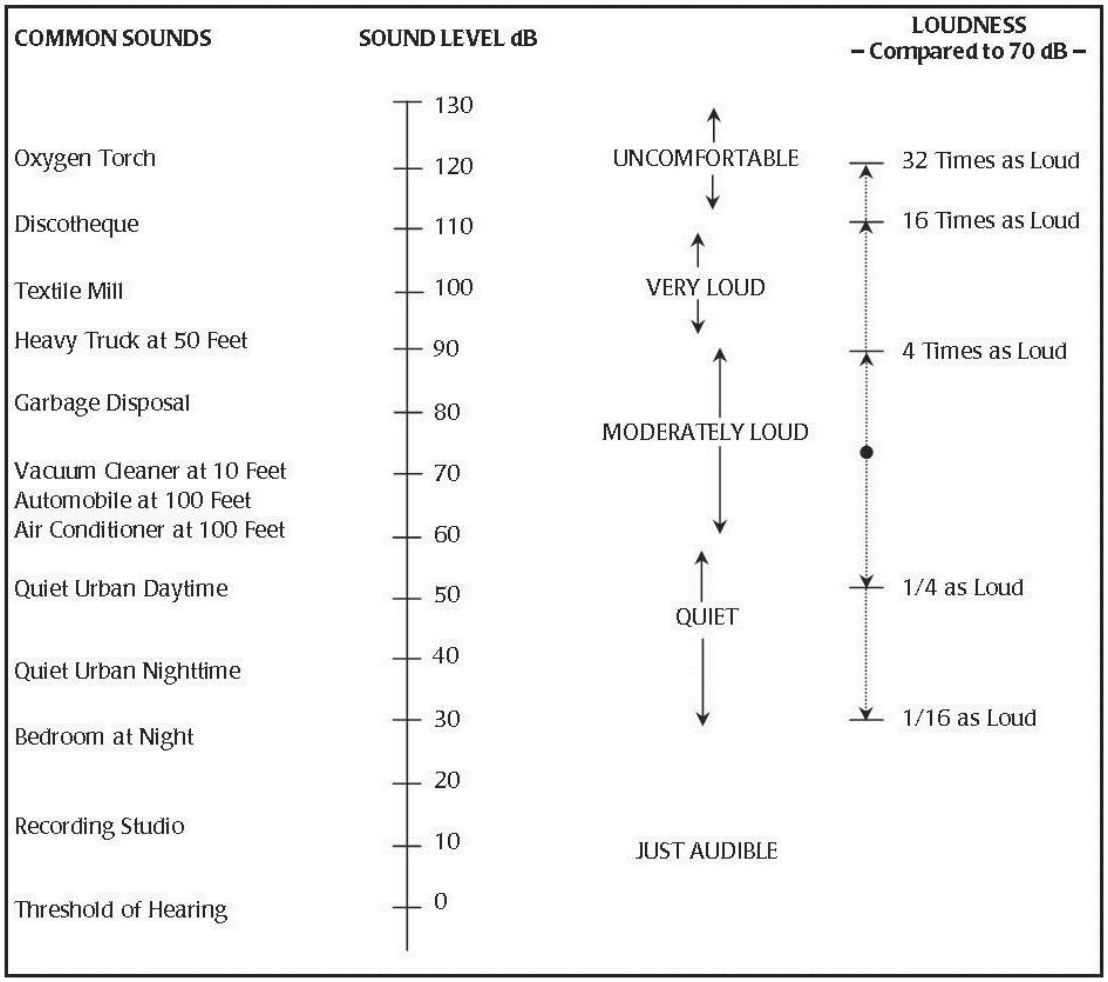
Most environmental sounds are measured using A-weighting. They're called A-weighted sound levels, and sometimes use the unit dBA or dB(A) rather than dB. When the use of A-weighting is understood, the term "A-weighted" is often omitted and the unit dB is used. Unless otherwise stated, dB units refer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

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

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

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

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



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

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

A.2 Noise Metrics

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

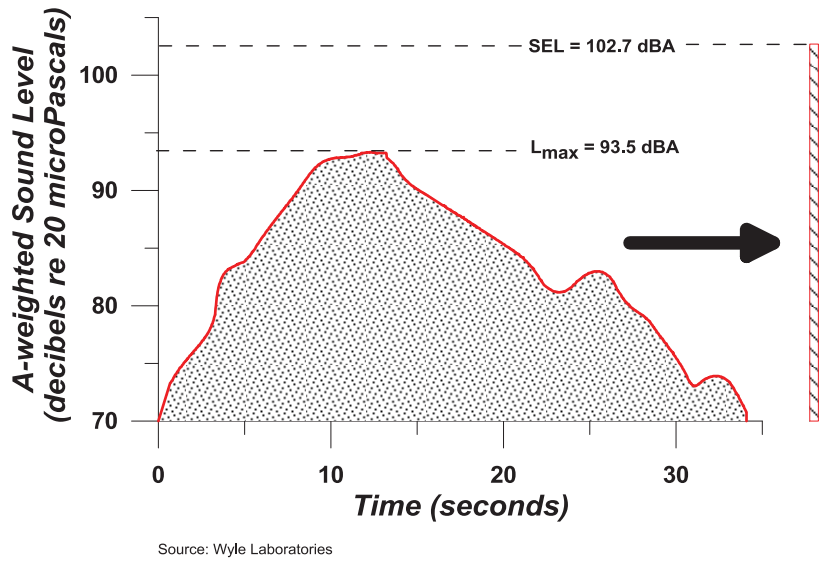


Figure A-4. Example Time History of Aircraft Noise Flyover

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

A.2.1 Single-events

Maximum Sound Level (L_{max})

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

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

Peak Sound Pressure Level (L_{pk})

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

Sound Exposure Level (SEL)

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

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

A.2.2 Cumulative Events

Equivalent Sound Level (L_{eq})

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

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

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

Source: Wyle Laboratories

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

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

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

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

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

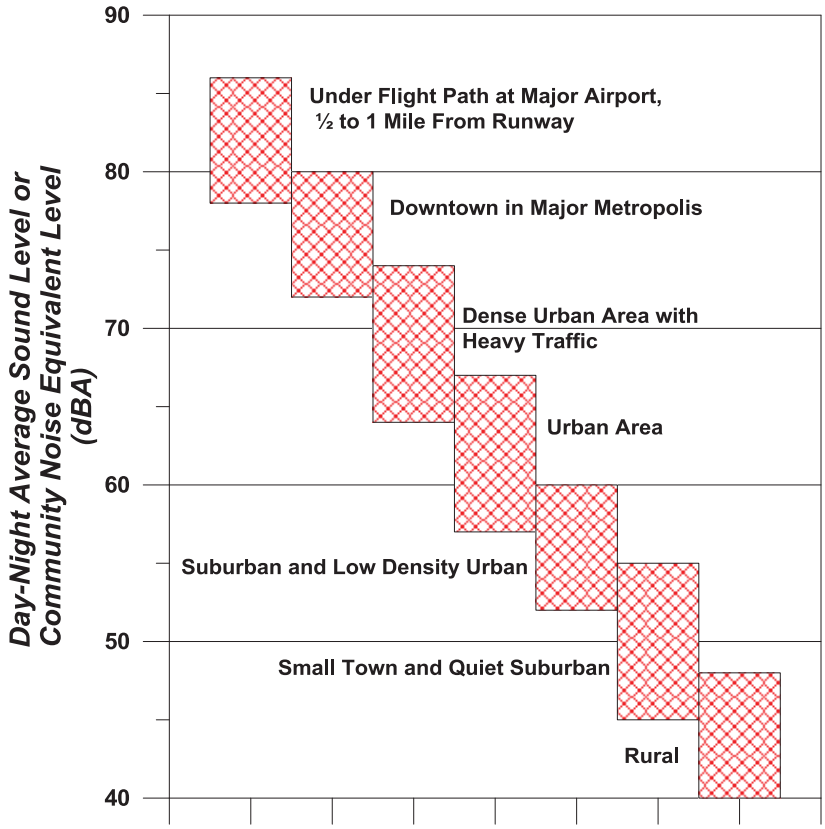
Figure A-5 gives an example of DNL and CNEL using notional hourly average noise levels ($L_{eq(h)}$) for each hour of the day as an example. Note the $L_{eq(h)}$ for the hours between 10 p.m. and 7 a.m. have a 10 dB penalty assigned. For CNEL the hours between 7p.m. and 10 p.m. have a 4.8 dB penalty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

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

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

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

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



Source: DOD 1978.

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

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

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

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

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

A.2.3 Supplemental Metrics

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

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

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

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

Time Above (TA) a Specified Level (L)

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

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

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

A.3 Noise Effects

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

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

A.3.1 Annoyance

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

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

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

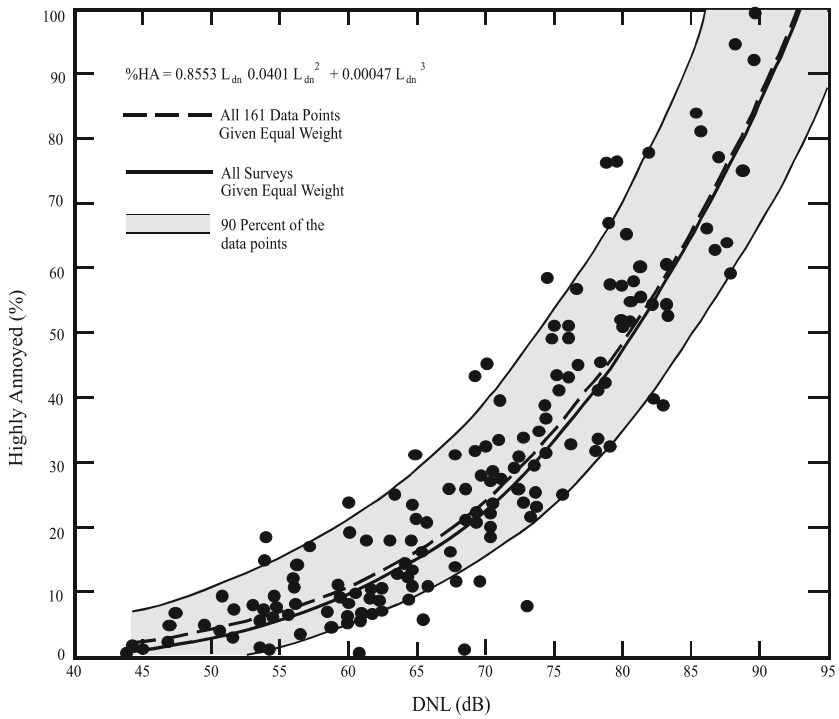


Figure A-7. Schultz Curve Relating Noise Annoyance to DNL (Schultz 1978)

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

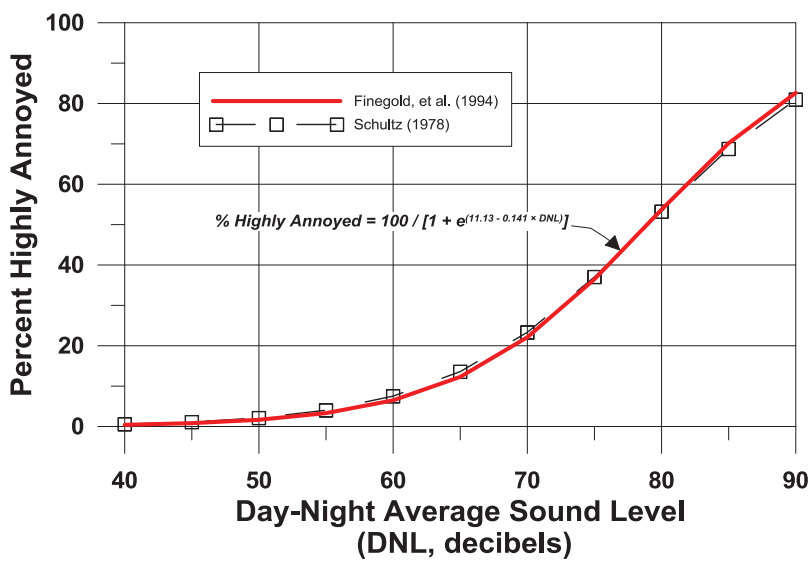


Figure A-8. Response of Communities to Noise; Comparison of Original Schultz (1978) with Finegold et al (1994)

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

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

Emotional Variables	Physical Variables
Feeling about the necessity or preventability of the noise;	Type of neighborhood;
Judgement of the importance and value of the activity that is producing the noise;	Time of day;
Activity at the time an individual hears the noise;	Season;
Attitude about the environment;	Predicitabiltiy of the noise;
General sensitivity to noise;	Control over the noise source; and
Belief about the effect of noise on health; and	Length of time individual is exposed to a noise.
Feeling of fear associated with the noise.	

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

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

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

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

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

Source: Miedema and Vos 1998.

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

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

A.3.2 Speech Interference

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

There are two measures of speech comprehension:

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

U.S. Federal Criteria for Interior Noise

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

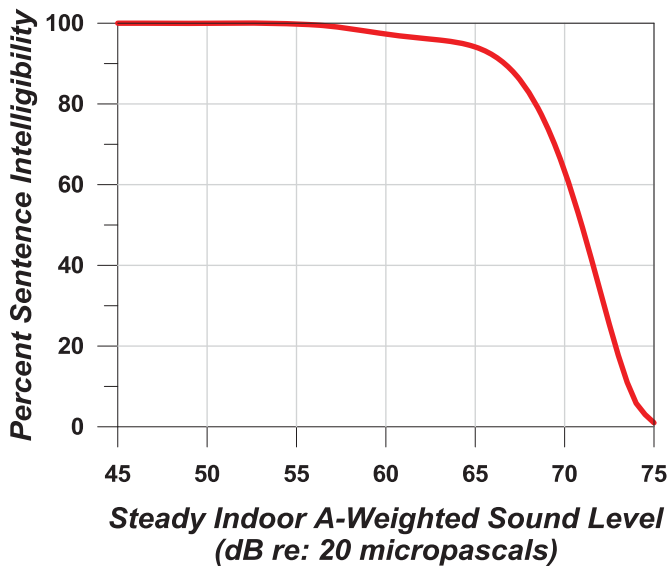


Figure A-9. Speech Intelligibility Curve (digitized from USEPA 1974)

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

Classroom Criteria

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

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

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

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

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

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

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

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

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

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

A.3.3 Sleep Disturbance

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

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

Initial Studies

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

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

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

Recent Sleep Disturbance Research – Field and Laboratory Studies

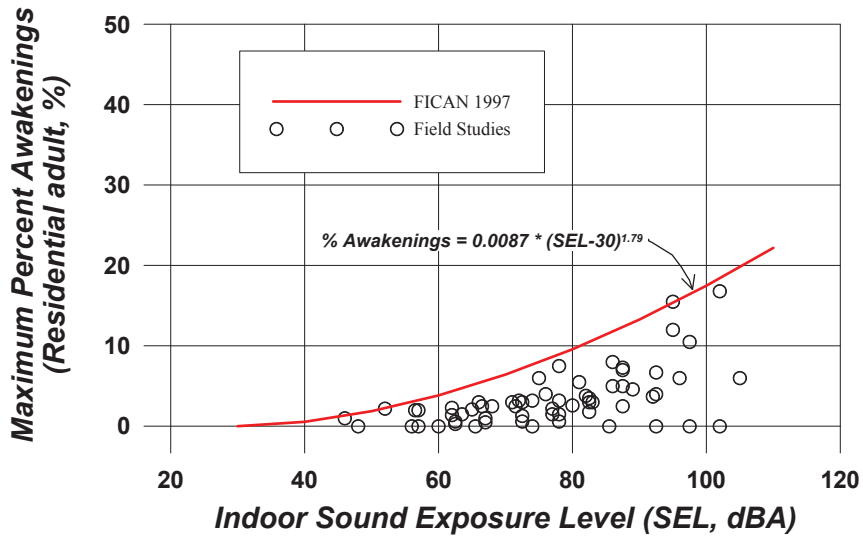
It was noted that early sleep laboratory studies did not account for some important factors. These included habituation to the laboratory, previous exposure to noise, and awakenings from noise other than aircraft. In the early 1990s, field studies in people's homes were conducted to validate the earlier laboratory work conducted in the 1960s and 1970s. The field studies of the 1990s found that 80-90% of

sleep disturbances were not related to outdoor noise events, but rather to indoor noises and non-noise factors. The results showed that, in real life conditions, there was less of an effect of noise on sleep than had been previously reported from laboratory studies. Laboratory sleep studies tend to show more sleep disturbance than field studies because people who sleep in their own homes are used to their environment and, therefore, do not wake up as easily (FICAN 1997).

