Department of Defense

Legacy Resource Management Program

Assessing BASH Risk Potential of Migrating and Breeding Osprey in the Mid-Atlantic Chesapeake Bay Region.

FINAL REPORT
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DISCLAIMER

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EXECUTIVE SUMMARY

The recovery and expansion of Osprey populations in North America in recent years has resulted in an increased threat of collisions (strikes) with aircraft. High Osprey population levels and this species' ability to adapt to human development and activity have resulted in concerns among military pilots, flight safety officers, and natural resource managers about Osprey-strike risks.

The objectives of this project were to evaluate and identify Osprey-strike risk by: (1) monitoring spatial and temporal patterns of Osprey activity and movement during the breeding season, (2) identifying specific travel routes, timing, and movements of migrating Ospreys along the Atlantic seaboard, and (3) providing recommendations for effective management strategies designed to conservatively mitigate Osprey-strike hazards.

The project encompassed a collaborative multi-agency (state and federal) effort, where breeding adult and nestling Osprey were live-captured, fitted with satellite transmitters, and released from selected nest locations on or near Langley Air Force Base, Virginia. Location and activity data from satellite-tagged Osprey were obtained via the Argos satellite network using pre-defined transmission cycles for the breeding and migratory seasons and the wintering period. The information collected was digitally processed, geo-referenced, and analyzed using a geographic information system. Movement and location data of satellite-tagged Osprey during migratory periods was cross referenced with military training airspace to develop a novel methodology for developing geographic information system based strike-risk models.

This study provides an unprecedented understanding of Osprey movements during all parts of their annual cycle (i.e., breeding season, fall migration, wintering period, and spring migration). During the breeding season, Ospreys exhibited a diurnal activity pattern with most movements occurring during daylight hours. Overall, Osprey activity during summer varied among months and between genders. The size of Osprey home ranges during the breeding season did not vary by gender, but was clearly influenced by reproductive success. Migrating Ospreys (in fall and spring) used similar geographic routes along the Eastern seaboard and primarily made migratory movements during a defined period (11:00–17:00 hr local eastern standard time) each day. Ospreys wintered in the Caribbean and South America. During their winter period, Ospreys were relatively sedentary and had relatively small home ranges.

Detailed information gained from this research effort demonstrates the utility of global position tracking capable satellite telemetry for studying bird migration patterns. By understanding the breeding ecology, wintering ecology, and migration patterns of Ospreys, conservation and management efforts for this species can be enhanced.

Findings from this study clearly demonstrated that during the breeding season Ospreys nesting near Langley Air Force Base posed a hazard to military aircraft operating in the vicinity of the airfield. By developing and employing new analytical methods, we conducted a quantitative risk assessment that considered both temporal and spatial patterns in the hazard that breeding Ospreys posed to military aircraft operating from Langley Air Force Base.

We identified the times of day and portions of the breeding season when the risk of an Osprey-aircraft collision was highest. This information will allow military flight planners to consider this safety factor and reduce the risk of Osprey–aircraft collisions.

During their fall and spring migrations, Ospreys also pose a risk to military aircraft operating along the Atlantic seaboard. Our findings suggest that this risk is highest during late-morning to afternoon hours and lowest during early morning and evening hours. Ultimately, using information provided by this research effort, the timing and routing of military training flights could be scheduled to avoid airspace and times frequented by Osprey.

This project demonstrated an advanced operational risk management process emphasizing the safe-guarding of military assets and preserving readiness while supporting the mission of the United States Air Force. The deliverable products (available electronically on the DENIX website at http://www.denix.osd.mil/nr/FishandWildlife/Birds.cfm) resulting from this project expanded current bird avoidance model systems (http://www.usahas.com/bam) while determining effective solutions for reducing Osprey-strike risks implemented through the combined partnerships of flight safety officers, airspace managers, natural resource managers, wildlife biologists, and geospatial analysts.

Osprey in flight over the Chesapeake Bay with a fish in its talons.

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ACRONYMS

AFB	Air Force Base
AGL	Above Ground Level
BASH	Bird Aircraft Strike Hazard
DDT	Dichloro-Diphenyl-Trichlorethane
DENIX	DoD Department of Environment, Safety, and Occupational Health Network and Information Exchange
DoD	Department of Defense
FW	Fighter Wing
GIS	Geographic Information System
GPS	Global Position System
IS	Imaginary Surfaces
MSL	Mean Sea Level
MTA	Military Training Airspace
MTR	Military Training Route
NM	Nautical Miles
SUA	Special Use Airspace
U.S.	United States
USAF	United States Air Force

1. INTRODUCTION

The Osprey (*Pandion haliaetus*) is one of the most widely distributed and well studied bird species of the Northern Hemisphere (Poole 1989, Poole et al. 2002); however, little is known about the potential impacts of this species to military flight operations. From 1995 to 2006, the United States Air Force (USAF) Safety Center documented 25 Osprey aircraft strikes resulting in excess of $1.3 million cumulative damages (USAF BASH Team, Pers. Comm.). Based on research conducted by the United States (U.S.) Department of Agriculture/Animal Plant Health Inspection Service/Wildlife Services National Wildlife Research Center, Osprey are ranked sixth out of the 21 most hazardous bird species to civilian aircraft (Dolbeer et al. 2000). Furthermore, Osprey populations in North America have shown a dramatic recovery in the past decade, with breeding populations continuing to expand along the Atlantic Coast. From 1973 to 1996, the Chesapeake Bay population increased from 1,400 to over 3,500 breeding pairs (Watts et al. 2004). This population growth and other factors suggest that Ospreys are a serious safety and economic concern to military flight operations.

Osprey in flight over the Chesapeake Bay.

In an effort to better understand and quantify the risks to military aircraft posed by breeding and migrating Osprey, a collaborative research effort conducted by state and federal agencies through a grant award from the U.S. Department of Defense (DoD) Legacy Resource Management Program was initiated at Langley Air Force Base (AFB), Virginia. The goal of this research project was to quantify Osprey strike risk by using Osprey movement information derived from satellite tracking of Ospreys during the breeding season and during fall and spring migratory periods in relation to military flight operations in the mid-Atlantic Chesapeake Bay region and along the U.S. Atlantic coastal migratory flyway.

The objectives of this project were to evaluate and identify Osprey strike risk by: (1) monitoring spatial and temporal activity and movement of Ospreys during the breeding season, (2) identifying specific migratory routes, timing, and movements of Ospreys along the Atlantic seaboard, and (3) providing recommendations for effective management strategies designed to conservatively mitigate Osprey strike hazards.

2. BACKGROUND

The recovery of the Osprey in North America is an example of a successful conservation management initiative. Nearly thirty years ago, the unregulated use of pesticides, most notably dichloro-diphenyl-trichlorethane (DDT), adversely affected hatchling success of Osprey in the Chesapeake Bay Region and throughout the United States. Following the ban on the use of DDT in 1973 and supported by intensive recovery programs, a resurgence of Osprey populations began.

Translocation (i.e., the process of relocating a wild species to a new location) efforts by state wildlife agencies in Minnesota, Colorado, North Carolina, and Ohio contributed to the establishment of healthy Osprey populations in those states (Martell et al. 2002). Within the Chesapeake Bay, avian propagation and captive rearing programs along with the construction of several hundred nesting platforms influenced the colonization of one of the world's largest breeding populations of Osprey (Henny 1983).

Photo of aircraft damage to an A-10 Warthog after colliding with an Osprey.

Although thriving Osprey populations can now be found within many areas of the mid-Atlantic region, breeding pairs are now forced to deal with an overabundant population (Byrd 1986). In Region 5 of the U.S. Fish and Wildlife Service (which includes the Chesapeake Bay Region), Osprey populations increased at a rate of 8.04% per year during 1987–2007 (Sauer et al. 2008). The expansion of breeding Osprey populations combined with this species' ability to adapt to human encroachment has resulted in a growing concern to military pilots, flight safety officers, and natural resource managers. In April of 1990, a military aircraft landing at Dover AFB in Delaware struck an Osprey. This strike resulted in $170,000 in damage to the aircraft. In 2000, an F-15 Eagle stationed at Langley AFB collided with an Osprey, causing over $750,000 in engine damage. The pilot was forced to terminate the mission and conduct an emergency landing. In response to this incident, the Langley AFB Bird Aircraft Strike Hazard (BASH) Program launched an aggressive Osprey monitoring program and initiated an Osprey nestling translocation program.

Monitoring of Osprey nesting near Langley AFB began in 2001. Nest surveys were used to identify active nests and to monitor productivity of Osprey nests surrounding the airfield. During 2001–2004, 72 nests were documented within a 20-mile radius of the Langley AFB airfield, with an average reproductive rate of 1.6 young per active nest (USDA 2005). Bi-monthly point-count surveys were also conducted during 2001–2004 to monitor the presence of Ospreys on the airfield. Over 500 individual observations of Ospreys were made during the point-count surveys, yielding an average airfield occurrence of 3.2 Ospreys per survey (USDA 2005). In 2004, Langley AFB initiated an Osprey banding program where a total of 30 adult and 11 nestling were banded to support current Osprey monitoring efforts (USDA 2005).

To reduce the BASH threat potential and simultaneously promote their conservation, Langley AFB began translocating nestling Ospreys in 2001. Since that time, a total of 152 nestlings (ranging from 5 to 7 weeks of age) were hand-collected, transported, and released at various hacking sites throughout Ohio and Indiana, where state wildlife agencies were attempting to reintroduce sustainable Osprey populations.

Nestling translocation efforts have proven effective for mitigating the immediate strike threats from fledglings and subsequent threats from returning adults, while supporting the recovery programs in states where this species is listed as Threatened or Endangered (Olexa 2006).

The ecology of the Chesapeake Bay Osprey is well researched, especially in the mid-Atlantic Chesapeake Bay Region. Previous research projects have focused on distribution, breeding rates, and migration. Consequently, Langley AFB developed and implemented a regional research project effort to assess the BASH risk potential of breeding and migrating Ospreys pose to military aircraft. The project was awarded funding through the DoD Legacy Resource Management Program criteria for monitoring and predicting migratory birds and wildlife studies to ensure the safety of military operations.

3. STUDY AREA

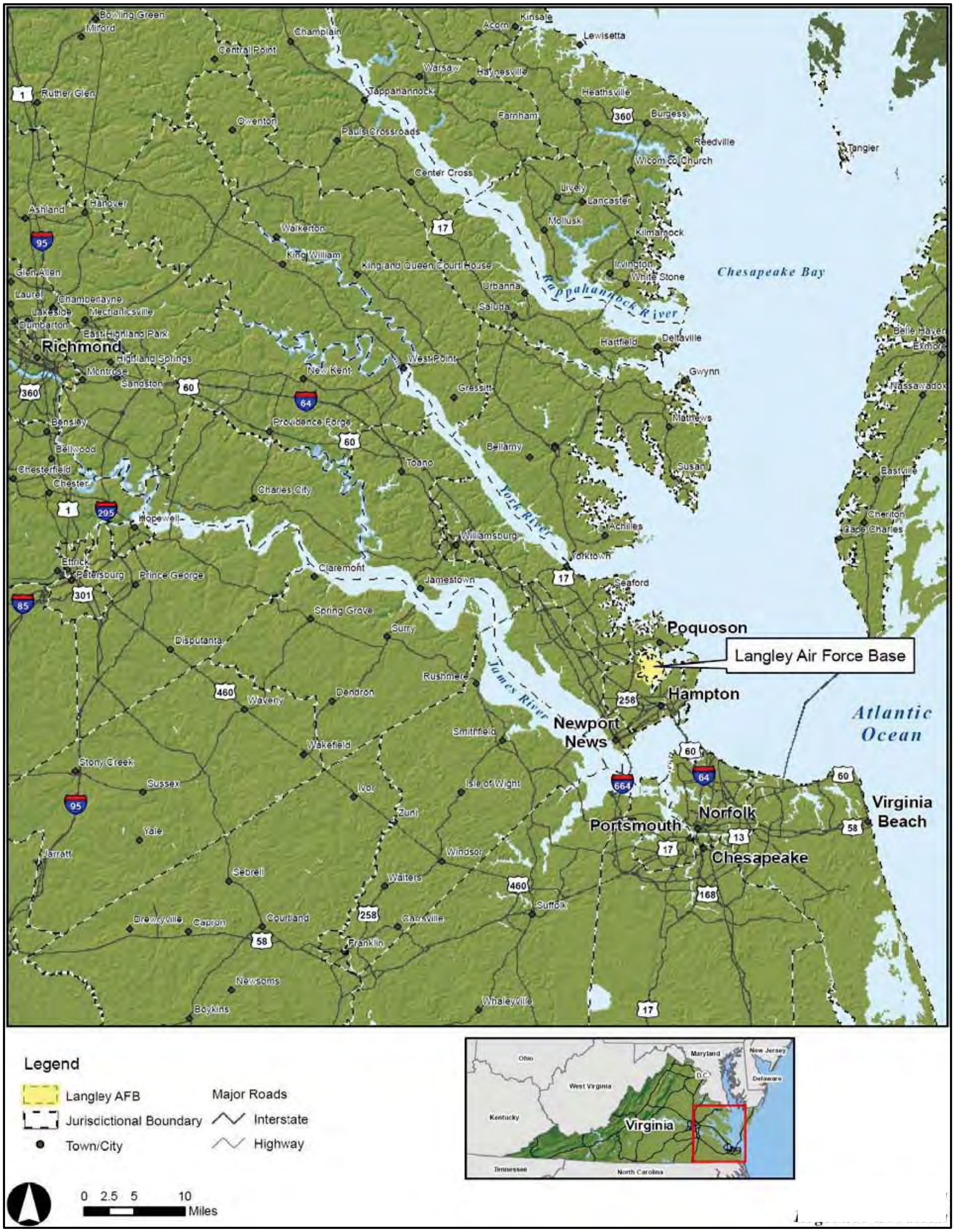
3.1. Langley Air Force Base

Langley AFB is an urban research and military complex jointly occupied by Headquarters Air Combat Command, 633d Air Base Wing, 1st Fighter Wing (FW), 192d FW, 119th FW, 480th Intelligence, Surveillance, and Reconnaissance Wing, and the Langley Research Center of the National Aeronautics and Space Administration. Nearly $3 billion in military assets, in addition to 24,500 military and civilian personnel, operate at this installation. The primary mission performed at Langley AFB is to support 1st and 192d FW fighter aircraft operations. Over 13,000 hours of military flight operations are executed each year. Aircraft stationed at Langley AFB during this project included 40 F-22s, 25 F-15s, four F-16s, and two C-21s. In addition, the airfield is the easternmost stopping point for many overseas flights and consequently receives a large number of transient military aircraft, including C-130s, C-5s, F-117s, T-38s, A-10s, B-1s, B-2s, and a variety of commercial aircraft.

Aerial photograph of Langley Air Force Base.

Langley AFB is located at 37° 05.00’ N and 76° 22.30’ W in the area known as the Virginia Peninsula and within the mid-Atlantic region of the Chesapeake Bay (Figure 1). The airfield encompasses 850 acres with a single runway (10,000 feet long by 150 feet wide) oriented along an east (26) and west (08) axis and intersecting taxiways and ramp space to the south for taxing aircraft. The main base is 2,883 acres on a peninsula bordered by the northwest and southwest branches of the Back River, which is a tidal tributary of the Chesapeake Bay. An estimated 652 acres of wetlands and 205 acres of forested woodlands remain on base and comprise the majority of natural, undeveloped lands at this installation (USAF 2006).

Figure 1. Location of Langley AFB within the mid-Atlantic region of the Chesapeake Bay, Virginia – Map 1.



Although much of the area adjacent to Langley AFB is developed and urbanized, this installation is also surrounded by natural communities and ecosystems, such as Plum Tree Island National Wildlife Refuge, Grandview Nature Preserve, Poquoson River, Hampton River, Tide Mill Creek, New Market Creek, and Tabbs Creek. Each year, over four-dozen breeding pairs of Ospreys nest within these natural areas surrounding Langley AFB. Our research investigation involved this breeding population of Ospreys and focused on individuals with nest sites within the Langley AFB airspace.

3.2. Langley AFB Airspace and Imaginary Surfaces

Controlled airspace at Langley AFB is referred to as Class D, which extends outward 5 nautical miles (NM) from the airfield and upward to an elevation of 2,500 feet (ft) mean sea level (MSL). A series of imaginary surfaces (IS) exists within the Langley AFB Class-D airspace and includes the primary surface, approach-departure clearance surface, inner horizontal surface, conical surface, outer horizontal surface, and transitional surfaces (Figure 2). The terms associated with Langley AFB IS are defined by Federal Regulation Title 14 Part 77 and are further described below:

The primary surface defines the limits of the obstruction clearance requirements in the immediate vicinity of the landing area. The primary surface comprises surfaces of the runway, runway shoulders, and lateral safety zones and extends 200 ft beyond the runway ends. The width of the primary surface for a single Class "B" runway is 2,000 ft (i.e., 1,000 ft on each side of the runway centerline).

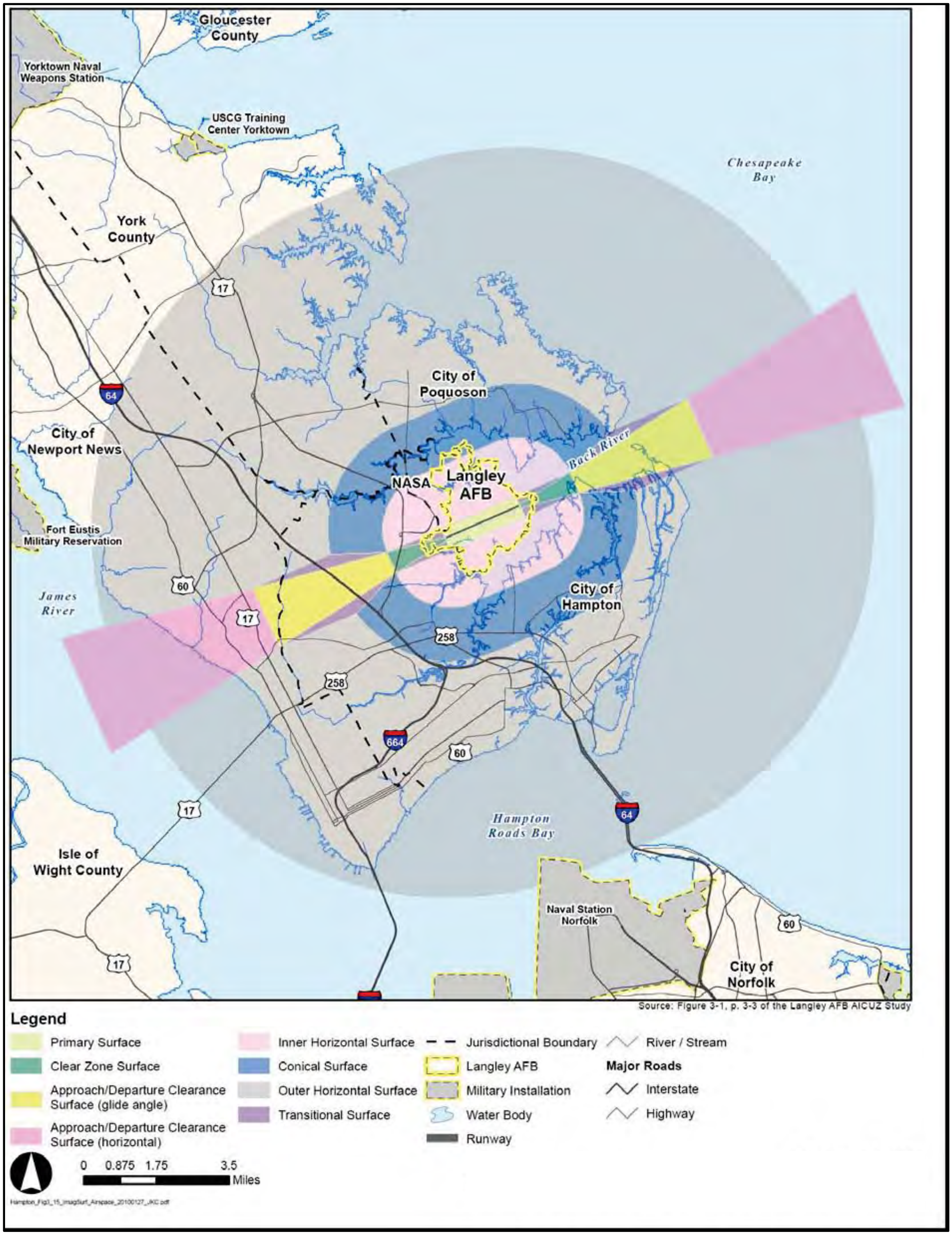
The clear zone surface defines the limits of the obstruction clearance requirements in the vicinity contiguous to the ends of the primary surface. The clear zone surface length and width (for a single runway) is 3,000 ft by 3,000 ft.

The approach-departure clearance surfaces are symmetrical about the extended runway centerline, begin as an inclined plane (glide angle) at each end of the primary surface of the centerline elevation of the runway end, and extend for 50,000 ft. The slope of each approach-departure clearance surface is 50:1 along the extended runway (glide angle) centerline until it reaches an elevation of 500 ft above the established airfield elevation. It then continues horizontally at this elevation to a point 50,000 ft from the start of the glide angle. The width of this surface at the runway end is 2,000 ft; it flares uniformly, and the width at 50,000 ft from the primary surface is 16,000 ft.

The inner horizontal surface is an oval-shaped plane located at a height of 150 ft above ground level (AGL) above the airfield. It is constructed by scribing an arc with a radius of 7,500 ft above the centerline at the end of the runway and interconnecting these arcs with tangents.

The conical surface is an inclined surface extending outward and upward from the outer periphery of the inner horizontal surface for a horizontal distance of 7,000 ft to a height of 500 ft above the established airfield elevation. The slope of the conical surface is 20:1.

Figure 2. Part 77 terminology for imaginary surfaces and controlled airspace at Langley AFB, Virginia – Map 2.



The outer horizontal surface is a plane located 500 ft above the established airfield elevation. It extends for a horizontal distance of 30,000 ft from the outer periphery of the conical surface.

The transitional surfaces connect the primary, and approach-departure surfaces to the inner-horizontal, conical, and the outer-horizontal surfaces. The slope of each transitional surface is 7:1 (outward and upward) at right angles to the runway centerline.

3.3. Osprey Atlantic Coast Migratory Route

The Atlantic coastal flyway extends from the offshore waters of the Eastern seaboard west to the Allegheny Mountains from Canada to the Gulf Mexico and Florida. The flyway encompasses several primary migration routes and many important tributaries for over 60 different land and water bird species (USFWS 1998). During the Osprey migratory periods (both fall and spring), our study encompassed the entire area along their migratory routes (i.e., from their breeding grounds near Langley AFB to their individual wintering areas in the Caribbean and South America) and integrated types of airspace used by the military for training along the Atlantic coast of the United States.

3.4. Military Training Airspace

Along the Atlantic coastal flyway, we considered and examined the different types of military training airspace (MTA) to include airfields (Class-D), alert areas, military operations areas, restricted areas, warning areas, instrument routes, visual routes, and slow routes (Figure 3). These terms are defined by the Chapter 3 of the Federal Aeronautical Manual and are further described below:

Class-D airspace is controlled airspace from the ground surface to 2,500 ft AGL and extending in a radius of 5 NM surrounding an airbase or military airfield with an operational control tower.