FICAN

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

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



Source: FICAN 1997

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

Number of Events and Awakenings

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

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

Currently, there are no established criteria for evaluating sleep disturbance from aircraft noise, although recent studies have suggested a benchmark of an outdoor SEL of 90 dB as an appropriate tentative

criterion when comparing the effects of different operational alternatives. The corresponding indoor SEL would be approximately 25 dB lower (at 65 dB) with doors and windows closed, and approximately 15 dB lower (at 75 dB) with doors or windows open. According to the ANSI (2008) standard, the probability of awakening from a single aircraft event at this level is between 1 and 2% for people habituated to the noise sleeping in bedrooms with windows closed, and 2-3% with windows open. The probability of the exposed population awakening at least once from multiple aircraft events at noise levels of 90 dB SEL is shown in Table A-4.

Table A-4. Probability of Awakening from NA90SEL

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

Source: DOD 2009b.

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

Summary

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

A.3.4 Noise-Induced Hearing Impairment

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

Hearing Threshold Shifts

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

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

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

Criteria for Permanent Hearing Loss

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

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

Hearing Loss and Aircraft Noise

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

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

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

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

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

** rounded to the nearest 0.5 dB*

Source: DOD 2012.

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

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

Summary

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

A.3.5 Non-auditory Health Effects

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

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

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

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

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

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

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

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

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

Summary

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

A.3.6 Performance Effects

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

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

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

A.3.7 Noise Effects on Children

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

A.3.7.1 Effects on Learning and Cognitive Abilities

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

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

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

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

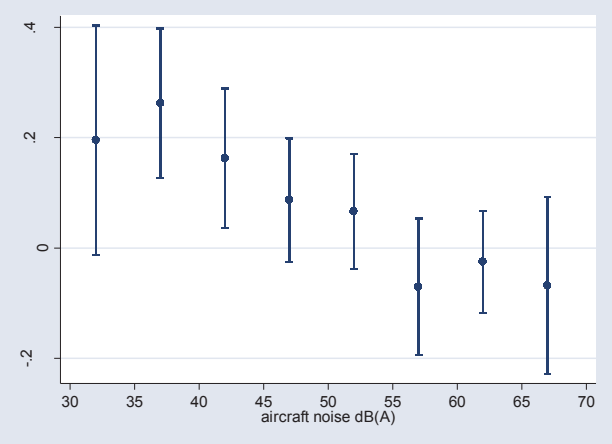


Figure A-11. RANCH Study Reading Scores Varying with L_{eq}
Sources: Stansfeld et al. 2005; Clark et al. 2006

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

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

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

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

A.3.7.2 Health Effects

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

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

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

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

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

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

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

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

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

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

A.3.8 Property Values

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

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

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

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

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

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

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

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

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

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

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

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

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

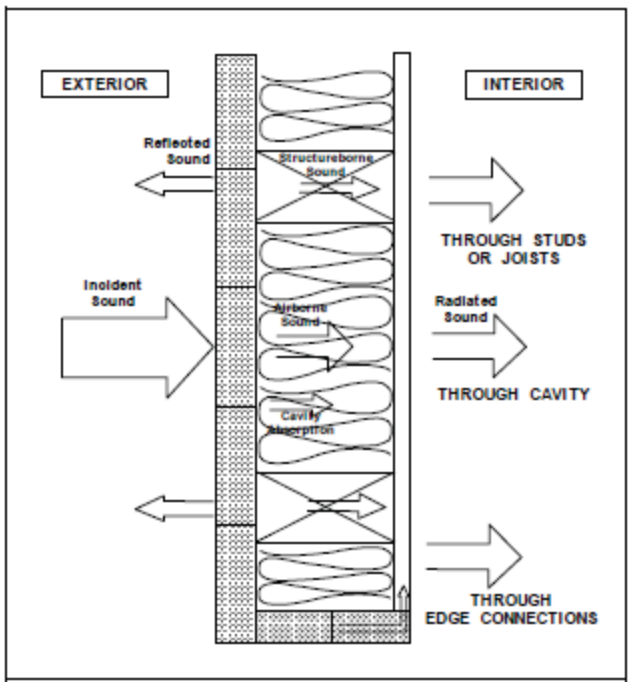


Figure A-12. Depiction of Sound Transmission through Built Construction

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

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

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

Source: ISO 1989.

A.3.10 Noise Effects on Terrain

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

A.3.11 Noise Effects on Historical and Archaeological Sites

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

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

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

A.3.12 Effects on Domestic Animals and Wildlife

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

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

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

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

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

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

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

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

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

A.3.12.1 Domestic Animals

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

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

Cattle

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

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

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

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

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

Horses

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

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

Swine

Generally, the literature findings for swine appear to be similar to those reported for cows and horses. While there are some effects from aircraft noise reported in the literature, these effects are minor. Studies of continuous noise exposure (i.e., 6 hours, 72 hours of constant exposure) reported influences on short-term hormonal production and release. Additional constant exposure studies indicated the observation of stress reactions, hypertension, and electrolyte imbalances (Dufour 1980). A study by Bond et al. (1963), demonstrated no adverse effects on the feeding efficiency, weight gain, ear physiology, or thyroid and adrenal gland condition of pigs subjected to observed aircraft noise. Observations of heart rate increase

were recorded; noting that cessation of the noise resulted in the return to normal heart rates. Conception rates and offspring survivorship did not appear to be influenced by exposure to aircraft noise.

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

Domestic Fowl

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

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

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

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

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

A.3.12.2 Wildlife

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

Mammals

Terrestrial Mammals

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

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

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

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

Marine Mammals

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

In 1980, the Acoustical Society of America held a workshop to assess the potential hazard of manmade noise associated with proposed Alaska Arctic (North Slope-Outer Continental Shelf) petroleum operations on marine wildlife and to prepare a research plan to secure the knowledge necessary for proper assessment of noise impacts (Acoustical Society of America 1980). Since 1980 it appears that research on responses

of aquatic mammals to aircraft noise and sonic booms has been limited. Research conducted on northern fur seals, sea lions, and ringed seals indicated that there are some differences in how various animal groups receive frequencies of sound. It was observed that these species exhibited varying intensities of a startle response to airborne noise, which was habituated over time. The rates of habituation appeared to vary with species, populations, and demographics (age, sex). Time of day of exposure was also a factor (Muyberg 1978 in Manci et al. 1988).

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

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

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

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

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

Birds

Auditory research conducted on birds indicates that they fall between the reptiles and the mammals relative to hearing sensitivity. According to Dooling (1978), within the range of 1,000 to 5,000 Hz, birds show a level of hearing sensitivity similar to that of the more sensitive mammals. In contrast to mammals,

bird sensitivity falls off at a greater rate to increasing and decreasing frequencies. Passive observations and studies examining aircraft bird strikes indicate that birds nest and forage near airports. Aircraft noise in the vicinity of commercial airports apparently does not inhibit bird presence and use.

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

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

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

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

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

Raptors

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

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

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

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

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

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

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

agitation, and aggressive displays. Adult osprey showed high nest occupancy rates during incubation regardless of external influences. The osprey observed occasionally stared in the direction of the flight before it was audible to the observers. The birds may have been habituated to the noise of the flights; however, overflights were strictly controlled during the experimental period. Strong reactions to float planes and helicopter may have been due to the slower flight and therefore longer duration of visual stimuli rather than noise-related stimuli.

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

Migratory Waterfowl

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

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

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

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

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

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

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

Wading and Shorebirds

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

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

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

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

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

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

Fish, Reptiles, and Amphibians

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

A.3.12.3 Summary

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

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

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

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

Animal responses to aircraft noise appear to be somewhat dependent on, or influenced by, the size, shape, speed, proximity (vertical and horizontal), engine noise, color, and flight profile of planes. Helicopters also appear to induce greater intensities and durations of disturbance behavior as compared to fixed-wing

aircraft. Some studies showed that animals that had been previously exposed to jet aircraft noise exhibited greater degrees of alarm and disturbance to other objects creating noise, such as boats, people, and objects blowing across the landscape. Other factors influencing response to jet aircraft noise may include wind direction, speed, and local air turbulence; landscape structures (i.e., amount and type of vegetative cover); and, in the case of bird species, whether the animals are in the incubation/nesting phase.

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APPENDIX B
NOISE ANALYSIS – NS NORFOLK

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NOISE ANALYSIS

In Support of Environmental Assessment for Transition of HMM-774 to VMM-774, Naval Station Norfolk Chambers Field, Norfolk, Virginia

Final

Prepared for:

Naval Facilities Engineering Command – Atlantic

6506 Hampton Boulevard

Norfolk, VA 23508-1278

July 2015

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Noise Analysis in Support of Environmental Assessment for Transition of HMM-774 to VMM-774, Naval Station Norfolk Chambers Field, Norfolk, Virginia

Final

Contract N62470-10-D-3008, Delivery Order 0092

July 2015

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LIST OF ACRONYMS

°F	degrees Fahrenheit
%QQBPA	Percent Torque
AAD	Annual Average Daily
CPLO	Community Plans and Liaison Officer
dB	Decibel
DLG	Digital Line Graph
DNL	Day-Night Average Sound Level
DOD	Department of Defense
ft	feet
GCA	Ground Controlled Approach
HMM	Marine Medium Helicopter Squadron
ID	Identification
IGE	In Ground Effect
in Hg	inches mercury
ISHP	Indicated Shaft Horsepower
kPa-s/m^2	kilopascal-seconds per square meter
L_{max}	Maximum Sound Level
m	meter
MARFORRES	Marine Forces Reserve
NED	National Elevation Dataset
NS	Naval Station
OGE	Out of Ground Effect
PA	Probability of Awakening
POI	Point of Interest
RNM	Rotorcraft Noise Model
SEL	Sound Exposure Level
T&G	Touch-and-Go
U.S.	United States
USGS	United States Geological Survey
USMCR	United States Marine Corps Reserve
VA	Virginia
VMM	Marine Medium Tiltrotor Squadron

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1.0 INTRODUCTION

The United States (U.S.) Marine Corps Reserve (USMCR) proposes the transition of Marine Medium Helicopter Squadron 774 (HMM-774), currently operating 12 CH-46E aircraft from Naval Station (NS) Norfolk, Virginia (VA), to Marine Medium Tiltrotor Squadron 774 (VMM-774) (operating 12 MV-22B aircraft) following retirement of the CH-46E helicopter, which is nearing the end of its service life.

This noise study is in support of the VMM-774 transition at NS Norfolk, and considers three scenarios: Baseline, No Action, and Proposed Action. For this analysis, the Baseline scenario reflects NS Norfolk operations data taken from NS Norfolk air traffic activity reports from for the last four whole years (2011-2014). The No Action Alternative would include the retirement of 12 CH-46E aircraft, but no replacement MV-22 aircraft at NS Norfolk. The Proposed Action would include replacement of retired CH-46E aircraft with MV-22B aircraft at NS Norfolk. Projected flight operation frequency by MV-22B was determined by Marine Forces Reserve (MARFORRES) staff, with reference to the MV-22B Training and Readiness Manual. Under the Proposed Action, the number of MV-22B operations at NS Norfolk would be the same as the current number of CH-46E operations (in the Baseline), but they would be slightly different in that they would fly different patterns and types of training activities at the airfield.

Section 2 describes the methodology of this study. Section 3 includes the modeling data used and the noise exposure for the Baseline condition. Section 4 includes the modeling data used and the noise exposure for the No Action scenario. Section 5 includes the modeling data used and the noise exposure for the Proposed Action scenario.

2.0 METHODOLOGY

Table 2-1 summarizes the noise model parameters used in this analysis. This analysis utilizes the Department of Defense (DOD) NOISEMAP suite of computer programs (Czech and Plotkin 1998; Wasmer Consulting 2006a, 2006b) containing the core computational programs called “NMAP”, version 7.0, and Rotorcraft Noise Model (RNM) version 7.2.2.

Table 2-1. Noise Modeling Parameters		
Software	**Analysis**	**Version**
NMAP	Fixed wing aircraft	7.0
RNM	Rotorcraft	7.2.2
Parameter	**Description**	
Receiver Grid Spacing	500 ft in x and y	
Metric	DNL	
Basis	AAD Operations	
Topography		
Elevation Data Source	USGS 30m NED	
Elevation Grid Spacing	500 ft in x and y	
Impedance Data Source	USGS Hydrography DLG	
Impedance Grid spacing	500 ft in x and y	
Flow Resistivity of Ground (soft/hard)	225 kPa-s/m^2 / 100,000 kPa-s/m^2	
Modeled Weather (Monthly Averages 2009-2013; April selected)		
Temperature	63 °F	
Relative Humidity	63 %	
Barometric Pressure	30.03 in Hg	

Source: Cardno 2015.
Notes: ft = feet; DNL = Day-Night Average Sound Level; AAD = Annual Average Daily; USGS = U.S. Geological Survey; m = meters; NED = National Elevation Dataset; DLG = Digital Line Graph; kPa-s/m^2 = kilopascal-seconds per square meter; ^{o}F = degrees Fahrenheit; in Hg = inches Mercury.

2.1 Primary Noise Metric and Modeling

Day-Night Average Sound Level (DNL) is the relevant noise metric for this study and is based on annual average daily aircraft operations. DNL is the U.S. Government standard for modeling the cumulative noise exposure and assessing community noise impacts. DNL has two time periods of interest: daytime and nighttime. Daytime hours are from 7:00 a.m. to 10:00 p.m. local time. Nighttime hours are from 10:00 p.m. to 7:00 a.m. local time. DNL weighs operations occurring during its nighttime period by adding 10 decibels (dB) to their single-event sound level. Note that "daytime" and "nighttime" in calculation of DNL are sometimes referred to as "acoustic day" and "acoustic night" and always correspond to the times given above. This is often different than the "day" and "night" used commonly in military aviation, which are directly related to the times of sunrise and sunset, and vary throughout the year with the seasonal changes.