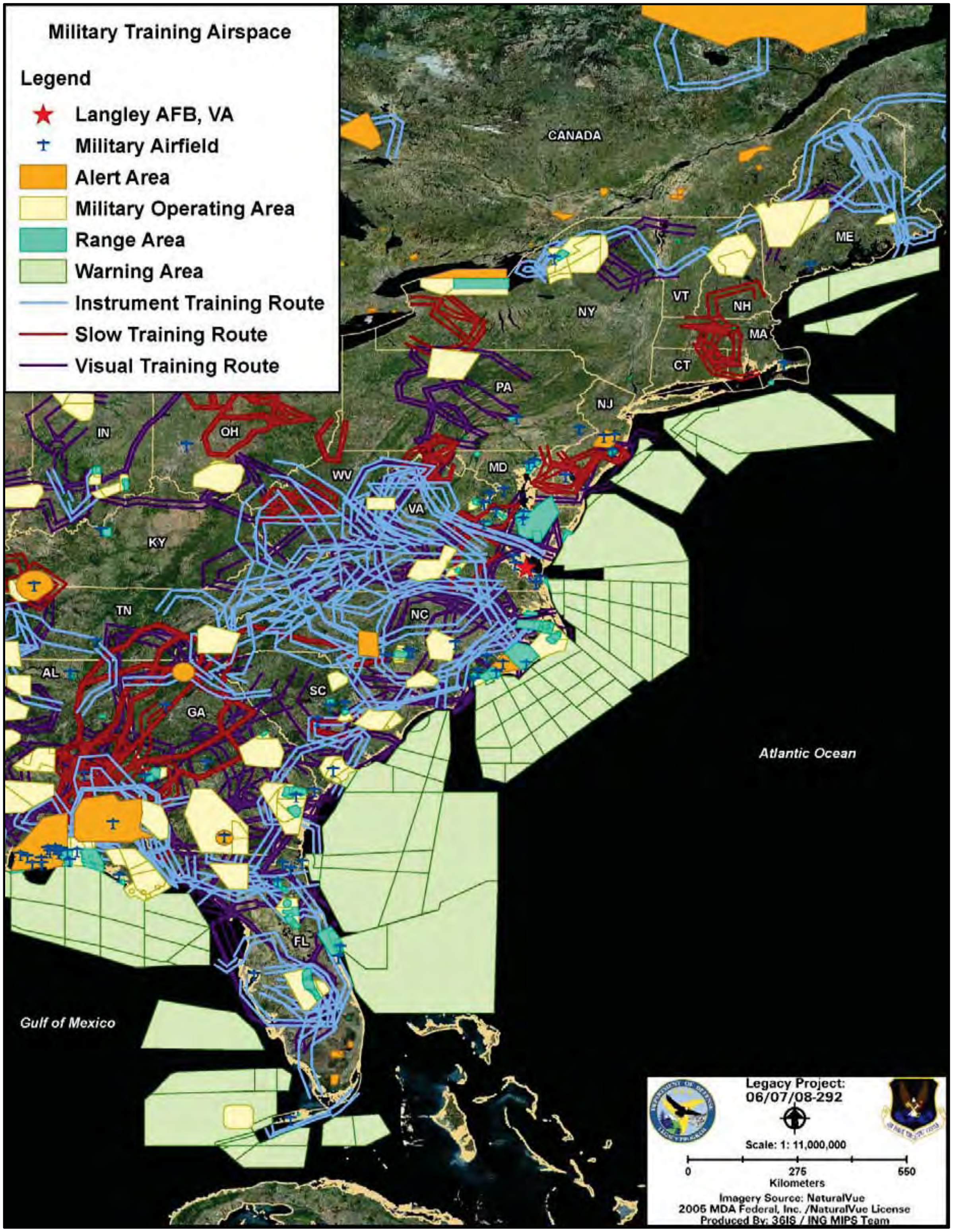
Alert areas are depicted on aeronautical charts to inform participating pilots regarding areas of airspace that may contain a high volume of pilot training or an unusual type of aerial activity. Pilots should be particularly alert when flying in these areas.

Military operations areas are blocks of airspace with defined vertical and lateral boundaries in which certain non-hazardous military flight activities are conducted. Examples of activities conducted in the military operation areas include, but are not limited to: air combat tactics, air intercepts, aerobatics, formation training, and low-altitude tactics.

Restricted areas are blocks of airspace of defined dimensions within which the flight of non-participating aircraft, while not wholly prohibited, is subject to restriction. Restricted areas are designated when it is necessary to segregate activities that may be hazardous to non-participating aircraft. Restricted areas denote the existence of unusual, often invisible, hazards to aircraft, such as artillery firing, aerial gunnery, or guided missiles.

Warning areas are considered airspace of defined dimensions that contains activity that may be hazardous to nonparticipating aircraft. The purpose of warning areas is to warn nonparticipating pilots of the potential danger. A warning area might be located over domestic or international waters.

Figure 3. Military training airspace along the U.S. Atlantic coastal migratory flyway – Map 3.



Military training routes are a typically long, low-altitude corridor that serves as flight path to a particular destination. The corridor is often 10 miles wide, 70 to 100 miles long, and may range from 500 to 1,500 ft AGL; occasionally higher. Types of military training routes include instrument flight routes, visual flight, and slow routes.

4. METHODS

4.1. Capture and Tagging Adult Ospreys

During 2006–2009, we studied Ospreys from a breeding population that had nesting territories located adjacent to Langley AFB, in the Back River on the western shore of the Chesapeake Bay of Virginia. Osprey capture and tagging efforts were conducted in late May and June of 2006 and during late May of 2007.

Adult Osprey fitted with a solar-powered GPS-PTT 100 satellite transmitter.

Adult Ospreys were captured within their nesting territories using a carpet-noose trap placed over their nest (Bloom 1987). Gender of all captured Ospreys was determined by plumage, size, and behavior at the nest (Poole 1989, Poole et al. 2002). Each captured Osprey was banded with a standard U.S. Geological Survey aluminum leg band on one leg and an aluminum color alpha-numeric coded band on the other leg. In addition, each Osprey was fitted with a 30-gram solar-powered satellite transmitter (Solar Argos/GPS PTT-100, Microwave Telemetry, Inc., Columbia, MD) via a standard backpack configuration (Kenward 2001, Martell et al. 2001) using a Teflon ribbon (Bally Ribbon Mills, Bally, PA) harness. Each Osprey was released at the respective nest site and monitored for a 15-minute period.

4.2. Capture and Tagging Juvenile Ospreys

During 2006, four nestling Ospreys were hand captured prior to fledging from their nests. Two juveniles were tagged and released at the respective nest sites and monitored for a 15−minute period. Two juvenile Ospreys were translocated to Indiana via aircraft within an 18−hr period. One juvenile was placed in a hacking program at the Minnehaha Wildlife Area near Sullivan, Indiana, whereas the other was placed in the hacking program at the Jasper–Pulaski Wildlife Area near Wheatfield, Indiana. Similar to the adult Ospreys, each juvenile bird was fitted with a standard U.S. Geological Survey aluminum leg band, an aluminum color alpha-numeric coded leg band, and a 30-gram GPS PTT-100 (Microwave Telemetry Inc., Columbia, MD) via a standard backpack configuration (Kenward 2001, Martell et al. 2001) using a Teflon ribbon (Bally Ribbon Mills, Bally, PA) harness.

4.3. Monitoring Ospreys by Satellite Telemetry

The satellite telemetry units were programmed to operate at varying intervals during the summer, migratory, and wintering periods. The satellite telemetry units were programmed to operate at 2–hr intervals between 05:00 and 23:00 hr local time and provided location information (i.e., 10 times per day) prior to 1 November and after 14 January of each year.

During 1 November – 14 January (i.e., during much of the wintering period), the telemetry units were programmed to provide information 3 times per day (at 06:00, 12:00, and 18:00 hr local time). At each individual operation, the GPS receiver within the satellite telemetry unit estimated the geographic position (± 18 m), altitude above MSL (± 22 m), and flight speed (± 1 kph; all accuracy estimates provided by the manufacturer) of the bird.

Osprey point locations were acquired from the ARGOS satellite network through a joint tariff agreement with CLS America (Largo, MD). Location and activity data arrived via email from the Argos processing center and included information such as the date, time, altitude, flight speed, and geographic coordinates for each individual Osprey location. A series of GIS databases were created to store, manage, and display spatial and movement data from each Osprey being tracked during the project. Formatted location data were digitally processed using ArcGIS 9.2 software (ESRI, Redlands, CA) and evaluated for data transmission, geo-referencing, and mapping efficiency.

4.4. Monitoring of Ospreys

As part of a long-term Osprey nest inventory and productivity monitoring program, each Osprey nest where one (or both) of the mating pair were captured and fitted with a satellite telemetry transmitter was inspected once during a two-week period throughout the summer (i.e., from egg-laying to fledging) each year. The number of eggs, chicks, or fledglings was counted and recorded at each visit. For analyses in this study, we defined a successful nest as an Osprey nest that had one or more chicks at some point during a given breeding season. In addition, we calculated the linear distance from the center of Langley AFB's primary runway to each Osprey nest where one (or both) of the mating pair were captured and fitted with a satellite telemetry package using GIS.

Osprey F46 duck blind nest with a hatchling and three eggs.

4.5. Data Management

We developed a coding/naming system to identify each individual Osprey using an alpha-numeric code that incorporates each birds gender (M = male; F = female) or age (J = juvenile) and a two-digit number from its satellite transmitter. For example, Osprey M54 represents an adult male Osprey with satellite tag #66054. This system is used throughout this report when referencing individual Ospreys. All data within this report are presented as mean ± 1 standard error.

We developed a series of databases related to biologically important time periods, utilizing the location and activity information of individual Osprey, to further enhance the analysis and interpretation of data. More specifically, we parsed data received from the satellite transmitters into four biological periods: breeding (summer), fall migration, wintering, and spring migration.

The satellite telemetry units provided altitude information for each individual GPS location as meters above MSL. However, this measure of altitude does not take topography into consideration. Therefore, converting all Osprey altitude measurements to AGL provides information that is more biologically relevant.

We obtained the elevation of the ground surface at each individual Osprey GPS location using Google Earth™ (Google, Inc., Mountain View, CA) and converted the altitude for each individual Osprey location (during the breeding, migration, and wintering periods) to meters (and feet) AGL.

4.6. Activity Patterns of Ospreys

For the location of each individual Osprey, we determined whether or not the bird was actively moving using the information provided by the satellite transmitters. At each individual location, the bird was considered as being active (i.e., flying) when the flight speed was > 0 kph, when the flight speed was 0 kph and the altitude was > 35 m AGL, or when the flight speed was 0 kph and the altitude was < 35 m AGL but the bird was clearly over an area of water with no apparent perch location (as determined from satellite imagery).

We determined the proportion of activity for each Osprey during 10 time periods within a day (i.e., at 2–hr intervals) during the breeding (summer), fall migration, wintering, and spring migration periods. In addition, we determined the proportion of activity for each Osprey during each month of the breeding season (combined across daily time periods).

4.7. Home Ranges of Ospreys

In an effort to obtain an understanding of the spatial ecology of Ospreys during the breeding season (summer), we used a home range analysis approach. We estimated breeding season (summer) home range (95 % utilization distribution [UD]) and core-use area (50 % UD) sizes for each Osprey using the fixed-kernel method (Seaman and Powell 1996, Kernohan et al. 2001). We used least-squares cross-validation for bandwidth selection (Seaman et al. 1999, Kernohan et al. 2001) and used Hawth's Analysis Tools (http://www.spatialecology.com/htools) and ArcGIS 9.2 (ESRI, Redlands, CA) to calculate the sizes of breeding home ranges and core-use areas for each Osprey (in each year).

To gain insight into the spatial ecology of Ospreys during the wintering period, we determined home range sizes of Ospreys while they were on their respective wintering grounds. We parsed the data and used only locations obtained at 06:00, 12:00, and 18:00 hr local time (i.e., 3 locations per day) for consistency across the entire wintering period. We used the fixed-kernel method (Seaman and Powell 1996, Kernohan et al. 2001) to estimate wintering home range (95 % UD]) and core-use area (50 % UD) sizes for each Osprey during each wintering period (i.e., year). We used least-squares cross-validation for bandwidth selection (Seaman et al. 1999, Kernohan et al. 2001) and used Hawth's Analysis Tools and ArcGIS 9.2 to calculate the sizes of wintering home ranges and core-use areas for each Osprey (in each year).

4.8. Osprey Migration Data

We monitored the fall migration of adult and juvenile Ospreys as they traveled to their wintering areas (outside of the U.S.). We defined the fall migration period as the day each bird left its breeding/summer grounds near Langley AFB to the day it appeared to arrive on its wintering grounds.

Following the wintering period, we monitored the spring migration of adult Ospreys as they traveled to their breeding grounds (near Langley AFB). We defined the spring migration period as the day each bird left its wintering area to the day it appeared to arrive on its breeding grounds.

4.9. Assessing BASH Risk Potential of Breeding Ospreys

Female Osprey perched on a channel mark nest in the Back River.

Through consultations with airspace managers, flight planners, and military pilots, we explored various options to assess the BASH risk potential of Ospreys at Langley AFB. We decided an appropriate risk assessment model was to consider specific Osprey locations as being similar to other aircraft hazards, most notably vertical obstructions. Vertical obstructions are generally created by buildings, structures, or other natural features that may encroach into navigable airspace (Class-D airspace and military training routes), presenting an aircraft and public safety hazard (USDOT 1993). Code of Federal Regulations Title 14 Part 77 regulation provides a standardized calculation for assessing the elevation of vertical obstructions in relation to an airfield using criteria defined by airfield IS. We geo-referenced all Osprey location and movement data acquired from the satellite transmitters during the breeding (summer) period to create a dataset that contained only Osprey locations that were within the Langley AFB IS. These datasets were used to determine spatial and temporal patterns of Osprey activity and airspace use to determine the level of risk Ospreys pose to Langley AFB aircraft and the potential impact to military readiness. These data sets also provide a baseline from which to model and evaluate proposed BASH risk reduction management programs.