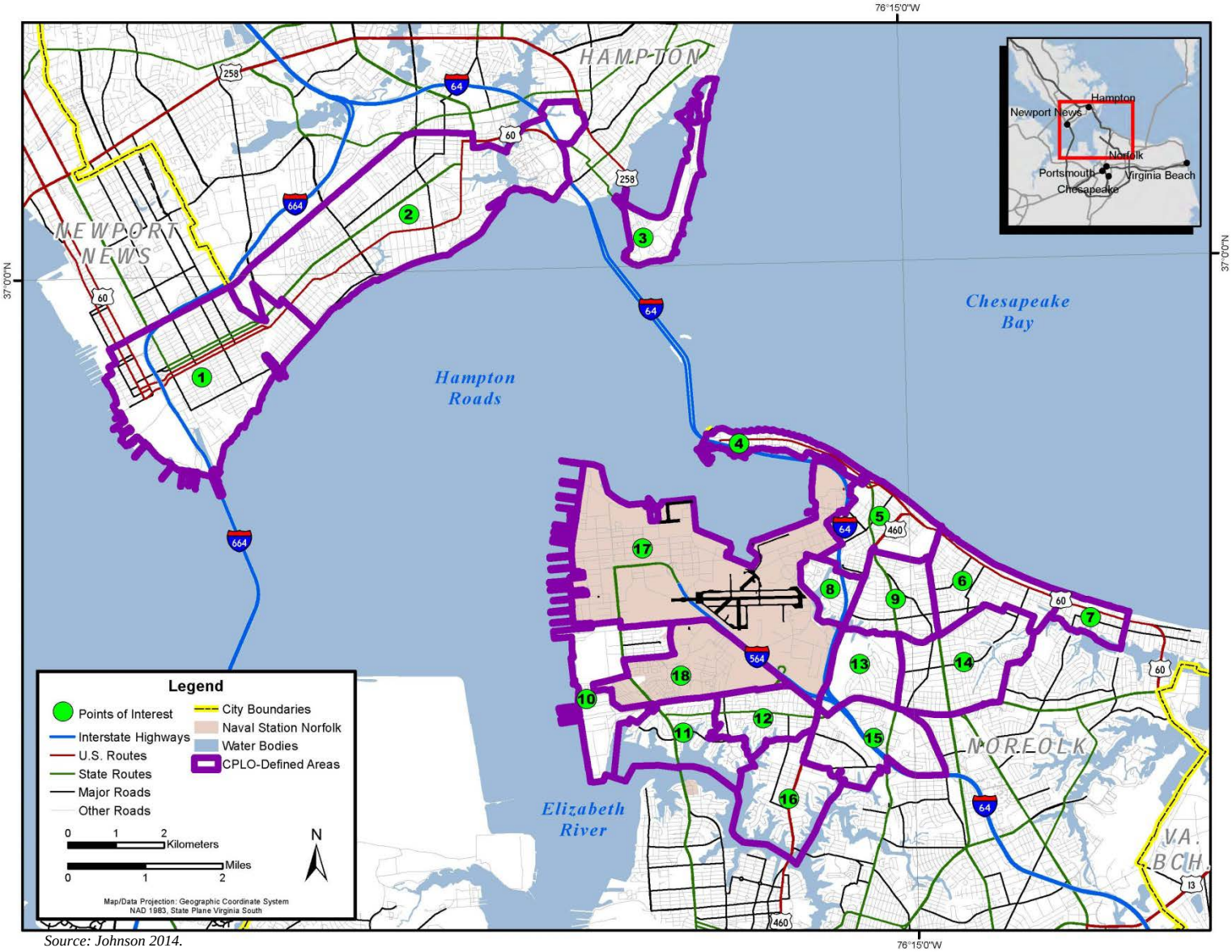
Modeling of noise, using the NOISEMAP software suite, is accomplished by determining and building each aircraft's flight tracks (paths over the ground) and profiles (which include data such as altitude, airspeed, power settings, and other flight conditions). This is combined with information about the numbers of each type of operation by aircraft/track/profile, local climate, ground surrounding the airfield, and similar data related to ground runup of aircraft engines to sum the total noise energy experienced annually at a grid of points on the ground. In this case, as indicated in Table 2-1, that grid spacing was 500 ft. Noise exposure is presented in terms of contours, i.e., lines of equal value, of DNL. DNL contours of 65 to 85 dB, presented in 5-dB increments, provide a graphical depiction of the aircraft noise environment. NOISEMAP's ability to account for the effects of sound propagation includes consideration of terrain elevation, taken from the USGS NED, and ground impedance conditions, taken from USGS Hydrography data. In this case, "soft ground" (e.g., grass-covered ground) is modeled with a flow resistivity of 225 kPa-s/m^2 and "hard ground" (in this case, water) is modeled with a flow resistivity of 100,000 kPa-s/m^2. The modeling does not include the effect of shielding of on-base buildings. For

ambient temperature, humidity, and pressure, each month was assigned a temperature, relative humidty, and barometric pressure from data available for that month for the years 2009 through 2013 (last full year of data available). NOISEMAP then determined and used the month with the weather values that produced the median results in terms of noise propagation effect, which in this case was the month of April (with the values noted in Table 2-1). This modeling process, using the NOISEMAP software suite, is the DOD-accepted method for representing the overall community noise exposure over time. Noise exposure is also presented in terms of DNL at representative Points of Interest (POI). Because of the large number of possible POIs that might include individual schools, hospitals, churches, etc., the surrounding area was broken into U.S. Census tracts, and smaller tracts combined into representative geographic areas. This allows for a diverse sample of points which are spread out relatively evenly by population, such that they are a good surrogate for having hundreds of closely-spaced points representing individual churches, hospitals, schools, and neighborhoods. This process was coordinated closely with the NS Norfolk Community Plans and Liaison Officer (CPLO). The resulting 18 POIs are listed in Table 2-2 and shown in Figure 2-1.

Table 2-2. POIs for NS Norfolk

ID	Description
1	Newport News
2	Hampton
3	Fort Monroe
4	Willoughby
5	West Ocean View
6	East Ocean View
7	Little Creek
8	North Granby
9	Northside
10	Terminal
11	Meadowbrook
12	Wards Corner
13	Central Granby
14	Brentwood
15	Suburban Park
16	South Granby
17	Naval Station
18	Camp Allen

Source: Johnson 2014.



Source: Johnson 2014.

Figure 2-1. POIs in the vicinity of NS Norfolk

3.0 BASELINE CONDITION

The following subsections detail the modeling data and the resultant noise exposure for the Baseline. The Baseline is derived from an average of the historical data in the last four full years (2011-2014) of air activity reports at NS Norfolk Chambers Field.

3.1 MODELING DATA

Table 3-1 details the modeled annual flight operations at NS Norfolk. The Baseline scenario includes 67,317 flight operations per year, about 40% of which are fixed wing (predominantly E-2 and C-2) and 60% rotary wing (predominantly H-60). Fixed wing aircraft (and some of the rotary wing aircraft) use the main runway 10/28, with about 49% in the 28 direction, and 51% in the 10 direction. Additionally, rotary wing aircraft use runway 09/27 and a series of pads on the northern edge of the airfield. The frequency of use for each of the pads and the approach and departure tracks leading to/from each is derived from historical data over the same period (2011-2014) and interviews with NS Norfolk staff conducted in 2014-2015.

Some aircraft (H-53, H-60, and H-46 series) are modeled with the RNM module, and the rest are modeled with NMAP (see chapter 2 for details on version numbers, etc). The outputs of those software modules were then combined into one overall resulting grid to generate the noise contours and other analyses for the Baseline condition. For this effort, new data was used for elevation and hydrography to ensure complete coverage with the latest available data (see chapter 2 for details). Additionally, the newest aircraft noise data for CH-46E, CH-53E (surrogate for MH-53E), and SH-60B (surrogate for MH-60S and HH-60H) were also used.

Table 3-1. Baseline Scenario Annual Flight Operations at NS Norfolk

BASELINE				ARRIVALS														
				Overhead			Straight-In			Main Field Pads			Heliport Pads			Heliport Runway		
		Aircraft	Note	Day (0700-2200)	Night (2200-0700)	TOTAL	Day (0700-2200)	Night (2200-0700)	TOTAL	Day (0700-2200)	Night (2200-0700)	TOTAL	Day (0700-2200)	Night (2200-0700)	TOTAL	Day (0700-2200)	Night (2200-0700)	TOTAL
FW	Based	E-2	1	2,061	437	2,498	811	80	891	-	-	-	-	-	-	-	-	-
	Transient	C-40	2	-	-	-	1,994	306	2,300	-	-	-	-	-	-	-	-	-
		C-5	3	-	-	-	171	26	198	-	-	-	-	-	-	-	-	-
		C-130	4	-	-	-	631	97	728	-	-	-	-	-	-	-	-	-
		FA-18	5	240	37	277	240	37	277	-	-	-	-	-	-	-	-	-
	FW Subtotal			*2,301*	*474*	*2,775*	*3,848*	*546*	*4,394*	-	-	-	-	-	-	-	-	-
RW	Based/Trans	H-60	6	-	-	-	1,328	715	2,043	224	121	345	1,965	1,058	3,023	959	516	1,475
	Based	H-53		-	-	-	295	159	455	50	27	77	1,604	864	2,468	-	-	-
		H-46		-	-	-	273	10	283	111	4	115	-	-	-	845	31	875
TR	Based	MV-22		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	RW/TR Subtotal			-	-	-	*1,896*	*884*	*2,780*	*385*	*152*	*537*	*3,569*	*1,922*	*5,490*	*1,804*	*547*	*2,351*
	TOTAL Operations			**2,301**	**474**	**2,775**	**5,744**	**1,430**	**7,174**	**385**	**152**	**537**	**3,569**	**1,922**	**5,490**	**1,804**	**547**	**2,351**

BASELINE				DEPARTURES						CLOSED PATTERNS						TOTAL OPERATIONS		
				Main Field			Heliport			Visual (T&G)			GCA Box					
		Aircraft	Note	Day (0700-2200)	Night (2200-0700)	TOTAL	Day (0700-2200)	Night (2200-0700)	TOTAL	Day (0700-2200)	Night (2200-0700)	TOTAL	Day (0700-2200)	Night (2200-0700)	TOTAL	Day (0700-2200)	Night (2200-0700)	TOTAL
FW	Based	E-2	1	2,881	508	3,389	-	-	-	9,817	2,022	11,839	1,308	123	1,431	16,877	3,171	20,048
	Transient	C-40	2	1,994	306	2,300	-	-	-	-	-	-	-	-	-	3,988	612	4,600
		C-5	3	171	26	198	-	-	-	-	-	-	-	-	-	342	53	395
		C-130	4	631	97	728	-	-	-	-	-	-	-	-	-	1,262	194	1,456
		FA-18	5	480	74	554	-	-	-	-	-	-	74	11	85	1,034	159	1,193
	FW Subtotal			*6,158*	*1,011*	*7,169*	-	-	-	*9,817*	*2,022*	*11,839*	*1,381*	*135*	*1,516*	*23,505*	*4,187*	*27,692*
																-	-	
RW	Based/Trans	H-60	6	1,552	836	2,388	2,924	1,574	4,498	8,563	4,611	13,174	1,026	553	1,579	18,541	9,983	28,524
	Based	H-53		345	186	531	1,604	864	2,468	-	-	-	229	123	352	4,127	2,222	6,349
		H-46		384	14	398	845	31	875	1,942	-	1,942	263	-	263	4,663	89	4,752
TR	Based	MV-22		-		-			-	-	-	-	-	-	-	-	-	-
	RW/TR Subtotal			*2,281*	*1,035*	*3,317*	*5,372*	*2,469*	*7,841*	*10,506*	*4,611*	*15,117*	*1,518*	*676*	*2,194*	*27,330*	*12,295*	*39,625*
	TOTAL Operations			**8,439**	**2,046**	**10,485**	**5,372**	**2,469**	**7,841**	**20,323**	**6,633**	**26,955**	**2,900**	**810**	**3,710**	**50,835**	**16,482**	**67,317**

Source: Cardno 2015.

Notes:
1. *Includes based C-2A.*
2. *Includes transient C-40, B-737, P-8.*
3. *Includes transient C-5, KC-10, B-767, MD-11, C-17.*
4. *Includes transient T-44, T-6, C-12, P-3, C-144.*
5. *Includes FA-18 series and all transient tactical jets. Modeled as FA-18E.*
6. *Includes based H-60 and all transient helicopters.*
7. *All numbers in table are rounded off to nearest whole number.*
8. *One pattern is counted as two operations.*
9. *T&G = Touch and Go; GCA = Ground Controlled Approach.*
10. *For this table, FW = Fixed Wing; RW = Rotary Wing; TR = Tiltrotor.*

Figure 3-1 shows all of the modeled static run-up profile locations. Consistent with the flight operations, maintenance run-up activity was modeled on an AAD basis. Table 3-2 presents the representative run-up operations profiles (each aircraft profile/location used for these static operations is individually represented in the noise model while the table shows the representative power settings by aircraft type). Note that the MV-22 only appears in the Proposed Action scenario, and the CH-46E only appears in the Baseline scenario.

Table 3-2. Representative Static Profiles

Aircraft Type	Run-up Type	Run-up Profile		
		Power Condition	Power Setting	Power Units
E-2C or C-2A	Low Power	Variable	1500	ISHP
E-2C or C-2A	High Power	Variable	4600	ISHP
CH-46E	Hover Check	Fixed	IGE/OGE	%QQBPA
CH-46E	High Power & Maint Check	Fixed	Ground Max	%QQBPA
MH-53E	Hover Check	Fixed	IGE/OGE	%QQBPA
MH-53E	High Power & Maint Check	Fixed	Ground Max	%QQBPA
H-60	Hover Check	Fixed	IGE	Power
H-60	Maint Check	Fixed	Idle	Power
MV-22B	Hover Check	Fixed	IGE	%QQBPA
MV-22B	Low Power	Fixed	Ground Idle	%QQBPA

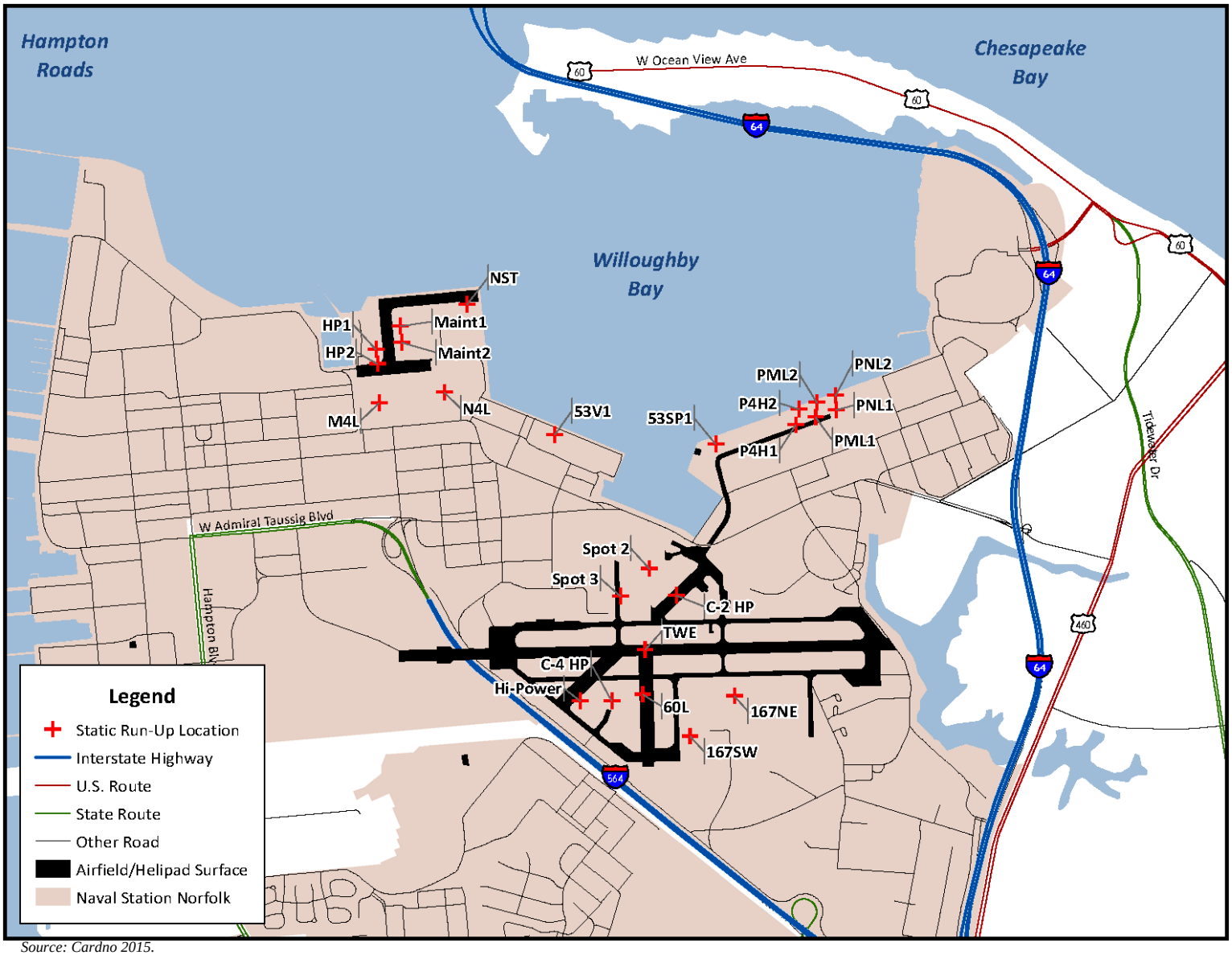
Source: Cardno 2015.
Notes: IGE = In Ground Effect; OGE = Out of Ground Effect; ISHP = Indicated Shaft Horsepower; %QQBPA = percent torque.