Using the Part 77 regulation as a template and a dimensional guide, we developed a series of altitude-based areas of local airspace at Langley AFB referred to as areas of critical airspace. These areas of critical airspace (each appropriately named for the IS below it) constitute a volume of airspace that is (horizontally and vertically) in the shape and dimension of the IS it is above.

Each area of critical airspace begins at the altitude of the IS and extends upward to an altitude of 2,500 ft AGL. Based on these criteria, we developed and conducted three types of analyses for quantifying the BASH risk potential of Ospreys during breeding season: control area, breeding points at-risk, and airspace risk polygon. These BASH risk criteria are defined as follows:

4.9.1. Control Area

The control area of an airfield includes both the primary surface and accident potential zone (also referred to as the clear zone). Due to several factors, including aircraft phase of flight and limited airspace for pilot action, there is a relatively high probability of an Osprey-strike with likely critical severity of mishaps in this critical area, resulting in a high level of BASH risk potential if Ospreys are frequently present within the control area. We considered any Osprey location (irrespective of activity) found within the control area to be a location where the bird was a hazard for aircraft operating at Langley AFB. Using GIS, we quantified the number of locations each individual satellite-tagged Osprey was found in the control area at Langley AFB during each breeding season.

4.9.2. Breeding Points At-Risk Analysis

We developed and implemented a breeding points at-risk analysis to quantify the proportion of time breeding Osprey represented a potential hazard to military aircraft operating within the controlled airspace at Langley AFB. Using GIS, we selected only those Osprey locations (for each individual bird during each breeding season) that were moving (e.g., flying) within one of the areas of critical airspace and considered these Osprey locations as at-risk for a collision with military aircraft.

At-risk Osprey locations were summarized and analyzed during the breeding season to determine if gender, time of day, or month (of the year) influenced the frequency that Ospreys were present in a location (airspace) that made them a potential hazard to safe aircraft operations. We calculated the number of at-risk locations as a proportion of all locations where the Osprey was moving (within the breeding period) and as a proportion of all Osprey locations (within the breeding period). Correlation analyses was used examine potential relationships between the distance from satellite-tagged Osprey nests to the airfield and the proportion of at-risk Osprey locations within each area of critical airspace.

4.9.3. Airspace Risk Polygon Analysis

We developed and implemented an airspace risk polygon analysis to provide a quantitative spatial model of airspace use by breeding Ospreys to determine which areas of critical airspace were used by these birds (i.e., where they were a potential or identified hazard to military aircraft). Using GIS, we queried the dataset and selected only those Osprey locations where the bird was actively flying at an altitude of 150 ft AGL or higher within the (horizontal dimensions) of the IS. Using this dataset, we developed an airspace risk polygon for each individual Osprey by determining a 75 % UD using the fixed-kernel method (Seaman and Powell 1996, Kernohan et al. 2001). We used least-squares cross-validation for bandwidth selection (Seaman et al. 1999, Kernohan et al. 2001) and used Hawth's Analysis Tools and ArcGIS 9.2 to calculate the size of the airspace risk polygon for each Osprey during each breeding season.

Using the IS associated with Langley AFB, we calculated the total area of overlap between the airspace risk polygon and each component of the area of critical airspace. Each airspace risk polygon was summarized and analyzed to determine if gender or nest/reproductive success influenced the size of these spatial risk models.

4.10. Assessing BASH Risk Potential of Migrating Osprey

Osprey data provided by satellite telemetry during fall and spring migration periods and U.S. military aeronautical data were geo-spatially evaluated to determine the level of risk migrating Osprey are to military aircraft operating in MTA along the Eastern seaboard of the United States. Only Osprey locations north of the 24° N parallel were considered for this analysis.

Using GIS, we extracted geo-referenced digital information representing all military airfields, special use airspace (SUA), and military training routes (MTR) within the U.S. obtained from the Digital Aeronautical Flight Information File database. In addition, we consulted DoD Flight Information Publication Area AP/1B, Area Planning Military Training Routes for North American, for guidance pertaining to military training routes (NGA 2009).

We developed and implemented two types of analyses quantifying BASH risk potential of Ospreys during their fall and spring migration periods: migration points at-risk and migration route risk.

4.10.1. Migration Points At-Risk Analysis

In an effort to quantify the proportion of time migrating Ospreys (during both fall and spring migrations) were a potential hazard to military aircraft operating along the Atlantic seaboard, we developed and conducted a migration points at-risk analysis. Each individual Osprey location (within each fall or spring migration period) was examined to determine if the bird was at-risk to military aircraft. Using GIS, we queried each individual Osprey location (while the birds were in the U.S.) and determined if it fell into the operational boundaries of a type of MTA. Next, we examined the activity status of the bird at that specific location and removed Osprey locations where the bird was not actively moving (as the bird would not pose a hazard to aircraft). Lastly, we compared the altitude (specifically using AGL) of each Osprey point location (of moving birds only) to determine if the bird was above, below, or within the altitudinal boundaries of MTA. The final at-risk datasets contained only those Osprey locations where the bird was actively moving (e.g., flying) within MTA and therefore posed a hazard to military aircraft operations.

We summarized and analyzed these at-risk locations (for fall and spring migrations separately) to determine if gender influenced the frequency that Ospreys were present in the various types of MTA and consequently posed a hazard to military aircraft operations. We calculated the number of at-risk points as a proportion of all locations where the bird was moving (while the bird was migrating in the U.S.) and as a proportion of all Osprey locations (while the bird was migrating in the U.S.).

4.10.2. Migration Route Risk Analysis

We developed and implemented a migration route risk analysis for identifying and quantifying the spatial distribution of BASH risk potential of Ospreys during the fall and spring migration periods. This analysis provides an assessment of the frequency that migrating Ospreys pass through MTA (hereafter referred to as an incursion) and allowed us to identify which airspace migrating Ospreys flew through most often.

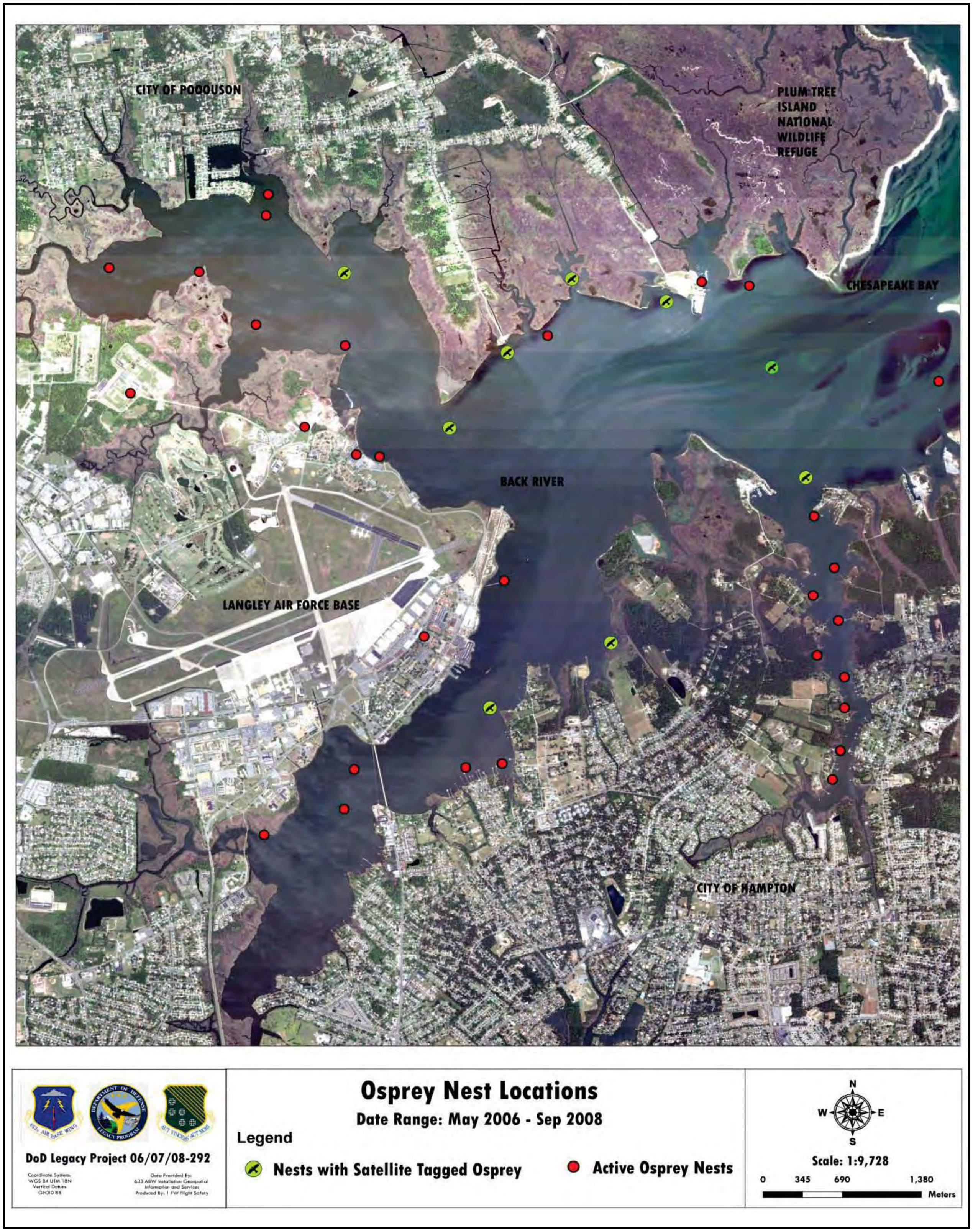
Using GIS, we created a geo-spatially referenced migration route for each individual Osprey by converting all Osprey locations for each bird during each migration (fall and spring) into a line feature (also referred to as a flight track). We analyzed the migration route of each Osprey and determined the number and identity of all MTA Osprey crossed along their respective migratory paths (i.e., Osprey incursions). The vertical dimensions of MTA intersected by migrating Osprey was compared to the average flight altitude (1,150 ft AGL) and those MTAs completely above the average flight altitude were removed. The final migration route risk datasets contained only MTA intersected by Osprey flying at 1,150 ft AGL. We summarized these datasets and determined the frequency of Osprey incursions into the various types of airspace used by military aircraft (for fall and spring migrations separately) and determine if gender influenced the frequency that Ospreys were present within various types of MTA.

5. RESULTS AND DISCUSSION

5.1. Breeding Ecology

We monitored 13 adult Ospreys (five males and eight females) fitted with satellite transmitters during the 2006 and 2007 tagging sessions near Langley AFB (Figure 4) during 17 cumulative breeding seasons (See Appendix B for detailed breeding period maps). Two Ospreys (M52 and F94) were monitored during two consecutive breeding periods and one Osprey (M54) was monitored during three consecutive breeding periods. A total of 19,241 individual GPS locations were collected and analyzed from 16 complete (i.e., bird left for fall migration) and 1 partial (i.e., mortality event occurred within) breeding period datasets (Table 1). In addition, we monitored two juvenile Ospreys (J51 and J54) during their first summer.

Figure 4. Locations of active and satellite tagged Osprey nests on and surrounding Langley AFB, Virginia – Map 4.



Analyses of the Osprey location data provided by the satellite tracking system suggests that adult female Ospreys were actively moving 12.5 % of the times they were tracked (averaged across the breeding period), whereas adult male Ospreys were actively moving 15.7 % of the times they were located by the satellite transmitter.

Table 1. Summary of data collected from satellite-tagged adult Osprey during the breeding (summer) period.

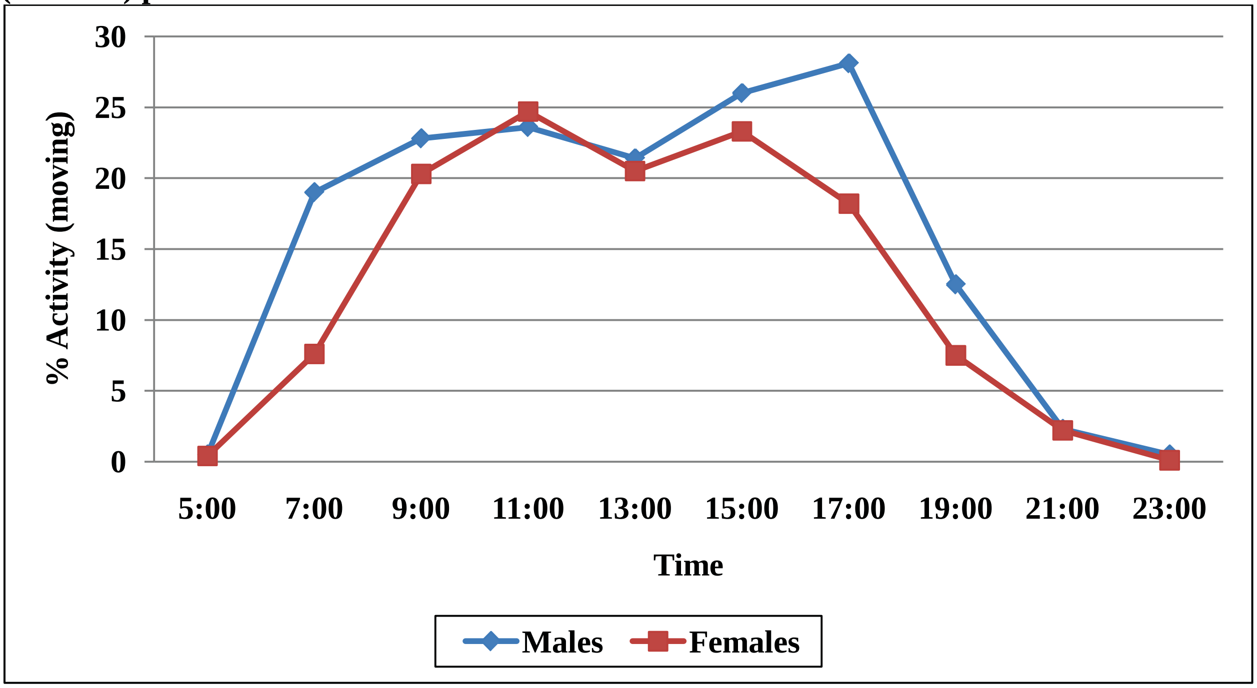
Nest Location	Bird ID	Study Year	Dates	No. of Locations
Duck Blind 222	F46	2006	16 May – 29 Aug	1,053
Duck Blind 222	M47	2006	16 May – 9 Sep	1,159
Duck Blind 211	F48A	2006	16 May – 15 Aug	912
Duck Blind 205	F49	2006	17 May – 22 Aug	969
Duck Blind 210	M50	2006	17 May – 26 Sep	1,319
Duck Blind 223	M52	2006	21 May – 6 Sep	1,091
Duck Blind 205	F27	2007	1 Jun – 30 Aug	901
Channel Marker 13	F28	2007	1 Jun – 25 Aug	849
Water Pylon 304	F94	2007	1 Jun – 12 Aug	720
Water Pylon 121	F48B	2007	2 Jun – 3 Sep	930
Duck Blind 223	M52	2007	12 Mar – 25 Aug	1,662
Duck Blind 210	F53	2007	31 May – 3 Sep	947
Duck Blind 202	M54	2007	31 May – 11 Sep	1,030
Water Pylon 121	M98 [a]	2007	2 Jun – 13 Aug [a]	720 [a]
Duck Blind 202	M54	2008	20 Mar – 14 Sep	1,779
Water Pylon 304	F94	2008	13 Apr – 18 Aug	1,266
Duck Blind 202	M54	2009	20 Mar – 29 Sep	1,930

[a] *Mortality of this Osprey occurred during the breeding (summer) period.*

During the breeding period, Ospreys exhibited a diurnal activity pattern. Information from the satellite transmitters shows that Osprey movements were generally restricted to daylight hours, with the majority of activity occurring between 09:00 and 17:00 hr local time (Figure 5). Adult Ospreys were typically active relatively equally throughout daylight hours (Figure 5).

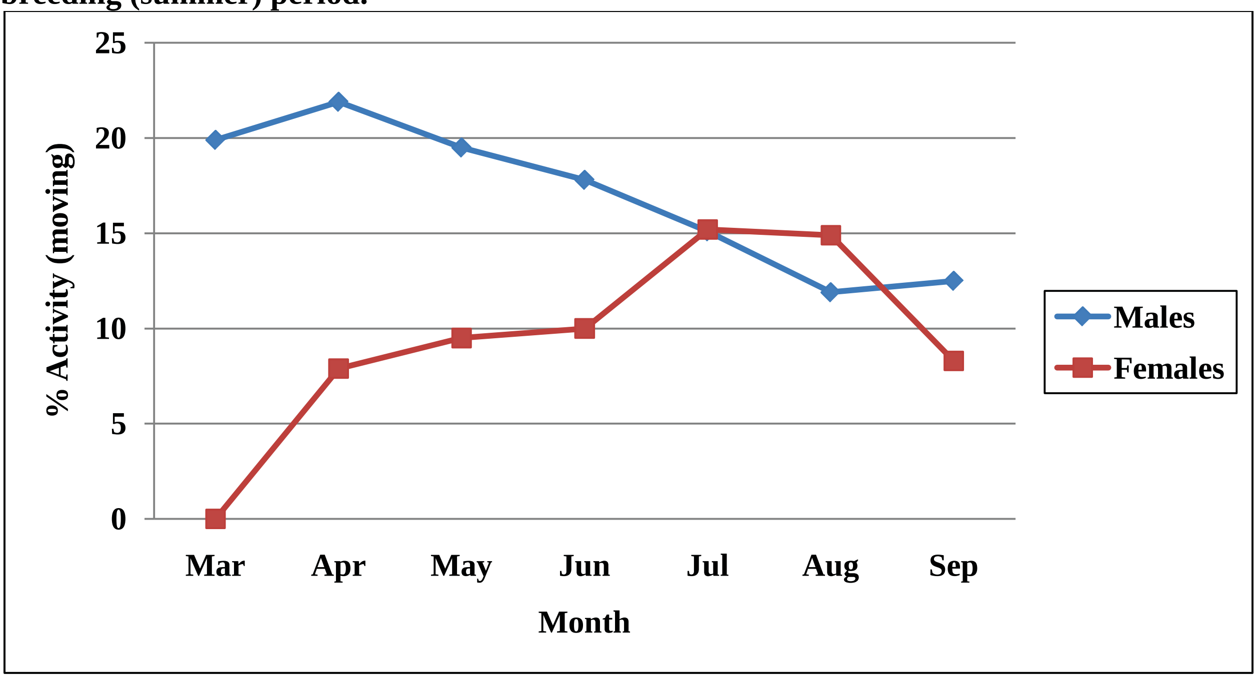
When examined across the breeding season, Osprey activity varied by month and by gender (Figure 6). Adult male Ospreys were relatively active throughout the breeding season, with a slight decline in overall activity as the breeding season progressed. In contrast, adult female Ospreys were least active during April through June and most active during July and August.

Figure 5. Daily activity patterns of male and female adult Ospreys during the breeding (summer) period.[a]



[a] *No female Ospreys were tracked during March.*

Figure 6. Activity patterns of male and female adult Ospreys by month during the breeding (summer) period.[a]



[a] *No female Ospreys were tracked during March.*

The average speed and altitude that female adult Ospreys flew at was 26.4 kilometers per hour (kph; range = 1 to 123 kph) and 64.9 meters (m) AGL; range = 1 to 1,136 m AGL), respectively. Males flew at an average speed of 26.4 kph (range = 1 to 85 kph) and at an average altitude of 58.5 m AGL (range = 1 to 1,460 m AGL).

During the breeding season, male and female adult Ospreys had home ranges and core-use areas (i.e., an assessment of space use by these birds) of similar size (Table 2). However, nest success (defined as the presence/absence of chicks) clearly influenced the home range size and core-use areas of adult Ospreys during the breeding season. Ospreys (irrespective of gender) associated with unsuccessful nests had home range sizes that were approximately twice as large as Ospreys associated with successful nests (Table 2).

Table 2. Average (± 1 SE) home range (95% utilization distribution) and core-use area (50% utilization distribution) sizes (km^2) of adult Ospreys during the breeding (summer) periods of 2006, 2007, 2008, and 2009.

Group	*n*	Home Range ± 1 SE (km^2)	Core-Use Area ± 1 SE (km^2)
Males	8	30.8 ± 4.44	2.8 ± 0.51
Females	9	31.7 ± 12.35	2.9 ± 1.51
Successful Nests	9	19.6 ± 5.56	1.7 ± 0.43
Unsuccessful Nests	8	44.5 ± 11.37	4.1 ± 1.59

During the 2006–2008 breeding seasons, two adult female and one adult male Ospreys left their breeding grounds (near Langley AFB) and made post-breeding dispersal movements prior to their fall migration.

On 5 August 2006, Osprey M50 left the Back River nesting territory near Langley AFB and travelled 130 km to an area on the Virginia–North Carolina border in southwestern Greenville County (VA). Osprey M54 remained in this area, apparently using a series of ponds, for seven days. Osprey M50 returned to the Back River on 13 August 2006 and remained there until fall migration.

Osprey F53 moved from the Back River nesting area near Langley AFB to Spotsylvania County in north central Virginia during 21 August 2007 to 24 August 2007. During this presumed pre-migratory dispersal, Osprey F53 traveled approximately 175 km in four days to an area near Fredericksburg Virginia. Osprey F53 remained in this area for a period of 10 days until fall migration.

On 22 June 2007, Osprey F94 left the Back River nesting area and began a series of movements to the Virginia–North Carolina border, to an area in south central Virginia, and ultimately to the Yadkin River in Davie County in central North Carolina (southwest of Winston-Salem, North Carolina). In mid-July, Osprey F94 traveled approximately 400 km (in two days) and returned to the Back River. After four days, Osprey F94 again flew to an area southwest of Winston-Salem, North Carolina and remained there until fall migration.

During the 2008 breeding season, Osprey F94 once again began a series of post-breeding dispersal movements, similar to the previous year. Osprey F94 left the Back River nesting area on 9 June 2008 and spent 12 days in a tidal area on the southern shore of the James River (near Bartlett, Virginia). Next, Osprey F94 then traveled across central Virginia and then southwest to the Yadkin River in Davie County in central North Carolina (the same general area as the previous summer). After spending the first two weeks of July on the Yadkin River (North Carolina), Osprey F94 traveled approximately 400 km (in two days) and returned to the Back River near Langley AFB. Osprey F94 spent 15 days in the Back River and then travelled back to North Carolina at the Yadkin River on 1 August 2008. Osprey F94 remained there until fall migration.

Two mortalities of adult Ospreys occurred while the birds were on their breeding grounds near Langley AFB (i.e., during the breeding period). Just 20 days after returning from spring migration to the Back River nesting site, Osprey F48A was found by the research team on 13 April 2007. Osprey F48A was entangled in a plastic grocery bag (e.g., trash) in the duck hunting blind where her nest was located. On 12 August 2007, the research team recovered the satellite transmitter and discovered the remains of Osprey M98 entangled in construction silt fencing adjacent to a storm water retention pond.

Remains of Osprey M98 found entangled in a silt fence at newly constructed retention pond.

Osprey J54 was satellite-tagged as a fledgling while in the nest near Langley AFB. During the initial 26 days Osprey J54 was tracked and remained at the nest with no evidence to suggest movement from the nest. Osprey J54 made a first flight attempt (that was noted by satellite tracking efforts) on 14 July 2006. During the next 12 days, Osprey J54 was actively moving 4.5 % of the time while located by the satellite tracking system. During most of this time the tracking locations suggested Osprey J54 was less than 1 km from nest.

Osprey J51 was sent (as a fledgling) from Langley AFB to Indiana as part of the translocation program. Osprey J51 was placed into the hacking program at the Jasper-Pulaski Wildlife Management Area and was satellite-tagged on 23 July 2006. During the initial 28 days Osprey J51 was actively moving (e.g., flying) 4.2 % of the times when located by the satellite tracking system. Osprey J51 spent most of the time within 5 km of the hacking site.

Osprey J51 perch at the hacking nest with temporary color markings, bands, and a GPS transmitter.

On 20 August 2006, Osprey J51 began flying east and traveled 355 km during a 2-day period and settled into an area along the southern shore of Grand Lake, located near St. Mary's Ohio. Osprey J51 spent the next 37 days in an area along the lakeshore and was actively moving 6.4 % of the time when located by satellite during this time period.

5.2. Fall Migration

We monitored 12 adult Ospreys (four males and eight females) fitted with satellite transmitters during the 2006 (Figure 7) and 2007 tagging sessions near Langley AFB through a total of 15 fall migration periods (see Appendix C for detailed fall migration period maps). Two adult Ospreys (M52 and F94) were monitored during two consecutive fall migrations and one adult Osprey (M54) was monitoring during three entire fall migrations. A total of 3,038 individual GPS locations were collected and analyzed from nine complete (i.e., bird arrived on wintering grounds) and six partial (i.e., lost contact with bird during migration) fall migration datasets (Table 3).