3.2 NOISE EXPOSURE

Figure 3-2 shows the resultant 65 dB to 85 dB DNL contours in 5 dB increments for Baseline daily aircraft events. The 65 dB DNL baseline contour extends off base over land just slightly over the industrial area west-southwest of the base, not at all to the south, and up to 3 miles off base to the east. The rest of the area within the baseline 65 dB DNL contour is primarily over water.

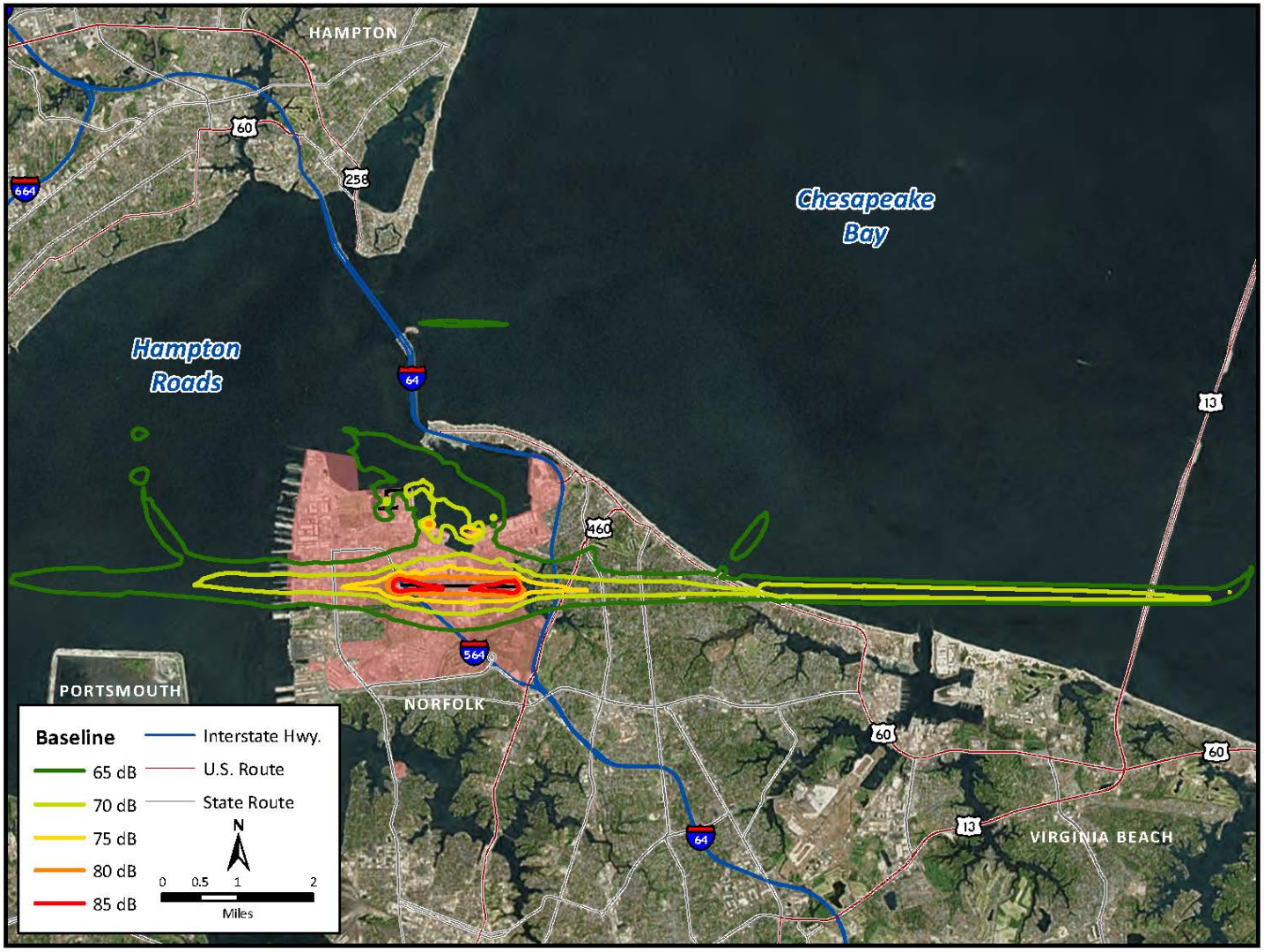
The various long, narrow segments observed in the baseline 65 dB DNL contour are due to closed GCA patterns and various arrival and departure routes to and from NS Norfolk.

The computed DNL for each of the 18 POIs are listed in Table 3-3, which shows that three locations are exposed to DNL greater than or equal to 65 dB with none of them exposed to DNL greater than or equal to 75 dB. POIs #8 and #9 (labeled ‘North Granby’ and ‘North End’, repsectively) are located very near the departure end of runway 10, and each has a baseline DNL of 72.3 dB. For Table 3-3, DNL values are reported to the nearest tenth of a dB. This was done to illustrate the small differences between scenarios and eliminate potential confusion generated by the normal process of rounding off to the nearest dB. Even under laboratory conditions, humans have a hard time detecting a difference of a whole dB, so results such as these are normally rounded off. In this case, the rounded-off numbers may have been misleading, so these values are being reported with more precision than normal.



Source: Cardno 2015.

Figure 3-1. Baseline Static Run-up Locations



Sources: Cardno 2015.

Figure 3-2. Baseline DNL Contours for AAD Aircraft Operations at NS Norfolk

Table 3-3. Baseline DNL at POIs		
ID	**Description**	**DNL (dB)**
1	Newport News	50.6
2	Hampton	45.1
3	Fort Monroe	51.2
4	Willoughby	62.1
5	West Ocean View	60.3
6	East Ocean View	65.9
7	Little Creek	56.4
8	North Granby	72.3
9	Northside	72.3
10	Terminal	54.8
11	Meadowbrook	52.6
12	Wards Corner	54.5
13	Central Granby	56.2
14	Brentwood	51.3
15	Suburban Park	48.8
16	South Granby	46.3
17	Naval Station	60.6
18	Camp Allen	58.1

Source: Cardno 2015.

4.0 NO ACTION SCENARIO

The following section details the modeling data and the resultant noise exposure for the No Action scenario, in which the CH-46E aircraft would be retired from NS Norfolk, but would not be replaced by MV-22B aircraft. All other aircraft operations are unchanged from those described in Section 3, Baseline Conditions.

4.1 MODELING DATA

Table 4-1 details the annual flight operations at NS Norfolk under the No Action scenario. This scenario's annual flight operations are similar to those in the Baseline scenario (refer to Table 3-1), except it excludes the 4,752 CH-46E operations from the Baseline scenario, making the No Action scenario total 61,049 operations. Additionally, all CH-46E static run-ups are also eliminated from the No Action scenario. All other flight and static operations remain unchanged from the Baseline.

Runway and track utilization for the remaining aircraft are identical to the Baseline scenario.

4.2 NOISE EXPOSURE

Figure 4-1 shows the resultant 65 dB to 85 dB DNL contours in 5 dB increments for No Action daily flight events. The noise exposure is almost identical to the Baseline scenario. Note that the dashed colored lines represent the noise contours for the No Action scenario, while the underlying grey lines represent the noise contours for the Baseline scenario. It is clear that the existing CH-46E activities do not contribute noticeably to the noise environment around NS Norfolk.

Table 4-2 lists the computed DNL for each of the 18 POIs under the No Action scenario, in addition to the change in DNL at each of those points, as compared to the Baseline scenario. Changing from Baseline to No Action (by removing the CH-46E static run-up and flight activities from Chambers Field) does not reduce the DNL at any of the POIs at a level detectable to the human ear.

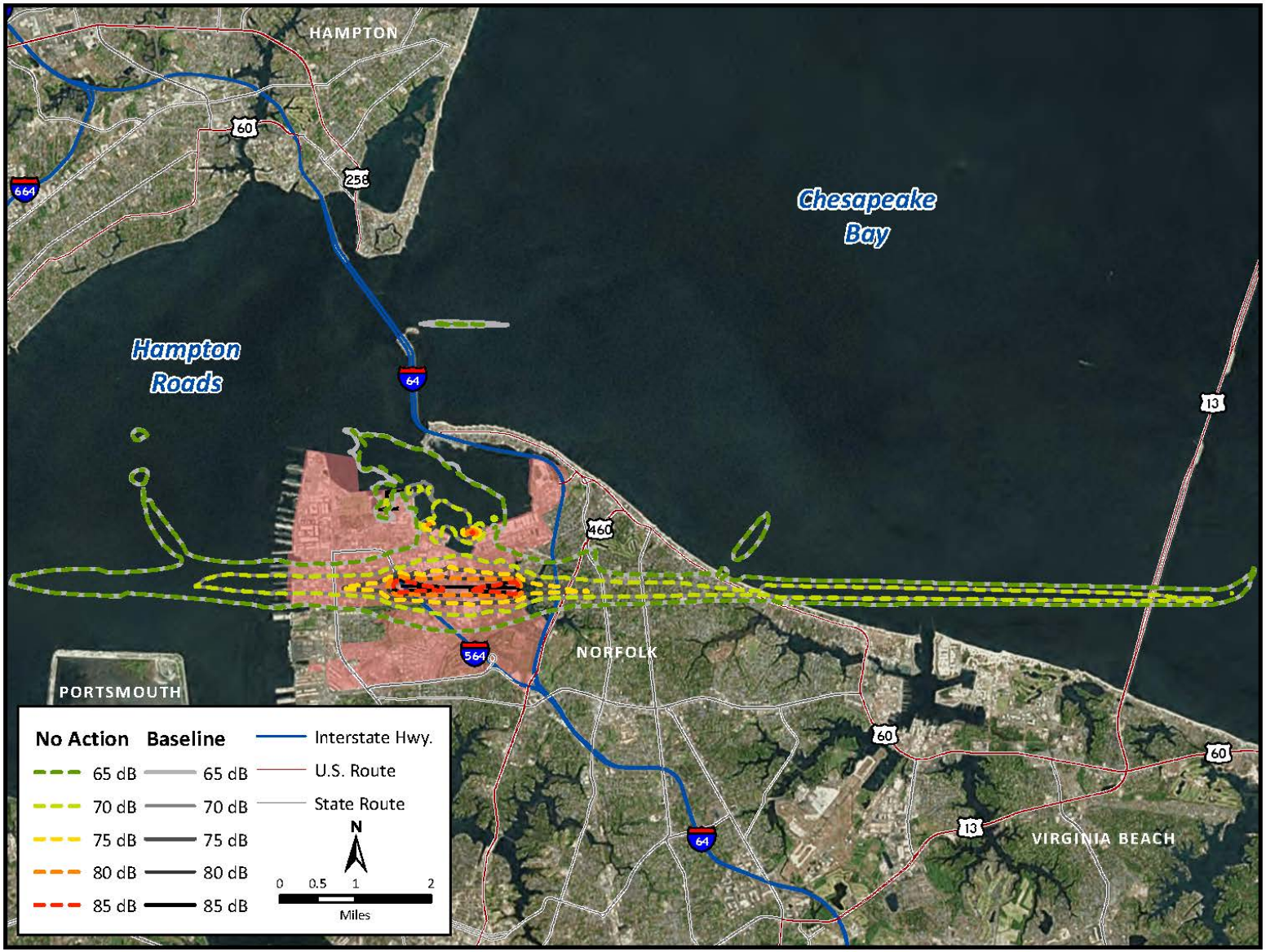
Table 4-1. No Action Scenario Annual Flight Operations at NS Norfolk

NO ACTION				ARRIVALS														
				Overhead			Straight-In			Main Field Pads			Heliport Pads			Heliport Runway		
		Aircraft	Note	Day (0700-2200)	Night (2200-0700)	TOTAL	Day (0700-2200)	Night (2200-0700)	TOTAL	Day (0700-2200)	Night (2200-0700)	TOTAL	Day (0700-2200)	Night (2200-0700)	TOTAL	Day (0700-2200)	Night (2200-0700)	TOTAL
FW	Based	E-2	1	2,061	437	2,498	811	80	891	-	-	-	-	-	-	-	-	-
	Transient	C-40	2	-	-	-	1,994	306	2,300	-	-	-	-	-	-	-	-	-
		C-5	3	-	-	-	171	26	198	-	-	-	-	-	-	-	-	-
		C-130	4	-	-	-	631	97	728	-	-	-	-	-	-	-	-	-
		FA-18	5	240	37	277	240	37	277	-	-	-	-	-	-	-	-	-
	FW Subtotal			*2,301*	*474*	*2,775*	*3,848*	*546*	*4,394*	-	-	-	-	-	-	-	-	-
RW	Based/Trans	H-60	6	-	-	-	1,328	715	2,043	224	121	345	1,965	1,058	3,023	959	516	1,475
	Based	H-53		-	-	-	295	159	455	50	27	77	1,604	864	2,468	-	-	-
		H-46		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TR	Based	MV-22		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	RW/TR Subtotal			-	-	-	*1,623*	*874*	*2,497*	*274*	*148*	*422*	*3,569*	*1,922*	*5,490*	*959*	*516*	*1,475*
	TOTAL Operations			**2,311**	**442**	**2,754**	**5,481**	**1,388**	**6,870**	**274**	**148**	**422**	**3,569**	**1,922**	**5,490**	**959**	**516**	**1,475**

NO ACTION				DEPARTURES						CLOSED PATTERNS						TOTAL OPERATIONS		
				Main Field			Heliport			Visual (T&G)			GCA Box					
		Aircraft	Note	Day (0700-2200)	Night (2200-0700)	TOTAL	Day (0700-2200)	Night (2200-0700)	TOTAL	Day (0700-2200)	Night (2200-0700)	TOTAL	Day (0700-2200)	Night (2200-0700)	TOTAL	Day (0700-2200)	Night (2200-0700)	TOTAL
FW	Based	E-2	1	2,881	508	3,389	-	-	-	9,817	2,022	11,839	1,308	123	1,431	16,877	3,171	20,048
	Transient	C-40	2	1,994	306	2,300	-	-	-	-	-	-	-	-	-	3,988	612	4,600
		C-5	3	171	26	198	-	-	-	-	-	-	-	-	-	342	53	395
		C-130	4	631	97	728	-	-	-	-	-	-	-	-	-	1,262	194	1,456
		FA-18	5	480	74	554	-	-	-	-	-	-	74	11	85	1,034	159	1,193
	FW Subtotal			*6,158*	*1,011*	*7,169*	-	-	-	*9,817*	*2,022*	*11,839*	*1,381*	*135*	*1,516*	*23,505*	*4,187*	*27,692*
																-	-	
RW	Based/Trans	H-60	6	1,552	836	2,388	2,924	1,574	4,498	8,563	4,611	13,174	1,026	553	1,579	18,541	9,983	28,524
	Based	H-53		345	186	531	1,604	864	2,468	-	-	-	229	123	352	4,127	2,222	6,349
		H-46		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TR	Based	MV-22		-		-			-	-	-	-	-	-	-	-	-	-
	RW/TR Subtotal			*1,897*	*1,021*	*2,919*	*4,528*	*2,438*	*6,965*	*8,563*	*4,611*	*13,174*	*1,255*	*676*	*1,931*	*22,667*	*12,206*	*34,873*
	TOTAL Operations			**8,076**	**1,969**	**10,045**	**4,528**	**2,438**	**6,965**	**17,194**	**6,388**	**23,582**	**2,646**	**801**	**3,447**	**45,037**	**16,012**	**61,049**

Source: Cardno 2015.

Notes:
1. *Includes based C-2A.*
2. *Includes transient C-40, B-737, P-8.*
3. *Includes transient C-5, KC-10, B-767, MD-11, C-17.*
4. *Includes transient T-44, T-6, C-12, P-3, C-144.*
5. *Includes FA-18 series and all transient tactical jets. Modeled as FA-18E.*
6. *Includes based H-60 and all transient helicopters.*
7. *All numbers in table are rounded off to nearest whole number.*
8. *One pattern is counted as two operations.*
9. *For this table, FW = Fixed Wing; RW = Rotary Wing; TR = Tiltrotor.*



Source: Cardno 2015.

Figure 4-1. No Action DNL Contours for AAD Aircraft Operations at NS Norfolk (compared to the Baseline)

Table 4-2. No Action DNL at POIs			
ID	**Description**	**DNL (dB)**	**Change in DNL compared Baseline (dB)**
1	Newport News	50.5	-0.1
2	Hampton	45.0	-0.1
3	Fort Monroe	51.1	-0.1
4	Willoughby	62.0	0
5	West Ocean View	60.3	0
6	East Ocean View	65.9	0
7	Little Creek	56.4	0
8	North Granby	72.3	0
9	Northside	72.3	0
10	Terminal	54.7	0
11	Meadowbrook	52.6	0
12	Wards Corner	54.5	0
13	Central Granby	56.2	0
14	Brentwood	51.2	0
15	Suburban Park	48.8	0
16	South Granby	46.3	0
17	Naval Station	60.6	0
18	Camp Allen	58.1	0

Sources: Cardno 2015.

5.0 PROPOSED ACTION SCENARIO

The following section details the modeling data and the resultant noise exposure for the Proposed Action scenario, in which the CH-46E aircraft would be retired from NS Norfolk, and would be replaced by MV-22B aircraft. All other aircraft operations are unchanged from those described in Section 3, Baseline Conditions.

5.1 MODELING DATA

Table 5-1 details the annual flight operations at NS Norfolk under the Proposed Action scenario. The annual flight operations for the Proposed Action would be similar to the Baseline scenario (refer to Table 3-1), except it excludes the 4,752 CH-46E flight operations and adds in the proposed 4,752 MV-22B flight operations. Additionally, the CH-46E static run-up operations have been eliminated, and the appropriate MV-22B static run-up operations have been added to the scenario. All other flight and static operations remain unchanged from the Baseline.

New flight tracks and profiles were added to the model for this scenario to accommodate the flight characteristics of the MV-22B. Figure 5-1 depicts the flight tracks modeled for the MV-22B at NS Norfolk Chambers Field. There are arrival, departure, and a variety of GCA tracks that mimic other aircraft use of Chambers Field, as well as new flight tracks for closed visual patterns for the MV-22B in both Airplane and Conversion modes. MV-22B closed patterns to runway 28 were maintained as “left” patterns, where appropriate, to more closely simulate shipboard recovery, rather than make those patterns to the north (over water), similar to many of the existing helicopter patterns. Profile data (altitudes, airspeeds, power settings) for MV-22B were initially taken from the existing MV-22B profiles in the noise model for Marine Corps Air Station New River, then modified slightly (where applicable) for the local course rules (pattern altitudes, etc) at NS Norfolk, after consultation with experts at MARFORRES and NS Norfolk Chambers Field Air Traffic Control. Runway and track utilization for the remaining aircraft are identical to the Baseline scenario.

5.2 NOISE EXPOSURE

Figure 5-2 shows the resultant 65 dB to 85 dB DNL contours in 5 dB increments for the Proposed Action daily flight events. The noise exposure is almost identical to the No Action scenario. Note that the dashed colored lines represent the noise contours for the Proposed Action scenario, while the underlying grey lines represent the noise contours for the No Action scenario. It is clear that addition of the MV-22B activities do not contribute noticeably to the noise environment around NS Norfolk.

Figure 5-3 shows the same resultant contours (for the Proposed Action scenario), compared against the Baseline scenario, for those who are interested in comparing the projected future noise contours against the “existing conditions” of the last four years, represented by the Baseline in this study. Again, there is very little difference.

Figure 5-4 shows the Proposed Action results in a gradient format, which shows more of what is happening with the noise contours and why. Some of the tracks that do not individually result in creating areas greater than 65 dB DNL can be seen to cross, producing small “islands” with DNL exposure that rises above 65 dB. These areas are over water, and so are not particularly relevant, but this view better shows the reasons for the small 65 dB “islands”.

Table 5-2 lists the computed DNL for each of the 18 POIs under the Proposed Action, in addition to the change in DNL at each of those points, as compared to the No Action, as well as the Baseline conditions. Changing from No Action to Proposed Action (by adding in the MV-22 static run-up and flight activities) does not change the DNL at any of the POIs to a level detectable to the human ear.

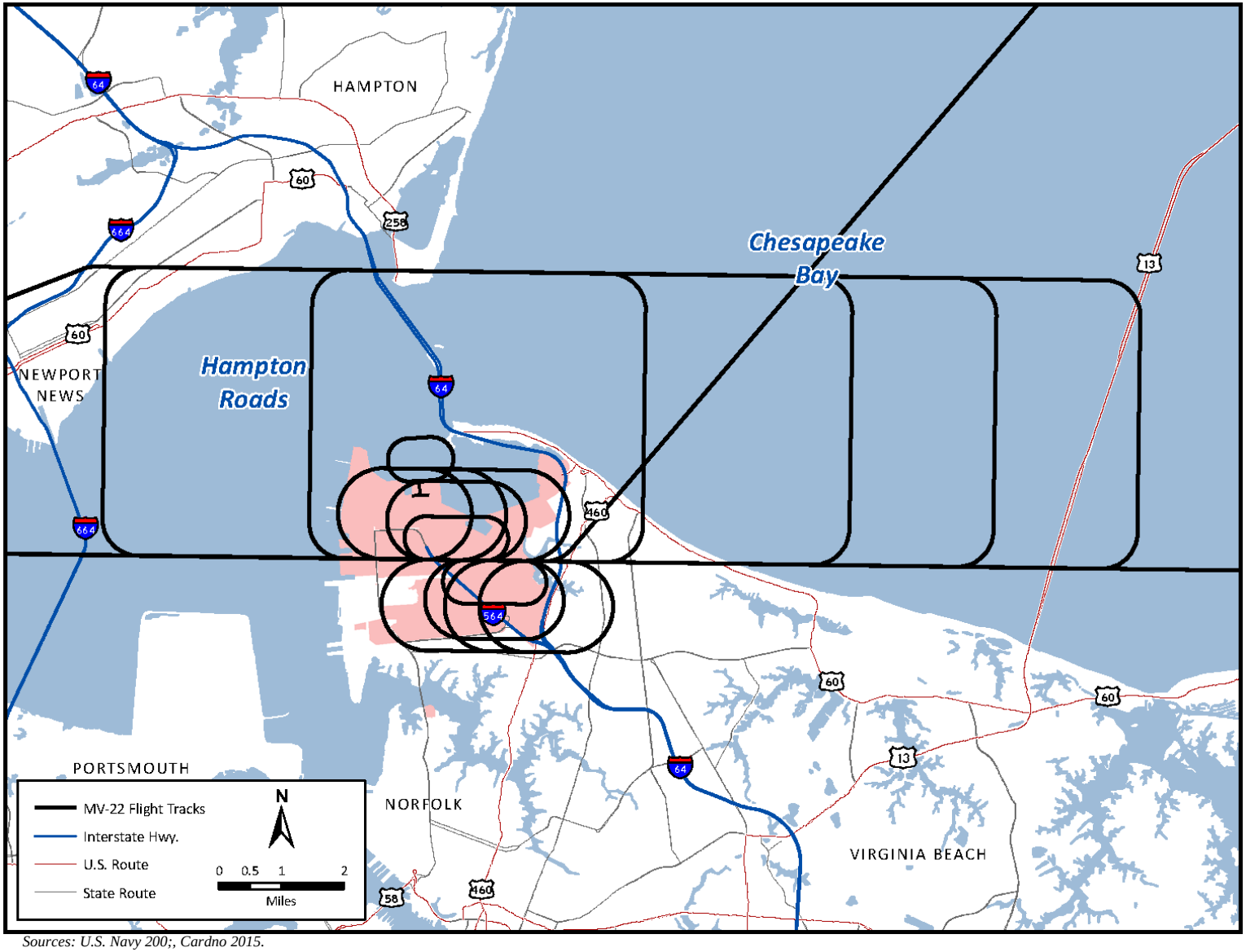
Table 5-1. Proposed Action Annual Flight Operations for NS Norfolk

PROPOSED ACTION				ARRIVALS														
				Overhead			Straight-In			Main Field Pads			Heliport Pads			Heliport Runway		
		Aircraft	Note	Day (0700-2200)	Night (2200-0700)	TOTAL	Day (0700-2200)	Night (2200-0700)	TOTAL	Day (0700-2200)	Night (2200-0700)	TOTAL	Day (0700-2200)	Night (2200-0700)	TOTAL	Day (0700-2200)	Night (2200-0700)	TOTAL
FW	Based	E-2	1	2,061	437	2,498	811	80	891	-	-	-	-	-	-	-	-	-
	Transient	C-40	2	-	-	-	1,994	306	2,300	-	-	-	-	-	-	-	-	-
		C-5	3	-	-	-	171	26	198	-	-	-	-	-	-	-	-	-
		C-130	4	-	-	-	631	97	728	-	-	-	-	-	-	-	-	-
		FA-18	5	240	37	277	240	37	277	-	-	-	-	-	-	-	-	-
	FW Subtotal			*2,301*	*474*	*2,775*	*3,848*	*546*	*4,394*	-	-	-	-	-	-	-	-	-
RW	Based/Trans	H-60	6	-	-	-	1,328	715	2,043	224	121	345	1,965	1,058	3,023	959	516	1,475
	Based	H-53		-	-	-	295	159	455	50	27	77	1,604	864	2,468	-	-	-
		H-46		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TR	Based	MV-22	7	399	33	432	244	20	264	-	-	-	-	-	-	-	-	-
	RW/TR Subtotal			*399*	*33*	*432*	*1,867*	*894*	*2,761*	*274*	*148*	*422*	*3,569*	*1,922*	*5,490*	*959*	*516*	*1,475*
	TOTAL Operations			**2,700**	**507**	**3,207**	**5,715**	**1,440**	**7,155**	**274**	**148**	**422**	**3,569**	**1,922**	**5,490**	**959**	**516**	**1,475**

PROPOSED ACTION				DEPARTURES						CLOSED PATTERNS						TOTAL OPERATIONS		
				Main Field			Heliport			Visual (T&G)			GCA Box					
		Aircraft	Note	Day (0700-2200)	Night (2200-0700)	TOTAL	Day (0700-2200)	Night (2200-0700)	TOTAL	Day (0700-2200)	Night (2200-0700)	TOTAL	Day (0700-2200)	Night (2200-0700)	TOTAL	Day (0700-2200)	Night (2200-0700)	TOTAL
FW	Based	E-2	1	2,881	508	3,389	-	-	-	9,817	2,022	11,839	1,308	123	1,431	16,877	3,171	20,048
	Transient	C-40	2	1,994	306	2,300	-	-	-	-	-	-	-	-	-	3,988	612	4,600
		C-5	3	171	26	198	-	-	-	-	-	-	-	-	-	342	53	395
		C-130	4	631	97	728	-	-	-	-	-	-	-	-	-	1,262	194	1,456
		FA-18	5	480	74	554	-	-	-	-	-	-	74	11	85	1,034	159	1,193
	FW Subtotal			*6,158*	*1,011*	*7,169*	-	-	-	*9,817*	*2,022*	*11,839*	*1,381*	*135*	*1,516*	*23,505*	*4,187*	*27,692*
																-	-	
RW	Based/Trans	H-60	6	1,552	836	2,388	2,924	1,574	4,498	8,563	4,611	13,174	1,026	553	1,579	18,541	9,983	28,524
	Based	H-53		345	186	531	1,604	864	2,468	-	-	-	229	123	352	4,127	2,222	6,349
		H-46		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TR	Based	MV-22	7	643	53	696	-	-	-	2,706	222	2,928	399	33	432	4,392	360	4,752
	RW/TR Subtotal			*2,540*	*1,074*	*3,615*	*4,528*	*2,438*	*6,965*	*11,269*	*4,833*	*16,102*	*1,654*	*709*	*2,363*	*27,059*	*12,566*	*39,625*
	TOTAL Operations			**8,698**	**2,085**	**10,783**	**4,528**	**2,438**	**6,965**	**21,086**	**6,854**	**27,941**	**3,036**	**843**	**3,879**	**50,564**	**16,753**	**67,317**

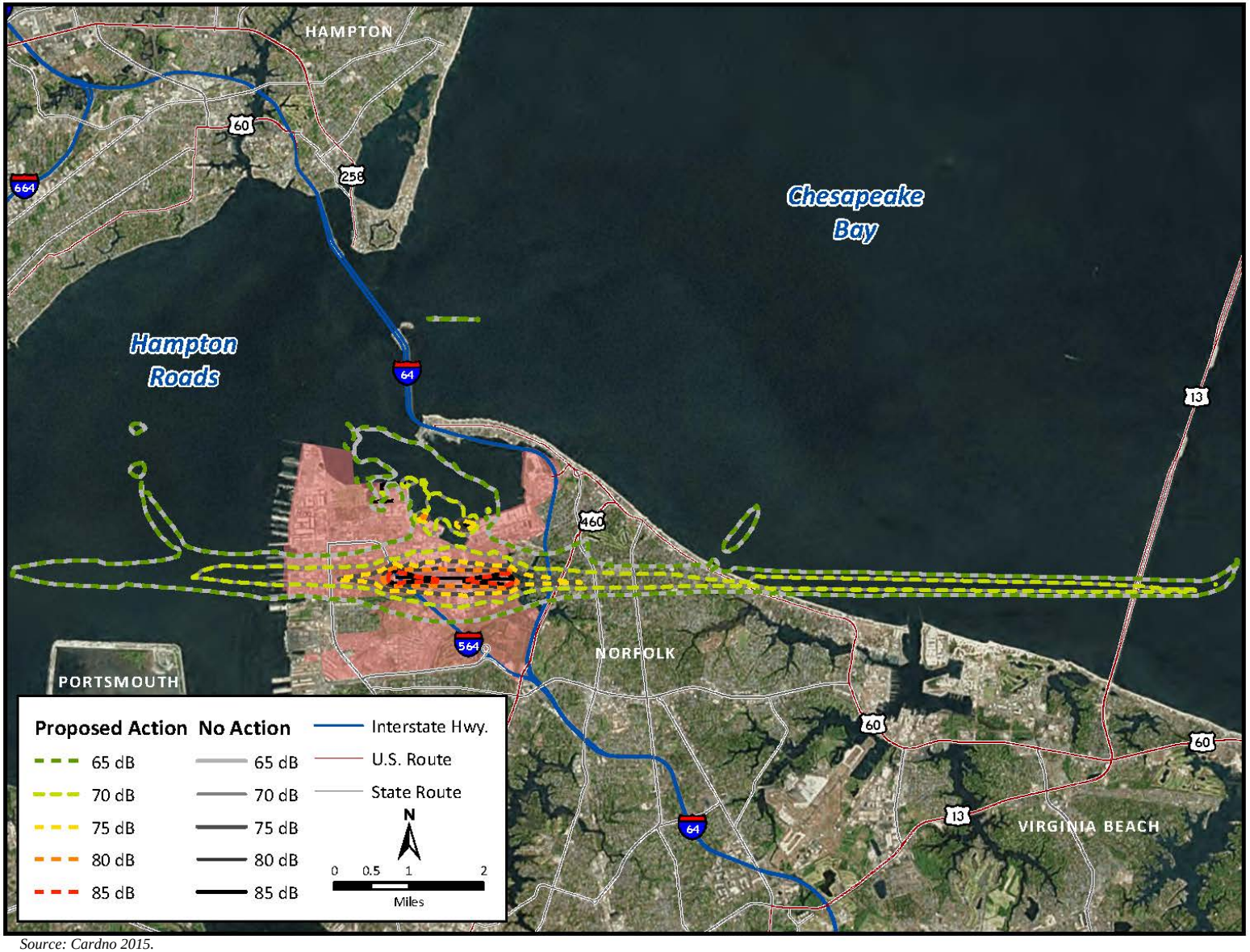
Source: *Cardno 2015.*

Notes:
1. Includes based C-2A.
2. Includes transient C-40, B-737, P-8.
3. Includes transient C-5, KC-10, B-767, MD-11, C-17.
4. Includes transient T-44, T-6, C-12, P-3, C-144.
5. Includes FA-18 series and all transient tactical jets. Modeled as FA-18E.
6. Includes based H-60 and all transient helicopters.
7. Visual Closed Patterns columns include MV-22 Field Carrier Landing Practice to runway 09.
8. All numbers in table are rounded off to nearest whole number.
9. One pattern is counted as two operations.
10. For this table, FW = Fixed Wing; RW = Rotary Wing; TR = Tiltrotor.