Table 3. Summary of data collected from satellite-tagged Osprey during the fall migration period.

Osprey ID	Study Year	Dates	Ave. Altitude (ft)	Ave. Altitude (m)	Total Distance (miles)	Total Distance (km)	No. of Locations
F46	2006	30 Aug – 26 Sep	1,177	358	3,324	5,350	270
M47	2006	10 Sep – 18 Sep	1,124	343	1,324	2,130	90
F48A	2006	16 Aug – 13 Sep	1,147	350	4,076	6,560	288
F49[a]	2006	23 Aug – 17 Sep [a]	1,086	331	2,566	4,130	252 [a]
M50[a]	2006	27 Sep – 17 Oct [a]	1,163	355	2,187	3,520	192 [a]
M52	2006	7 Sep – 22 Sep	994	303	2,790	4,490	160
F27	2007	31 Aug – 23 Sep	1,121	342	2,106	3,390	237
F28[a]	2007	26 Aug – 9 Sep [a]	1,385	422	2,138	3,440	144 [a]
F94	2007	13 Aug – 10 Sep	1,310	399	3,281	5,280	289
F48B[a]	2007	4 Sep – 21 Sep [a]	1,287	392	2,443	3,610	178 [a]
M52[a]	2007	26 Aug – 12 Sep [a]	1,040	317	2286	3,680	177 [a]
F53[a]	2007	4 Sep – 21 Sep a	1,156	352	2,579	4,150	166 [a]

Table 3. (CONTINUED)

Osprey ID	Study Year	Dates	Ave. Altitude (ft)	Ave. Altitude (m)	Total Distance (miles)	Total Distance (km)	No. of Locations
M54	2007	12 Sep – 27 Sep	1,399	426	2,579	4,150	159
F94	2008	19 Aug – 15 Sep	1,334	407	3,387	5,450	279
M54	2008	15 Sep – 30 Sep	1,093	333	2,548	4,100	157

[a] *Mortality of this Osprey or transmitter failure occurred during the fall migration period.*

Fall migration data provided by the satellite tracking system shows that adult female Ospreys began their fall migrations (average departure date of 26 August; range of departure dates among females: 13 August to 4 September) prior to adult male Ospreys (average departure date of 11 September; range of departure dates among males: 26 August to 27 September). Mated pairs of Ospreys did not leave their breeding grounds at the same time and did not migrate together.

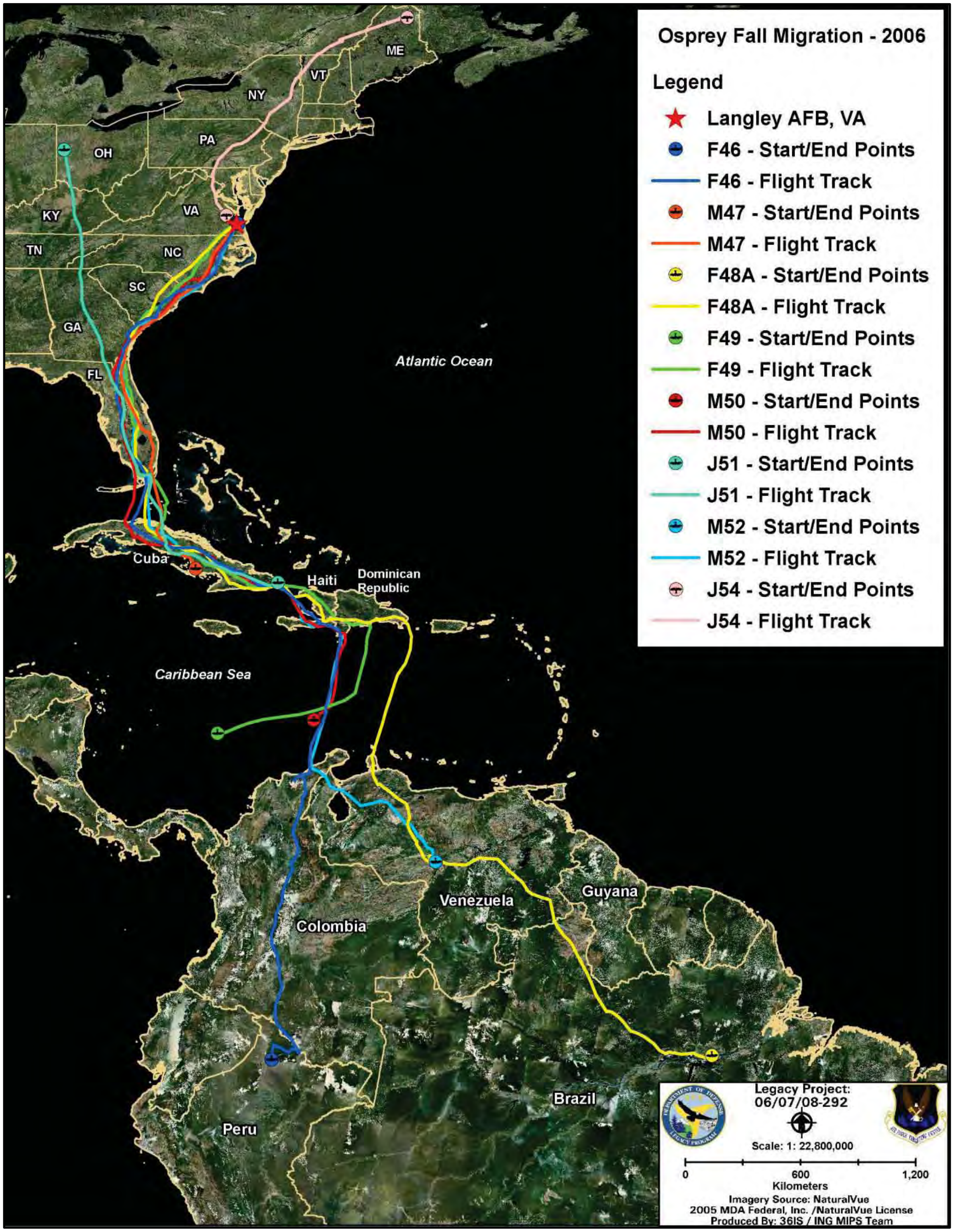
All adult Ospreys utilized a similar geographic route during their fall migrations, travelling along the eastern coast of the United States, through the state of Florida, and across the Straits of Florida to Cuba. Most Ospreys migrated through Cuba and into Hispaniola prior to making the open ocean crossing over the Caribbean Sea and into various wintering locations in South America.

Adult female Ospreys arrived on their respective wintering grounds (average arrival date of 11 September) earlier than adult males (average arrival date of 24 September). Ospreys arrived on their respective wintering grounds as early as 9 September (Osprey F28) and as late as 17 October (Osprey M50).

On average, adult female Ospreys spent 27 ± 0.9 days migrating to their wintering grounds. Adult male Ospreys spent less time on fall migration, traveling for only 14 ± 1.8 days to reach their wintering grounds. The duration of fall migration varied among individual Ospreys, ranging from nine days (Osprey M47) to 29 days (Osprey F48A).

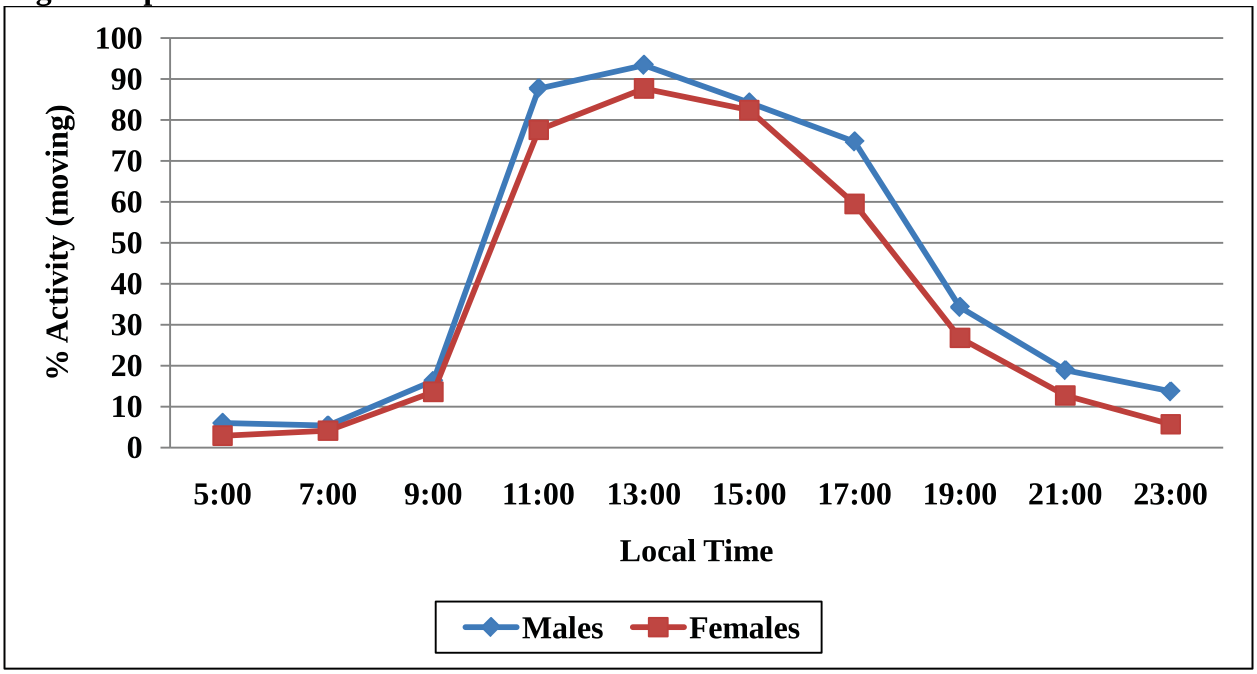
Female Ospreys traveled an average of 5,206 ± 510.7 km total distance during fall migration, whereas male Ospreys traveled an average of 3,718 ± 536.2 km to reach their wintering grounds. Female Osprey F48A migrated the furthest distance, traveling over 6,560 km to her wintering area on the Amazon River in Brazil.

Figure 7. Flight tracks of satellite-tagged Osprey during the 2006 fall migration period – Map 5.



Both male and female adult Ospreys migrated during daylight hours (primarily between 11:00 and 17:00) and typically roosted during night-time hours (Figure 8). On average, male Ospreys (234 ± 16.9 km per day) typically traveled greater distances per day when migrating compared to females (196 ± 10.4 km per day).

Figure 8. Daily activity patterns of male and female adult Ospreys during the fall migration period.



The flight characteristics of adult male and female Ospreys during fall migration were similar. Males migrated at an average speed of 39 ± 0.9 kph and at an altitude of 337 ± 16.2 m AGL, whereas females flew at an average speed of 40 ± 0.7 kph and at an altitude of 365 ± 11.7 m AGL.

An examination of the migration pattern of adult Ospreys revealed that during fall migration, all of the Ospreys in this study exhibited a consistent daily routine of diurnal migration and use of a resting area at night. We examined this migration pattern in more detail for the portion of fall migration that occurred while Ospreys were in the U.S.

We documented 84 uses of a resting area, with a duration of 1 night for 82 of the 84 (97 %) uses and a duration of 2 days (i.e., two consecutive nights spent in the same locality) for 2 uses. Osprey F46 and Osprey F49 each spent a two-day period in an area (i.e., they did not migrate for one day).

Osprey J54 left the Back River near Langley AFB and begin flying north during a suspected post-fledgling movement on 26 July 2006. During the next 12 days, Osprey J54 traveled over 1,400 km on a travel route through the states of Virginia, Maryland, Pennsylvania, New York and Vermont, across Canada, and finally into the northern areas of Maine. For approximately two weeks, Osprey J54 settled into a remote area near Ashland, Maine.

During this time, all of Osprey J54 locations were within 10 km of each other. Apparently the victim of a predator (perhaps a Great-horned Owl), the remains of Osprey J54 and the satellite transmitter were found by wildlife professionals on 20 August 2006.

Osprey J51 departed for fall migration on 28 September 2006 from Grand Lake near St. Mary's, Ohio. During the next 15 days, Osprey J51 migrated over 2,730 km. From Ohio, Osprey J51 traveled south across Kentucky and Tennessee, crossed the Appalachian Mountains near Gatlinburg, Tennessee, through the states of Georgia and Florida, crossed the straits of Florida into Cuba. The last information received from Osprey J51's satellite transmitter was on 12 October 2006 and the location information was from an area southeast of Baracoa, Cuba.