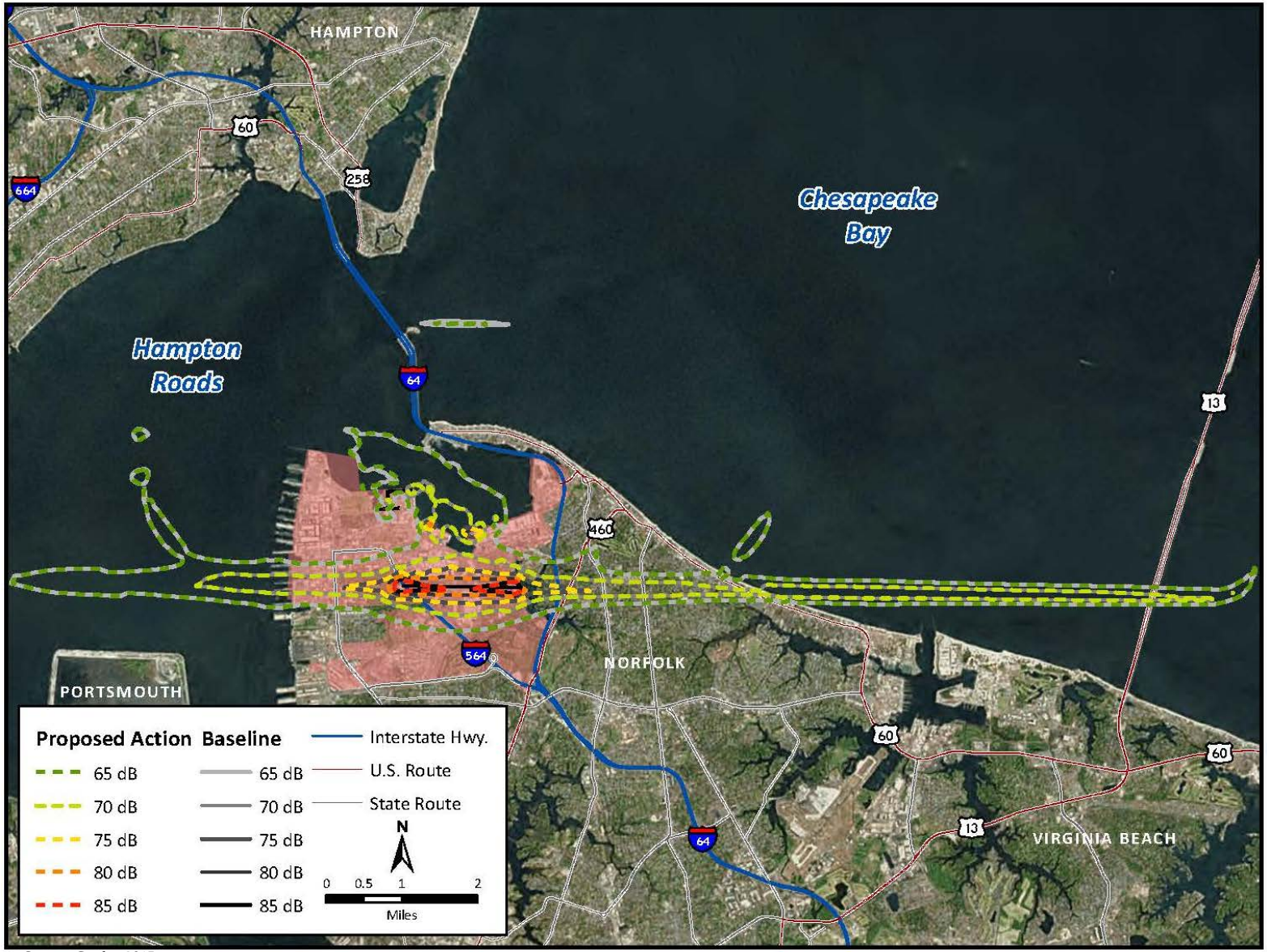
Sources: U.S. Navy 200;, Cardno 2015.

Figure 5-1. Flight Tracks Modeled for MV-22 Operations at NS Norfolk Chambers Field



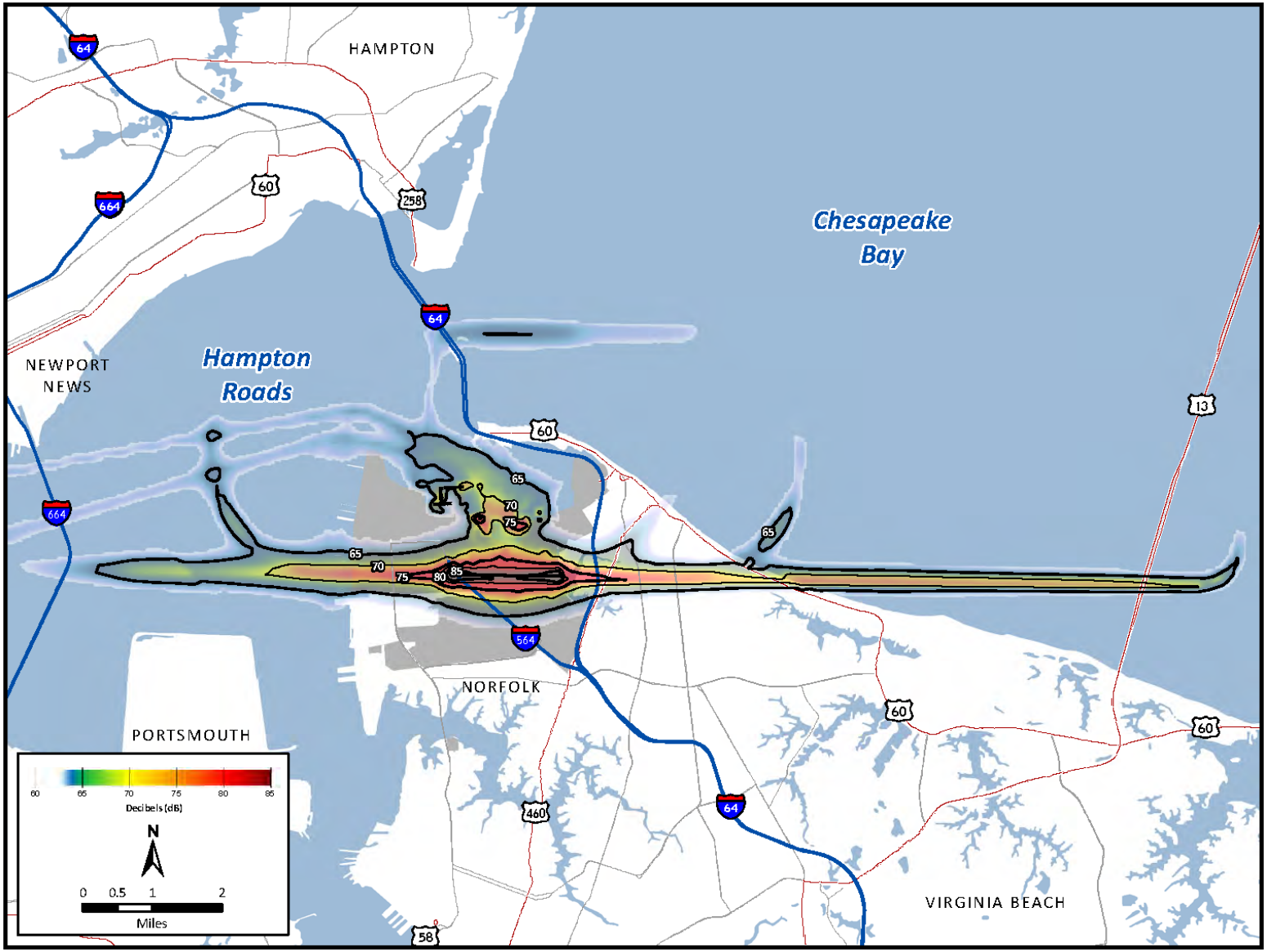
Source: Cardno 2015.

Figure 5-2. Proposed Action DNL Contours for AAD Aircraft Operations at NS Norfolk (compared to the No Action)



Source: Cardno 2015.

Figure 5-3. Proposed Action DNL Contours for AAD Aircraft Operations at NS Norfolk (compared to the Baseline)



Source: Cardno 2015.

Figure 5-4. Proposed Action DNL Gradient Shading for AAD Aircraft Operations at NS Norfolk

Table 5-2. Proposed Action DNL at POIs				
ID	**Description**	**DNL (dB)**	**Change in DNL compared to No Action (dB)**	**Change in DNL compared to Baseline (dB)**
1	Newport News	50.5	0	-0.1
2	Hampton	45.1	0.1	0
3	Fort Monroe	51.2	0.1	0
4	Willoughby	62.1	0.1	0.1
5	West Ocean View	60.3	0	0
6	East Ocean View	65.9	0	0
7	Little Creek	56.4	0	0
8	North Granby	72.3	0	0
9	Northside	72.3	0	0
10	Terminal	54.8	0	0
11	Meadowbrook	52.6	0	0
12	Wards Corner	54.5	0.1	0.1
13	Central Granby	56.3	0.1	0
14	Brentwood	51.3	0.1	0
15	Suburban Park	48.9	0.1	0.1
16	South Granby	46.4	0.1	0
17	Naval Station	60.7	0.1	0.1
18	Camp Allen	58.2	0	0

Source: Cardno 2015.

6.0 SINGLE-EVENT METRICS

Two metrics are typically used to characterize the noise during single events (i.e, an aircraft operation): maximum sound level (L_{max}) and Sound Exposure Level (SEL). L_{max} is the maximum sound level that occurs over a fraction of a second and is important in judging if a sound event would interfere with conversation, TV watching, or other activities. SEL represents the total sound energy in an event and includes the maximum and all lower noise levels produced as part of the event. It does not represent the sound heard at any given time during the event, but rather the sound of the entire event. SEL provides a better measure of an aircraft flyover noise exposure than L_{max} alone. Both L_{max} and SEL are discussed in more detail in Appendix A.

Single event noise modeling was performed to provide a comparison of the expected noise exposure for three representative airfield operations: a GCA Box pattern at Runway 10, a departure from Runway 10, and a touch-and-go pattern at Runway 09. As stated previously, the MV-22B operates differently than the CH-46E it is replacing; therefore, the flight profile used during the modeling scenario for each of these operations was specific to the aircraft and the way each aircraft would fly that event. Values for L_{max} and SEL were calculated for selected POIs (those closest to the flight track with the greatest potential for effect) for each of these representative airfield operations. This method allows the reader to compare the noise experience as it is expected to occur in the real world, vice modeling both aircraft with the same generic flight profile. The single event results are described for each representative airfield operation in the following sections.

6.1 GCA BOX PATTERN

Figure 6-1 depicts the flight tracks used for the two aircraft flying a GCA Box pattern to Runway 10 at NS Norfolk. Also depicted on the figure are the four representative POIs, those closest to the flight tracks, for which L_{max} and SEL are calculated. The metric results are shown in **Table 6-1**. For the representative GCA Box comparison, the calculated metrics at the sample POIs show that the observer would experience lower SEL and L_{max} for the MV-22B pattern than would be experienced for the CH-46E pattern at POIs 3, 5, and 9. At POI 10, the MV-22 pattern results in higher SEL and L_{max} values.

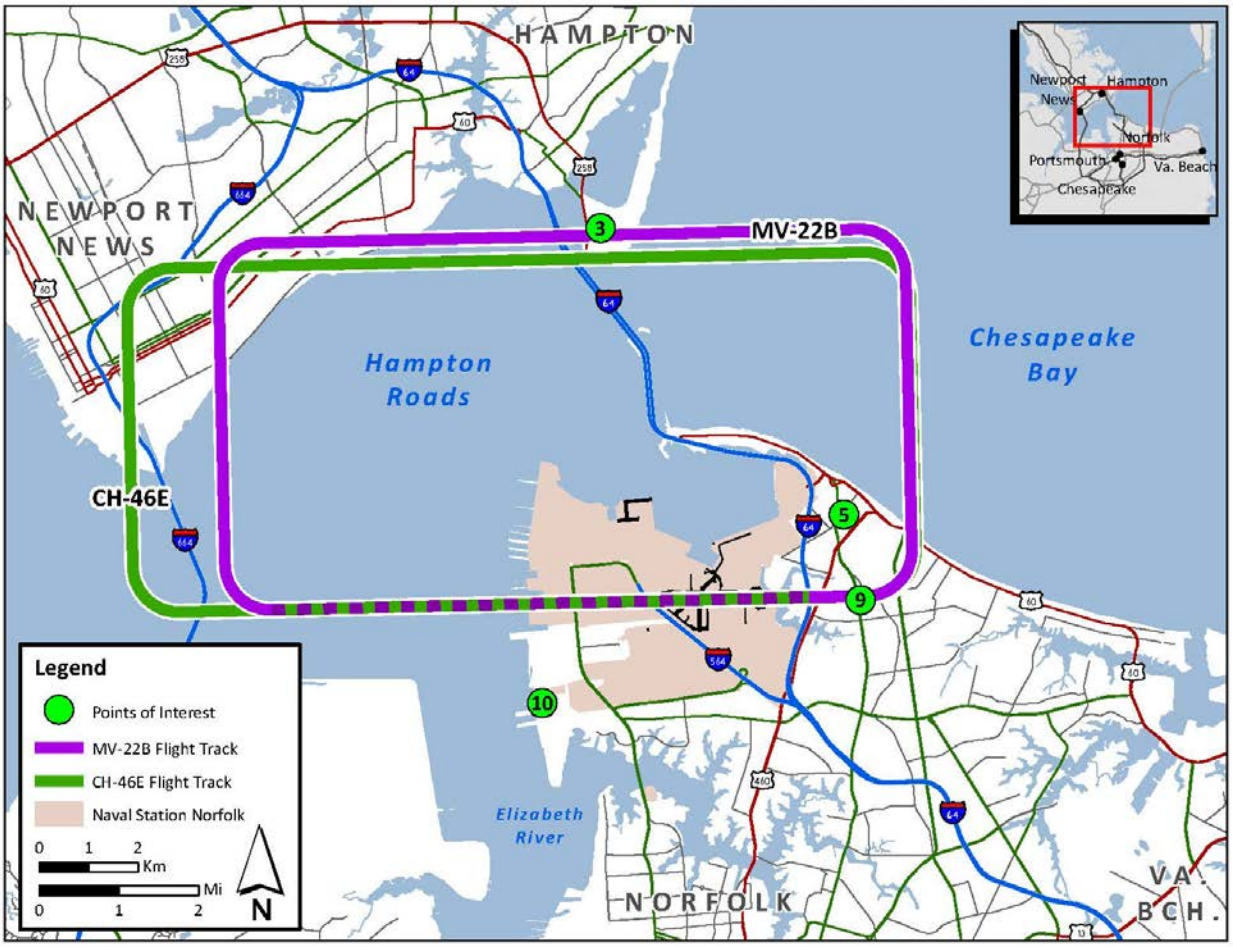


Figure 6-1 Representative GCA Box Pattern Flight Tracks

Table 6-1. Single Event Metrics for Representative GCA Box Pattern				
	CH-46E		MV-22B	
POI	SEL	L_{max}	SEL	L_{max}
3	82.2	67.9	78.0	65.6
5	77.1	65.2	74.1	54.7
9	97.8	90.4	93.9	84.5
10	69.2	51.6	73.5	58.95

6.2 DEPARTURE FROM RUNWAY 10

Figure 6-2 depicts the departure flight track used for the two aircraft flying a normal departure from Runway 10 at NS Norfolk. Note that in this case, the flight tracks (path over the ground) are the same, although the profiles (power settings, speeds, etc) are still different for the two aircraft. Also depicted on the figure are the four representative POIs, those closest to the flight track, for which SEL and L_{max} are calculated. The metric results are shown in **Table 6-2**. For the representative departure comparison, all of the points show that the observer would experience lower SEL and L_{max} for the MV-22B departure than would be experienced for the CH-46E departure. The decreases are expected to be noticeable; L_{max}

decreases between 6 and 11 dB and SEL decreases between 7 and 11 dB, depending on the POI. This is largely due to the fact that the CH-46E flies slower and lower, while the MV-22B accelerates and climbs much more like a fixed-wing aircraft. Increased altitude tends to reduce the noise experienced directly below or near the flight track.