5.3. Wintering Ecology

We monitored seven adult Osprey (three males and four females) fitted with satellite transmitters during the 2006 and 2007 tagging sessions near Langley AFB during eight wintering periods (see Appendix D for detailed winter period maps). Three Ospreys (M52, M54, and F94) were monitored (at least partially) during two consecutive wintering periods. One Osprey (M54) provided data for 2 consecutive complete wintering periods. A total of 6,572 individual GPS locations were collected and analyzed from five complete (i.e., bird left on spring migration) and three partial (i.e., lost contact with bird during winter) wintering period datasets (Table 5).

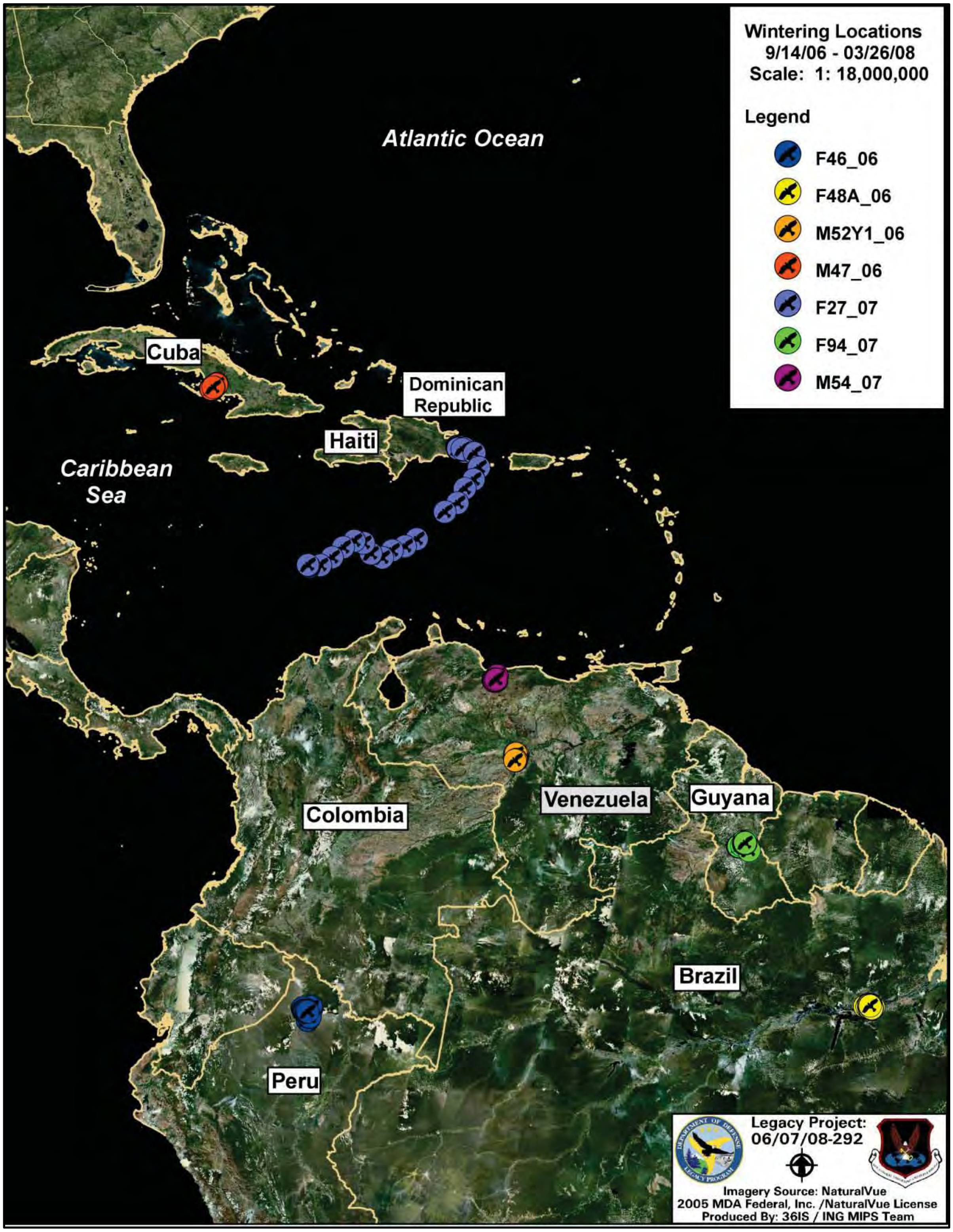
Table 4. Summary of data collected from satellite-tagged Osprey during the wintering period.

Osprey ID	Study Year	Dates	No. of Locations
F46[a]	2006	26 Sep - 28 Oct [a]	321[a]
M47[a]	2006	19 Sep - 22 Oct [a]	334[a]
F48A	2006	14 Sep - 2 Mar	1,183
M52	2006	23 Sep - 24 Feb	1,030
F27[a]	2007	24 Sep - 21 Oct [a]	275[a]
F94	2007	11 Sep - 26 Mar	1,404
M54	2007	28 Sep - 6 Mar	1,047
M54	2008	1 Oct – 8 Mar	989

[a] *Mortality of this Osprey or transmitter failure occurred during the wintering period.*

The satellite-tagged Ospreys in this study selected diverse wintering areas in the Caribbean or South America (Figure 9), including the Amazon River in Brazil (Osprey F48A), areas of northern Peru (Osprey F46), the southern coast of Cuba (Osprey M47), the Dominican Republic (Osprey F27), the Orinoco River in Venezuela (Osprey M52), the Berbice River in Guyana (Osprey F94 wintered in this location in 2 consecutive years), and Lake Valencia in Venezuela (Osprey M54 wintered in this location in 2 consecutive years).

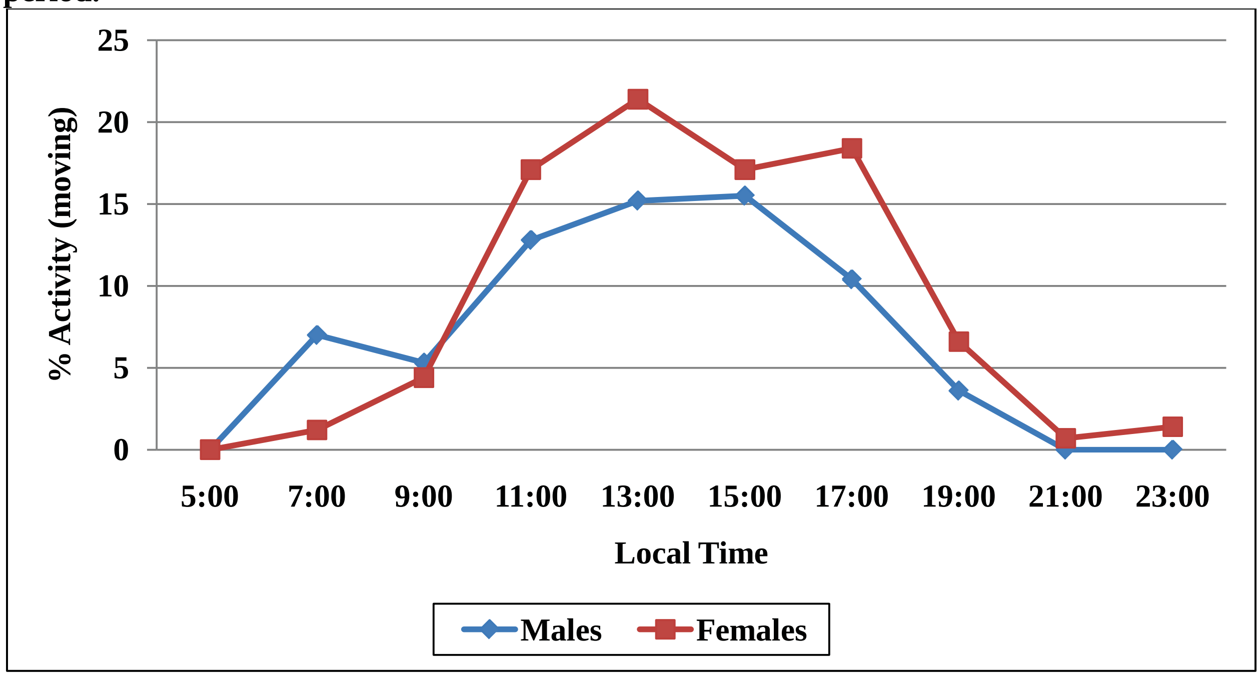
Figure 9. Wintering locations of satellite-tagged Osprey – Map 6.



The average time period Ospreys spent on their respective wintering grounds was from 17 September to 5 March. On average, female Ospreys spent 148 days on their wintering grounds whereas male Ospreys wintered for average of 170 days. Both male and female Osprey preferred to winter in isolated forested habitats located near a major water resource, such as river or lake.

Wintering Ospreys exhibited a diurnal activity pattern. Information from the satellite transmitters shows that Osprey movements were much less frequent than during migratory and breeding (summer) periods. Wintering Ospreys restricted their movements to daylight hours, with the majority of activity occurring between 10:00 and 16:00 hr local standard time (Figure 10). Female and male Ospreys exhibited similar activity patterns during the wintering period (Figure 10).

Figure 10. Daily activity patterns of male and female adult Ospreys during the wintering period.



The average winter home range size for the female Ospreys (22.1 ± 3.85 km^2) was larger than the males (6.4 ± 4.03 km^2). Similarly, the average size of the core-use area for female Ospreys (2.22 ± 0.30 km^2) was larger than for male Ospreys (0.8 ± 0.06 km^2) during their wintering period. Ospreys (n = 3) that wintered on a river had larger home ranges than the Osprey that wintered on a lake (Osprey M54; Table 5).

Table 5. Fixed-kernel home range (95% utilization distribution) and core-use area (50% utilization distribution) sizes (km^2) for four Ospreys during the wintering period. Adult male Osprey M54 was studied during 2 consecutive wintering periods.

Osprey ID	Wintering Location	Home Range (km^2)	Core-Use Area (km^2)
Female F48A	Amazon River, Brazil	25.98	1.92
Female F94	Berbice River, Guyana	18.28	2.51
Male M52	Orinoco River, Venezuela	14.45	0.87
Male M54 (2007)	Lake Valencia, Venezuela	2.24	0.67
Male M54 (2008)	Lake Valencia, Venezuela	2.53	0.76

5.4. Spring Migration

We monitored four adult Ospreys (two females and two males) fitted with satellite transmitters during 2006 or 2007 near Langley AFB through five spring migration periods (see Appendix E for detailed spring migration period maps). One Osprey (male Osprey 54) was monitored during two consecutive spring migrations. A total of 779 individual GPS locations were collected and analyzed from five complete (i.e., bird arrived on breeding grounds) spring migrations (Table 6).

Spring migration data provided by the satellite tracking system shows that tagged Ospreys departed their respective wintering grounds as early as 25 February (Osprey M52) and as late as 27 March (Osprey F94). On average, male Ospreys (average departure date of 4 March) left their wintering grounds earlier than female adult Ospreys (average departure date of 15 March).

Table 6. Summary of data collected from satellite-tagged Osprey during the spring migration period.

Osprey ID	Study Year	Dates	Ave. Altitude (ft)	Ave. Altitude (m)	Total Distance (miles)	Total Distance (km)	No. of Locations
F48A	2007	3 Mar – 24 Mar	977	298	3,672	5,910	221
M52	2007	25 Feb – 11 Mar	1,033	315	2,628	4,230	151
F94	2008	27 Mar - 12 Apr	1,242	379	3,250	5,230	169
M54	2008	7 Mar – 19 Mar	1,449	442	2,684	4,320	127
M54	2009	9 Mar – 19 Mar	1,184	361	2,656	4,275	111

Osprey migrated in the spring following similar routes from their wintering areas in South America through Venezuela, across the Caribbean Sea, and through Cuba to Florida (Figure 11). From Florida Osprey traveled northward along the U.S. Eastern Seaboard to their breeding grounds near Langley AFB. Two Ospreys flew directly to Cuba when crossing the Caribbean Sea from South America.

Adult male Ospreys arrived on their breeding grounds near Langley AFB (average arrival date of 16 March) earlier than adult female Ospreys (average arrival date of 3 April). Ospreys arrived on their respective breeding grounds as early as 11 March (Osprey M52) and as late as 12 April (Osprey F94).