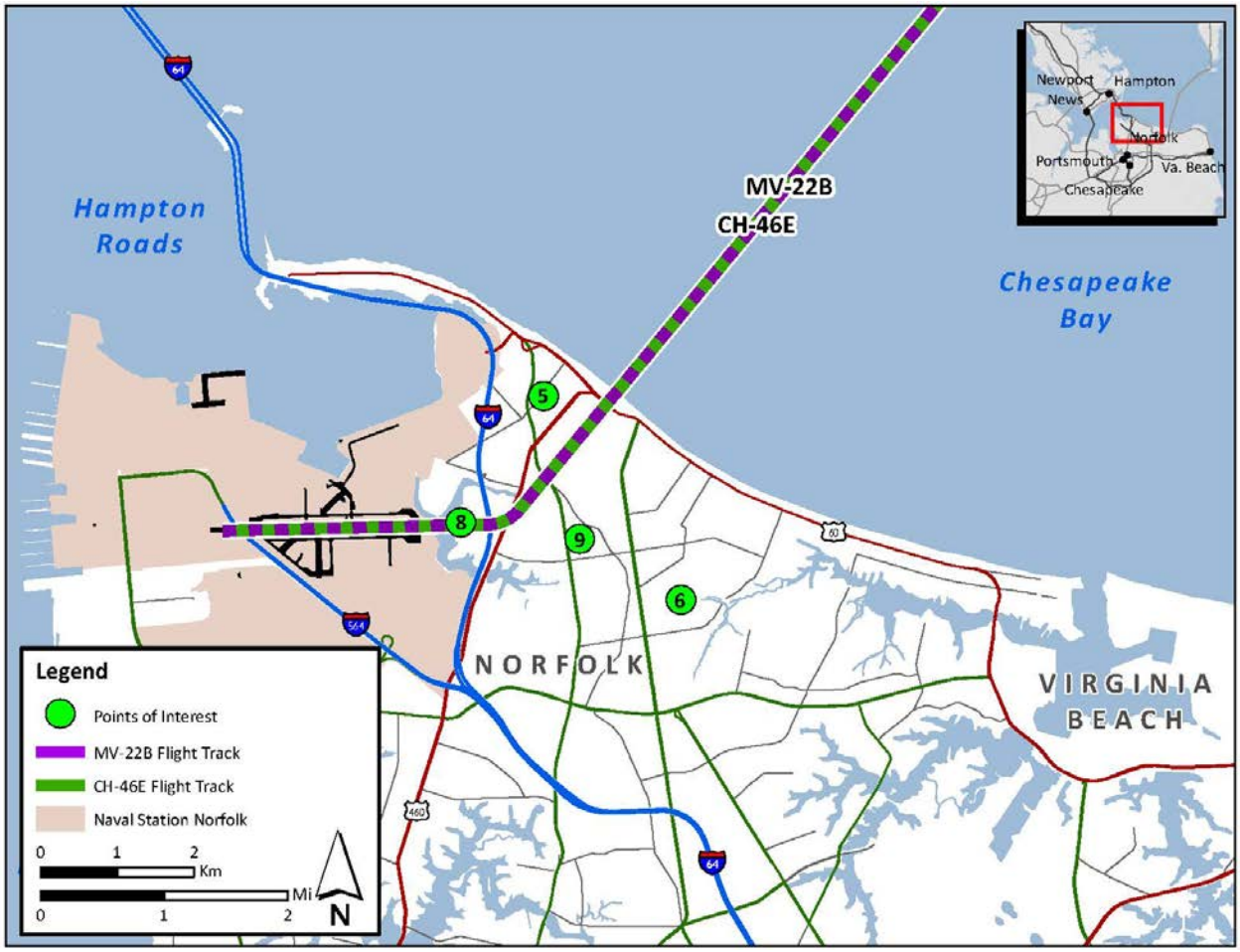


Figure 6-2 Representative Departure Flight Tracks

Table 6-2. Single Event Metrics for Representative Departure from Runway 10				
	CH-46E		MV-22B	
POI	SEL	L_{max}	SEL	L_{max}
5	79.4	65.9	72.3	59.7
6	73.4	58.6	62.6	47.8
8	92.5	82.9	82.5	74.1
9	78.8	66.7	69.4	57.1

6.3 TOUCH-AND-GO PATTERN

Figure 6-3 depicts a Touch-and-Go Pattern at Runway 09 for both aircraft at NS Norfolk. Also depicted on the figure are the four representative POIs, those closest to the flight tracks, for which SEL and L_{max} are calculated. The metric results are shown in **Table 6-3**. For the touch-and-go pattern comparison, all of the points show that the observer would experience greater SEL and L_{max} for the MV-22B than would be experienced for the CH-46E. The low altitude of the CH-46E tends to mean that less of that noise can propagate across the greater ground distance and thus there is less noise experienced at points further from the track. At POIs 5 and 8, the increases in L_{max}, while numerically large, may or may not be particularly noticeable in an active airfield environment. At POI 4, the SEL and L_{max} changes of 4-5 dB may be noticeable on a single event basis. At the more distant POI 10, there is also a difference, but the resulting SEL and L_{max} values are small enough that they may not be noticeable in an airfield environment.

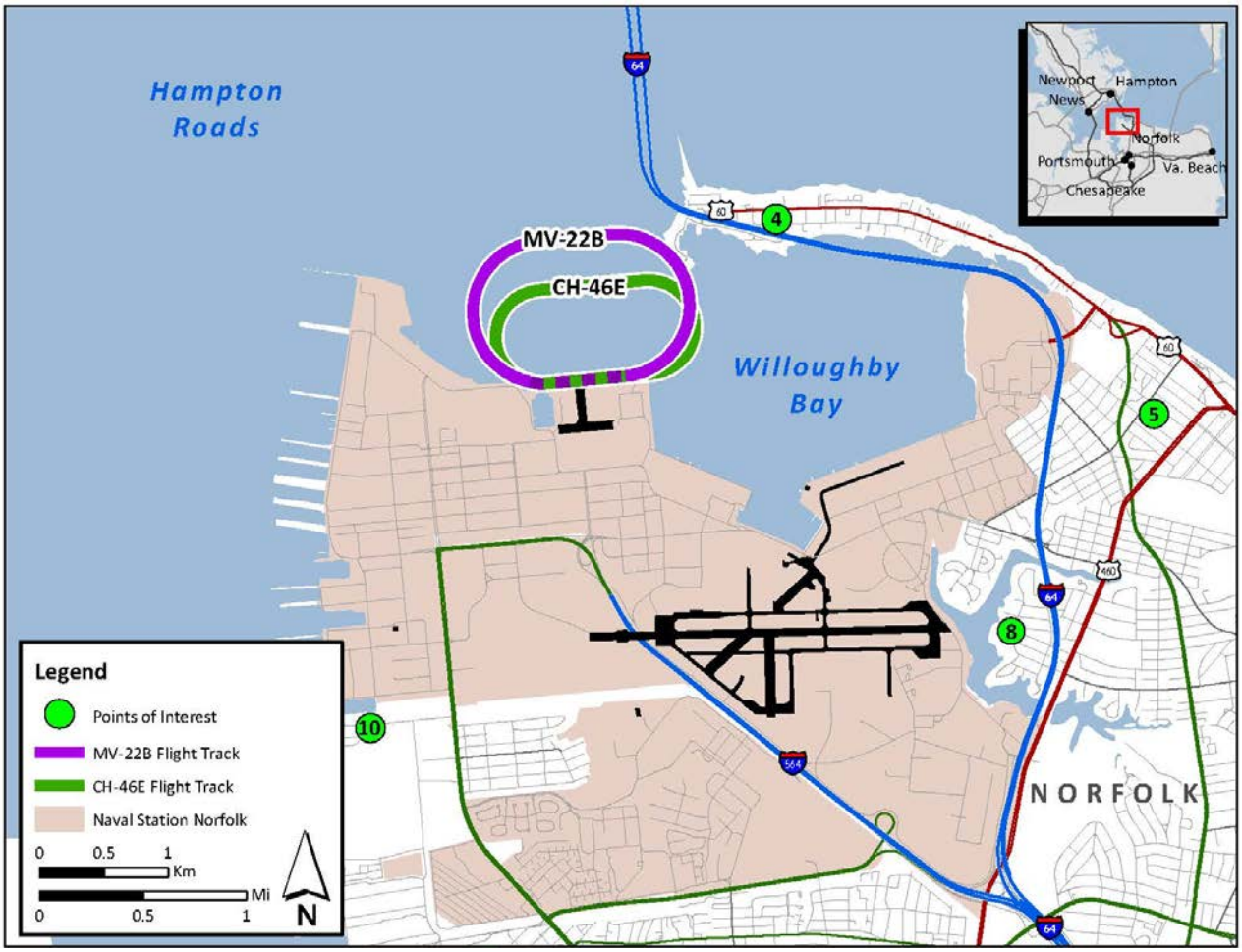


Figure 6-3 Representative Touch-and-Go Pattern Flight Tracks

Table 6-3. Single Event Metrics for Representative Touch-and Go Pattern				
	CH-46E		MV-22B	
POI	SEL	L_{max}	SEL	L_{max}
4	73.7	61.0	77.4	66.3
5	49.4	34.5	60.3	50.7
8	52.1	36.1	61.8	51.0
10	48.8	32.6	54.7	42.1

Single event metrics such as SEL and L_{max} are useful tools when properly applied. These examples show that there is not a simple answer to the question of "which aircraft is louder". As shown in this section, it depends on what each aircraft is doing and the location of the observer. The overall contribution to the noise environment from the proposed MV-22B operations would still be dwarfed by the jet traffic at NS Norfolk, which is why the small changes in CH-46E and MV-22B traffic don't make much difference in the noise exposure at the airfield (see **Figure 5-2**). For comparative purposes, a C-5 overflight on take-off (1,000 feet overhead) produces an SEL of 113.5 dB and an L_{max} of 106.3 dB directly below the flight track.

The DoD-accepted metric for determining overall impacts of a proposed action is DNL, which was shown to be relatively unchanged for the Proposed Action. The SEL and L_{max} calculations were performed to provide additional information to help further characterize the transition-related changes to the noise environment that may be experienced outside the airfield. The fact that SEL and L_{max} values for various overflight patterns increase in some cases and decrease in others further indicate that the overall noise impact of Proposed Action would be negligible.

7.0 CONCLUSION

The USMCR proposes to transition HMM-774 (currently operating 12 CH-46E aircraft from NS Norfolk, VA) to VMM-774 (operating 12 MV-22B aircraft) following retirement of the CH-46E helicopter, which is nearing the end of its service life.

Assuming a current Baseline condition based on average flight operations at NS Norfolk Chambers Field for the four-year period from 2011-2014, the noise analysis shows that the removal of the 12 CH-46Es (HMM-774) and the addition of 12 MV-22s (VMM-774) will result in negligible noise effects. Changes to the DNL at any of the POIs are negligible.

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APPENDIX C
PUBLIC INVOLVEMENT

[Note to Reviewer – this is a placeholder for public notice, external agency correspondence, and public meeting materials to be incorporated in the Final EA]

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APPENDIX D
AIR QUALITY CALCULATIONS

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TAB A. **AIRCRAFT OPS SUMMARY**

Table 1. Criteria Pollutant Emissions from Airfield Ops and Related Activities

	Tons Per Year					
Baseline Helos	**VOCs**	**CO**	**NOx**	**SO2**	**PM10**	**PM2.5**
Airfield	4.80	14.64	0.96	0.66	0.99	0.99
Maintenance Runups	0.60	1.94	0.13	0.09	0.12	0.12
Total	**5.40**	**16.58**	**1.09**	**0.75**	**1.10**	**1.10**
MV-22	**VOCs**	**CO**	**NOx**	**SO2**	**PM10**	**PM2.5**
Airfield	0.04	2.24	6.86	1.67	1.07	1.07
Maintenance Runups	0.03	1.78	3.15	0.81	0.52	0.52
Commuters	0.02	2.34	0.11	0.00	0.01	0.01
Total	**0.08**	**6.35**	**10.12**	**2.48**	**1.61**	**1.60**
Net from Baseline	***-5.32***	***-10.23***	***9.03***	***1.73***	***0.50***	***0.50***
de Minimis	***100***	***NA***	***100***	***NA***	***NA***	***NA***
Exceedance?	***No***	***NA***	***No***	***NA***	***NA***	***NA***

Table 2. GHG Emissions from Airfield Ops, Related Activities and Connected Actions

Baseline Helos	**CO_2 in Metric Tons**
Baseline Airfield Activities	953
Baseline Connected Actions	5,226
Total	**6,179**
MV-22	
Airfield Activities	3,416
Connected Actions	6,731
Total	**10,147**
Net from Baseline	**3,968**

Conclusion:

MV-22B emissions of VOCs and CO would be less than those from CH-46E operations, while emissions of NOx, SO2, PM10, and PM2.5 would be slightly more than the CH-46E. There would be no significant impacts to air quality for any of the criteria pollutants as a result of the transition from HMM-774 to VMM-774.

TAB B. **BASELINE HELO OPS - H-46**

Table 1. **Baseline H-46 Operations at the Airfield**

Flight Mode	Fuel Used (lbs)	Emission Indices (lb per 1,000 lb fuel)							Emissions from Single Operation in Flight Mode in Pounds						
		HC	CO	NOx	SO_2	PM_{10}	$PM_{2.5}$	CO_2	VOC	CO	NOx	SO_2	PM_{10}	$PM_{2.5}$	CO_2
Departure															
APU Use	10.2	9.04	42.77	3.94	2.22	0.22	0.22	3,154	0.10	0.44	0.04	0.02	0.00	0.00	32.17
Warm up GI	11.1	45.59	121.3	1.48	2.22	5.06	5.06	2,917	0.54	1.35	0.02	0.02	0.06	0.06	32.48
Warm up FI	31.7	39.18	107.86	1.68	2.22	5.06	5.06	2,974	1.32	3.42	0.05	0.07	0.16	0.16	94.18
Unstick	4.2	8.62	35.41	3.24	2.22	3.49	3.49	3,051	0.04	0.15	0.01	0.01	0.01	0.01	12.81
Taxi Out	37	11.98	44.55	2.95	2.22	4.29	4.29	3,136	0.47	1.65	0.11	0.08	0.16	0.16	116.03
Hover	6.3	2.16	15.37	4.25	2.22	1.78	1.78	3,182	0.01	0.10	0.03	0.01	0.01	0.01	20.05
Climbout	59.2	1.28	12.02	4.57	2.22	1.78	1.78	3,188	0.08	0.71	0.27	0.13	0.11	0.11	188.62
	160	Total Emissions in Pounds for a Single Departure							2.55	7.81	0.53	0.35	0.51	0.51	496.34
		Total Emissions in Tons for 1,273 Annual Departures							**1.63**	**4.97**	**0.34**	**0.23**	**0.32**	**0.32**	
		Total Emissions in Metric Tons for 1,273 Annual Departures													**287**
Arrival															
APU Use	5.1	9.04	42.77	3.94	2.22	0.22	0.22	3,154	0.05	0.22	0.02	0.01	0.00	0.00	16.09
Approach	33.3	5.09	25.05	3.65	2.22	2.21	2.21	3,167	0.18	0.84	0.12	0.07	0.07	0.07	105.57
Unstick	4.2	8.62	35.41	3.24	2.22	3.49	3.49	3,051	0.04	0.15	0.01	0.01	0.01	0.01	12.81
Taxi to Refuel	37.0	11.98	44.55	2.95	2.22	4.29	4.29	3,136	0.47	1.65	0.11	0.08	0.16	0.16	116.03
Hot Refuel	63.3	39.18	107.86	1.68	2.22	5.06	5.06	2,974	2.63	6.83	0.11	0.14	0.32	0.32	188.35
Taxi	49.3	11.98	44.55	2.95	2.22	4.29	4.29	3,136	0.63	2.20	0.15	0.11	0.21	0.21	154.71
Shut Down	13.9	49.59	121.3	1.48	2.22	5.06	5.06	2,917	0.73	1.69	0.02	0.03	0.07	0.07	40.59
		Total Emissions for a Single Arrival							4.73	13.57	0.54	0.46	0.85	0.85	634.16
		Total Emissions in Tons for 1,273 Annual Arrivals							**3.01**	**8.64**	**0.34**	**0.29**	**0.54**	**0.54**	
		Total Emissions in Metric Tons for 1,273 Annual Arrivals													**366**
Touch and Go															
Approach	16.7	5.09	25.05	3.65	2.22	2.21	2.21	3,167	0.09	0.42	0.06	0.04	0.04	0.04	52.78
Climbout	59.2	1.28	12.02	4.57	2.22	1.78	1.78	3,188	0.08	0.71	0.27	0.13	0.11	0.11	188.62
Circle	40	2.64	17.04	4.12	2.22	1.78	1.78	3,180	0.11	0.68	0.16	0.09	0.07	0.07	127.20
		Total Emissions for a Single Touch and Go							0.28	1.81	0.50	0.26	0.21	0.21	368.61
		Total Emissions in Tons for 971 Touch and Gos							**0.14**	**0.88**	**0.24**	**0.12**	**0.10**	**0.10**	
		Total Emissions in Metric Tons for 971 Touch and Gos													**162**
GCA Box															
Approach	16.7	5.09	25.05	3.65	2.22	2.21	2.21	3,167	0.09	0.42	0.06	0.04	0.04	0.04	52.78
Climbout	23.7	1.28	12.02	4.57	2.22	1.78	1.78	3,188	0.03	0.28	0.11	0.05	0.04	0.04	75.45
Circle	100	2.64	17.04	4.12	2.22	1.78	1.78	3,180	0.28	1.70	0.41	0.22	0.18	0.18	318.00
		Total Emissions for a GCA Box							0.40	2.41	0.58	0.31	0.26	0.26	446.23
		Total Emissions in Tons for 131 GCA Box							**0.03**	**0.16**	**0.04**	**0.02**	**0.02**	**0.02**	
		Total Emissions in Metric Tons for 131 GCA Box													**27**
		Total Emissions in Tons for All Annual Airfield Baseline Helo Ops							**4.80**	**14.64**	**0.96**	**0.66**	**0.99**	**0.99**	

Total Emissions in Metric Tons for All Annual Airfield Baseline Helo Ops	**842**

Table 2. Engine Maintenance Runups

	lb/Aircraft/Yr							
Operation	**Fuel Used**	**VOC**	**CO**	**NOx**	**SO_2**	**PM_{10}**	**$PM_{2.5}$**	**CO_2**
Maintenance Test Emissions for One Aircraft	6,596	100.53	323.38	21.46	14.64	19.29	19.29	20,375
Annual Emissions in Tons for 12 Aircraft		**0.60**	**1.94**	**0.13**	**0.09**	**0.12**	**0.12**	
Annual Emissions in Metric Tons for 12 Aircraft								**111**

TAB C. **ALTERNATIVE 1: NS NORFOLK**

Table 1. MV-22 Flight Operations at Airfield

Flight Mode	Fuel Used (lbs)	Emission Indices (lb per 1,000 lb fuel)							Emissions from Single Operation in Flight Mode in Pounds						
		HC	CO	NOx	SO_2	PM_{10}	$PM_{2.5}$	CO_2	VOC	CO	NOx	SO_2	PM_{10}	$PM_{2.5}$	CO_2
Vertical Take Off															
APU	103.3	0.19	5.89	5.95	2.22	0.22	0.22	3,235	0.02	0.61	0.61	0.23	0.02	0.02	334.01
Start/Warm up	60	0.1	8.9	4.09	2.22	1.58	1.58	3,221	0.01	0.53	0.25	0.13	0.09	0.09	193.26
Warm up	220	0.02	3.33	6.02	2.22	1.58	1.58	3,219	0.00	0.73	1.32	0.49	0.35	0.35	708.18
Taxi Out	110	0.02	3.33	6.02	2.22	1.58	1.58	3,219	0.00	0.37	0.66	0.24	0.17	0.17	354.09
Engine Run up	17.2	0.02	1.58	8.41	2.22	1.58	1.58	3,216	0.00	0.03	0.14	0.04	0.03	0.03	55.21
Takeoff to Hover	63.7	0.01	0.52	14.09	2.22	1.58	1.58	3,209	0.00	0.03	0.90	0.14	0.10	0.10	204.31
Hover	54.7	0.01	0.69	12.35	2.22	1.58	1.58	3,211	0.00	0.04	0.68	0.12	0.09	0.09	175.53
Helo Climbout	118	0.01	0.6	13.19	2.22	1.58	1.58	3,210	0.00	0.07	1.56	0.26	0.19	0.19	378.78
FW Climbout	54.7	0.01	0.69	12.35	2.22	1.58	1.58	3,211	0.00	0.04	0.68	0.12	0.09	0.09	175.53
	801	Emissions in Pounds for a Single Vertical Take Off Departure							0.04	2.45	6.79	1.78	1.13	1.13	2,579
Total Emissions in Tons for 278 Annual Vertical Take Off Departures									**0.01**	**0.34**	**0.94**	**0.25**	**0.16**	**0.16**	
Total Emissions in Metric Tons for 278 Annual Vertical Take Off Departures															**325**
Short Take Off															
APU	103.3	0.19	5.89	5.95	2.22	0.22	0.22	3,235	0.02	0.61	0.61	0.23	0.02	0.02	334.01
Start/Warm up	60	0.1	8.9	4.09	2.22	1.58	1.58	3,221	0.01	0.53	0.25	0.13	0.09	0.09	193.26
Warm up	220	0.02	3.33	6.02	2.22	1.58	1.58	3,219	0.00	0.73	1.32	0.49	0.35	0.35	708.18
Taxi Out	110	0.02	3.33	6.02	2.22	1.58	1.58	3,219	0.00	0.37	0.66	0.24	0.17	0.17	354.09
Engine Run up	17.2	0.02	1.58	8.41	2.22	1.58	1.58	3,216	0.00	0.03	0.14	0.04	0.03	0.03	55.21
Takeoff	68.7	0.01	0.45	15.06	2.22	1.58	1.58	3,208	0.00	0.03	1.03	0.15	0.11	0.11	220.28
FW Climbout	54.7	0.01	0.69	12.35	2.22	1.58	1.58	3,211	0.00	0.04	0.68	0.12	0.09	0.09	175.53
	634	Total Emissions in Pounds for a Short Take Off Departure							0.04	2.34	4.70	1.41	0.86	0.86	2,040.57
Total Emissions in Tons for 418 Annual ShortTake Off Departures									**0.01**	**0.49**	**0.98**	**0.29**	**0.18**	**0.18**	
Total Emissions in Metric Tons for 418 Annual Short Take Off Departures															**387**
Vertical Landing															
FW Approach	121.0	0.02	1.20	9.57	2.22	1.58	1.58	3,215	0.00	0.15	1.16	0.27	0.19	0.19	389.02
Transition (90°) Landing	43.7	0.02	1.04	10.22	2.22	1.58	1.58	3,214	0.00	0.05	0.45	0.10	0.07	0.07	140.34
Taxi to hot refuel	66.0	0.02	3.33	6.02	2.22	1.58	1.58	3,219	0.00	0.22	0.40	0.15	0.10	0.10	212.45
Hot refuel (main engines)	156	0.1	8.90	4.09	2.22	1.58	1.58	3,221	0.02	1.39	0.64	0.35	0.25	0.25	502.48
Hot refuel (APU)	89.5	0.19	5.89	5.95	2.22	0.22	0.22	3,235	0.02	0.53	0.53	0.20	0.02	0.02	289.48
Taxi to apron	66.0	0.02	3.33	6.02	2.22	1.58	1.58	3,219	0.00	0.22	0.40	0.15	0.10	0.10	212.45
Cool/Shut down	24.0	0.1	8.90	4.09	2.22	1.58	1.58	3,221	0.00	0.21	0.10	0.05	0.04	0.04	77.30
APU	34.4	0.19	5.89	5.95	2.22	0.22	0.22	3,235	0.01	0.20	0.20	0.08	0.01	0.01	111.34
	601	Total Emissions in Pounds for a Vertical Landing							0.05	2.96	3.87	1.33	0.78	0.78	1,934.86
Total Emissions in Tons for 418 Annual Vertical Landings									**0.01**	**0.62**	**0.81**	**0.28**	**0.16**	**0.16**	
Total Emissions in Metric Tons for 418 Annual Vertical Landings															**367**

Short Landing															
FW Approach	121.0	0.02	1.20	9.57	2.22	1.58	1.58	3,215	0.00	0.15	1.16	0.27	0.19	0.19	389.02
Transition (16°) Landing	43.7	0.02	1.04	10.22	2.22	1.58	1.58	3,214	0.00	0.05	0.45	0.10	0.07	0.07	140.34
Taxi to hot refuel	66.0	0.02	3.33	6.02	2.22	1.58	1.58	3,219	0.00	0.22	0.40	0.15	0.10	0.10	212.45
Hot refuel (main engines)	156.0	0.1	8.90	4.09	2.22	1.58	1.58	3,221	0.02	1.39	0.64	0.35	0.25	0.25	502.48
Hot refuel (APU)	89.5	0.19	5.89	5.95	2.22	0.22	0.22	3,235	0.02	0.53	0.53	0.20	0.02	0.02	289.48
Taxi to apron	66.0	0.02	3.33	6.02	2.22	1.58	1.58	3,219	0.00	0.22	0.40	0.15	0.10	0.10	212.45
Cool/Shut down	24.0	0.1	8.90	4.09	2.22	1.58	1.58	3,221	0.00	0.21	0.10	0.05	0.04	0.04	77.30
APU	34.4	0.19	5.89	5.95	2.22	0.22	0.22	3,235	0.01	0.20	0.20	0.08	0.01	0.01	111.34
	601	Total Emissions in Pounds for a Short Landing							0.05	2.96	3.87	1.33	0.78	0.78	1,934.86
		Total Emissions in Tons for 418 Annual Short Landings							**0.01**	**0.62**	**0.81**	**0.28**	**0.16**	**0.16**	
		Total Emissions in Metric Tons for 418 Annual Short Landings													**367**
Touch and Gos															
Approach	102	0.01	0.79	11.64	2.22	1.58	1.58	3,212	0.00	0.08	1.19	0.23	0.16	0.16	327.62
Climbout	68.7	0.01	0.45	15.06	2.22	1.58	1.58	3,208	0.00	0.03	1.03	0.15	0.11	0.11	220.28
Circle	109.3	0.01	0.69	12.35	2.22	1.58	1.58	3,211	0.00	0.08	1.35	0.24	0.17	0.17	351.07
	280	Total Emissions in Pounds for a Touch and Go							0.00	0.19	3.57	0.62	0.44	0.44	898.98
		Total Emissions in Tons for 1,200 Annual Touch & Go							**0.00**	**0.11**	**2.14**	**0.37**	**0.27**	**0.27**	
		Total Emissions in Metric Tons for 1,200 Annual Touch & Go													**489**
GCA Box															
Approach	153	0.01	0.79	11.64	2.22	1.58	1.58	3,212	0.00	0.12	1.78	0.34	0.24	0.24	491.44
Climbout	137.3	0.01	0.45	15.06	2.22	1.58	1.58	3,208	0.00	0.06	2.07	0.30	0.22	0.22	440.57
Circle	109.3	0.01	0.69	12.35	2.22	1.58	1.58	3,211	0.00	0.08	1.35	0.24	0.17	0.17	351.07
	400	Total Emissions in Pounds for a Short Landing							0.00	0.26	5.20	0.89	0.63	0.63	1283.07
		Total Emissions in Tons for 216 Annual GCA Box							**0.00**	**0.03**	**0.56**	**0.10**	**0.07**	**0.07**	
		Total Emissions in Metric Tons for 216 Annual GCA Box													**126**
FCLP															
Approach	102	0.01	0.79	11.64	2.22	1.58	1.58	3,212	0.00	0.08	1.19	0.23	0.16	0.16	327.62
Climbout	137.3	0.01	0.45	15.06	2.22	1.58	1.58	3,208	0.00	0.06	2.07	0.30	0.22	0.22	440.57
Circle	109.3	0.01	0.69	12.35	2.22	1.58	1.58	3,211	0.00	0.08	1.35	0.24	0.17	0.17	351.07
	349	Total Emissions in Pounds for a Short Landing							0.00	0.22	4.61	0.77	0.55	0.55	1119.26
		Total Emissions in Tons for 264 Annual FCLP							**0.00**	**0.03**	**0.61**	**0.10**	**0.07**	**0.07**	
		Total Emissions in Metric Tons for 264 Annual FCLP													**134**
		Total Emissions in Tons for All Annual Alternative 1 Airfield Helo Ops							**0.04**	**2.24**	**6.86**	**1.67**	**1.07**	**1.07**	
		Total Emissions in Metric Tons for All Annual Airfield Baseline Helo Ops													**2,195**

Table 2. Engine Maintenance Runups

Operation	Fuel Used	VOC	CO	NOx	SO_2	PM_{10}	$PM_{2.5}$	CO_2
		lb/Aircraft/Yr						
Maintenance Test Emissions for One Aircraft	65,132	4.87	296.11	525.64	135.50	87.27	87.27	209,662
Annual Emissions in Tons for 12 Aircraft		**0.03**	**1.78**	**3.15**	**0.81**	**0.52**	**0.52**	
Annual Emissions in Metric Tons for 12 Aircraft								**1,141**

Table 3. Additional Commuters 46 1st 2 years 30 thereafter

Assume all reside off-base

Vehicles	# vehicles	# days	mi/day	VOC	CO	NOx	SO_2	PM_{10}	$PM_{2.5}$	CO_2
				lb/mi	lb/mi	lb/mi	lb/mi	lb/mi	lb/mi	g/mi
passenger vehicles	30	365	40	0.0001	0.01	0.0005	0.00001	0.0001	0.0001	182.00
				VOCs	**CO**	**NOx**	**SO2**	**PM10**	**PM2.5**	**CO2**
				lb	lb	lb	lb	lb	lb	kg
				37.64	4675.57	213.43	3.22	24.92	22.74	79,716
Tons per Year				**0.02**	**2.34**	**0.11**	**0.00**	**0.01**	**0.01**	
Metric Tons per Year										**80**

TAB E. **ASSUMPTIONS AND REFERENCES**

Table 1. Distances to Training Areas

Fort AP Hill	NS Norfolk	97	
MCAF Quantico	NS Norfolk	125	
Blackstone AAF	NS Norfolk	91	
OLF Atlantic	NS Norfolk	62	
Camp Dawson, WV	NS Norfolk	255	
Muir AAF	NS Norfolk	247	
JB McGuire-Dix-Lakehurst	NS Norfolk	239	
MCB Camp Lejeune	NS Norfolk	168	
BT-11 NC (Piney Island)	NS Norfolk	156	
BT-9 (Brant Island)	NS Norfolk	46	
	Total	**1486**	
	Average	**149**	

Table 2. Cruising speeds of aircraft

CH-46 cruising speed =	155	mph (from boeing.com)
MV-22 cruising speed =	227	mph (from wikipedia.org)

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