The length of spring migration (i.e., number of days Ospreys spent migrating from their wintering areas to their breeding grounds) ranged from 11 days (Osprey M47) to 22 days (Osprey F48A). On average, females migrated for 19 ± 3.5 days and males migrated for 13 ± 1.1 days during spring migration.

Female Ospreys traveled an average of 5,570 ± 340.0 km, whereas male Ospreys traveled an average of 4,275 ± 26.0 km. Osprey M52 migrated the shortest distance, traveling approximately 4,230 km from his wintering grounds on the Orinoco River in Venezuela to his breeding area in the Back River in Virginia.

Both male and female adult Ospreys migrated during daylight hours (primarily between 11:00 and 17:00 hr) and typically roosted during night-time hours (Figure 11). On average, male Ospreys (334 ± 30.8 km per day) typically traveled approximately the same distance per day of spring migration compared to females (309 ± 40.0 km per day).

During spring migration, female adult Ospreys flew at an average speed of 47 ± 2.4 kph and at an average altitude of 339 ± 40.5 m AGL. Males traveled at an average speed of 49 ± 1.7 kph and at an altitude of 373 ± 37.1 m AGL during spring migration.

An examination of the migration pattern of adult Ospreys revealed that during spring migration, the Ospreys in this study exhibited a consistent daily routine of diurnal migration and use of a resting area at night. We examined this migration pattern in more detail for the portion of spring migration that occurred while Ospreys were in the U.S. We documented 32 uses of a resting area, with a duration of 1 night for 30 of the 32 (94 %) uses and a duration of 2 days (i.e., two consecutive nights spent in the same locality) for two uses. Osprey F48A and Osprey F94 each spent a two-day period in the same area (that is, they did not migration for one day).

Figure 11. Flight tracks of satellite-tagged Osprey during the 2007 spring migration period – Map 7.

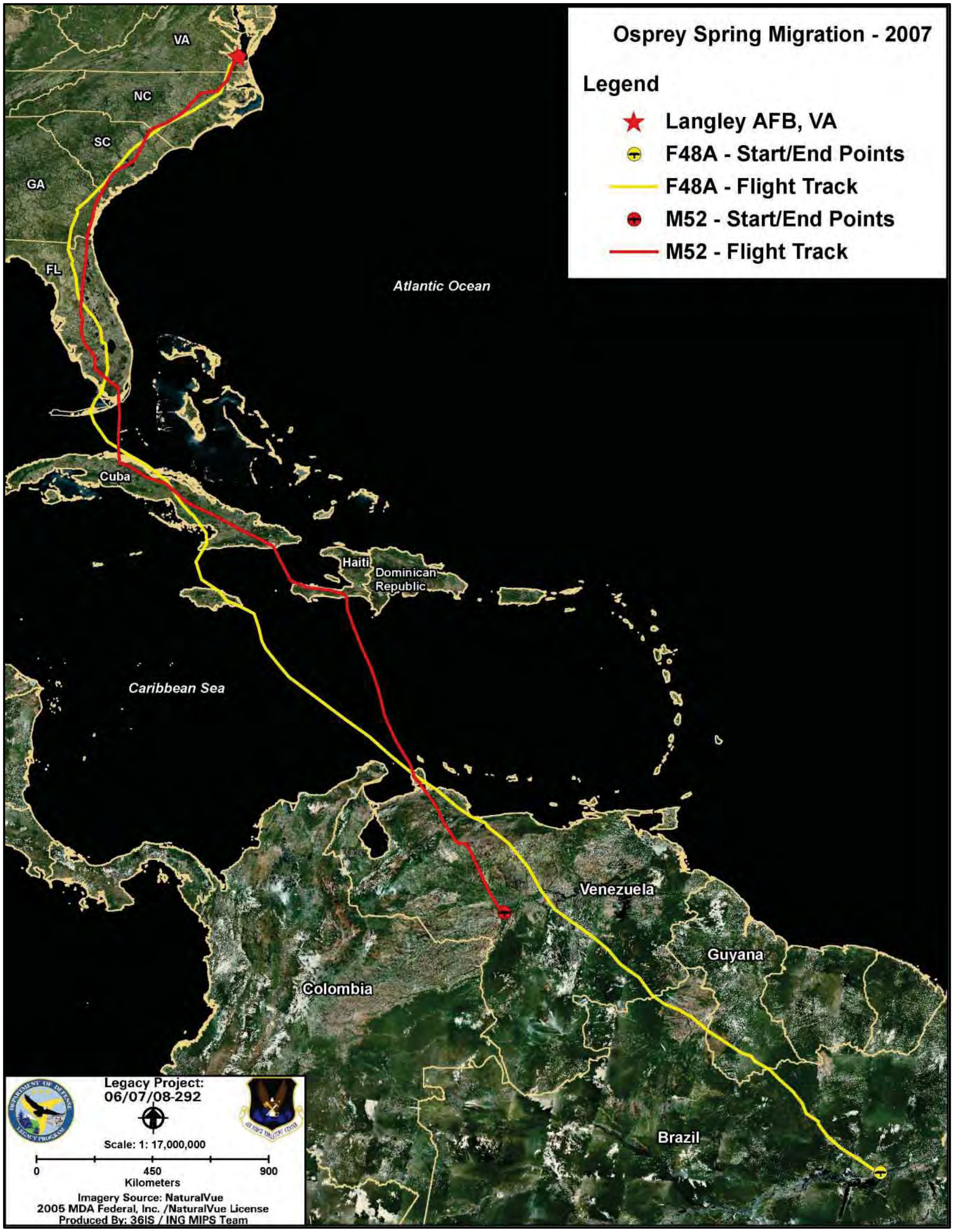
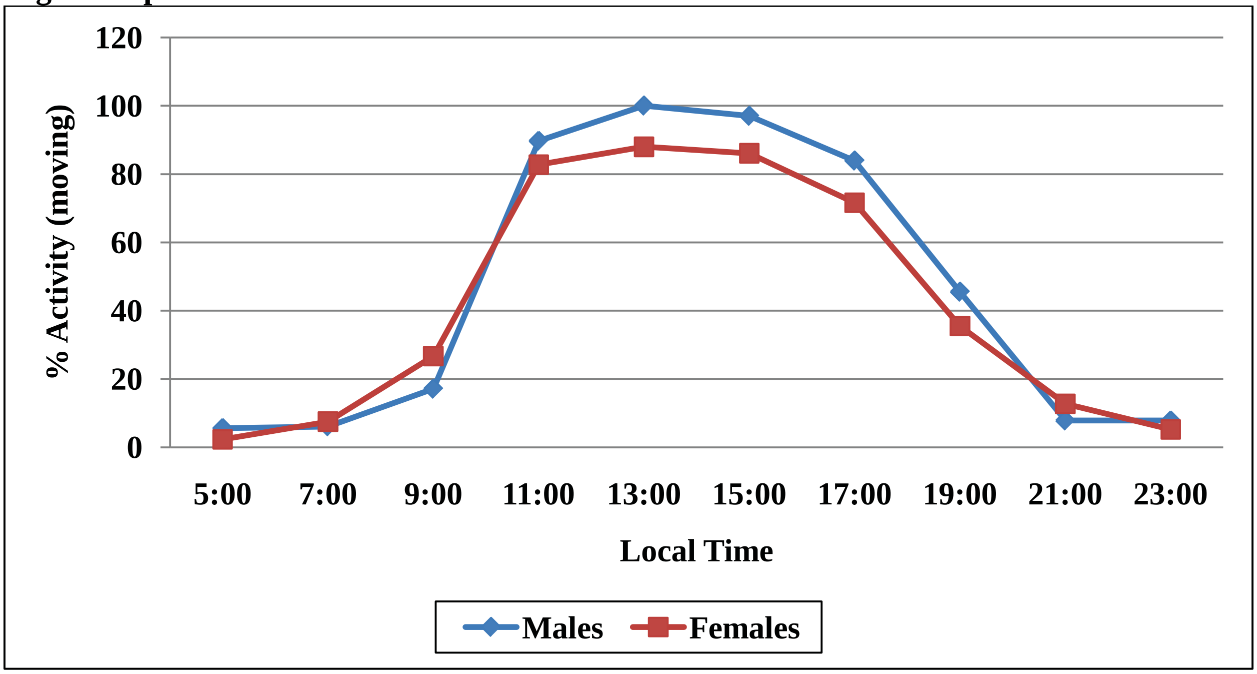


Figure 12. Daily activity patterns of male and female adult Ospreys during the spring migration period.



5.5. BASH Risk Potential of Breeding Ospreys

5.5.1. Points within Control Area

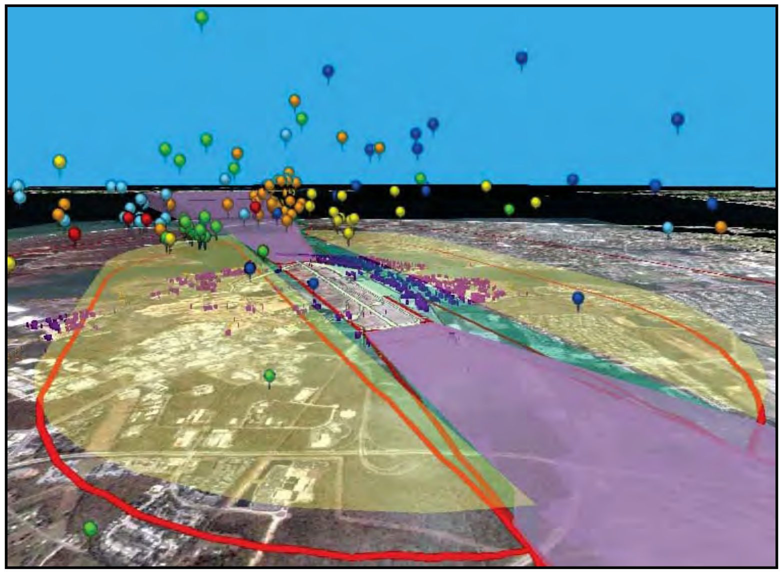
The points within the control area analysis was developed and implemented to quantify the BASH risk potential of Ospreys near Langley AFB within this crucial area of the airfield during the breeding season (see APPENDIX B and F for detailed BASH risk maps and illustrations). On average, during the breeding season adult Ospreys were present within the control area at Langley AFB (thereby posing a hazard to safe military aircraft operations) 0.1 ± 0.06 % (range for individual Ospreys = 0 % to 6.3 %) of the times they were located near Langley AFB by the satellite tracking system. When only locations from moving birds are considered, adult Ospreys were within the control area at Langley AFB 1.1 ± 0.45 % (range for individual Ospreys = 0 % to 0.9 %) of the times that they were located by the satellite tracking system.

Osprey gender and nest success did not influence Osprey use of the control area at Langley AFB during the breeding season. The proportion of Osprey locations in the control area at Langley AFB was not different between female (1.4 ± 0.69 % of times the bird was moving; 0.2 ± 0.09 % of all locations) and male (0.8 ± 0.57 % of times the bird was moving; 0.1 ± 0.07 % of all locations) adult Ospreys. Also, Ospreys that were associated with a successful nest (0.9 ± 0.56 % of times the bird was moving; 0.1 ± 0.07 % of all locations) were present in the control area with equal frequency as those Ospreys associated with unsuccessful nests (1.4 ± 0.74 % of times the bird was moving; 0.2 ± 0.10 % of all locations) during the breeding season.

The location of an Osprey nest (relative to the airfield) was not related to the proportion of Osprey locations (both sexes combined) that were within the control area. We did not find significant correlations between the distance of an Osprey nest (satellite-tagged birds) from the airfield and the proportion of Osprey locations within the control area when considering only the locations when the bird was moving ($r = 0.16$, $P = 0.55$) or when considering all Osprey locations near Langley AFB ($r = 0.19$, $P = 0.46$).

5.5.2. Breeding Period Points At-Risk

The points at-risk analyses were developed and implemented to quantify the BASH risk potential of Ospreys near Langley AFB during the breeding season (see APPENDIX B and F for detailed BASH risk maps and illustrations). Further, we determined if temporal and spatial patterns of BASH risk posed by breeding Ospreys were present. On average, during the breeding season adult Ospreys were at-risk (that is, posed a hazard to military aircraft operating in association with Langley AFB) 2.7 ± 0.28 % (range for individual Ospreys = 1.1 % to 4.7 %) of the times they were located near Langley AFB by the satellite tracking system. When only locations from moving birds are considered, adult Ospreys were at-risk 11.9 ± 2.14 % (range for individual Ospreys = 5.2 % to 44.6 %) of the times they were located by the satellite tracking system.

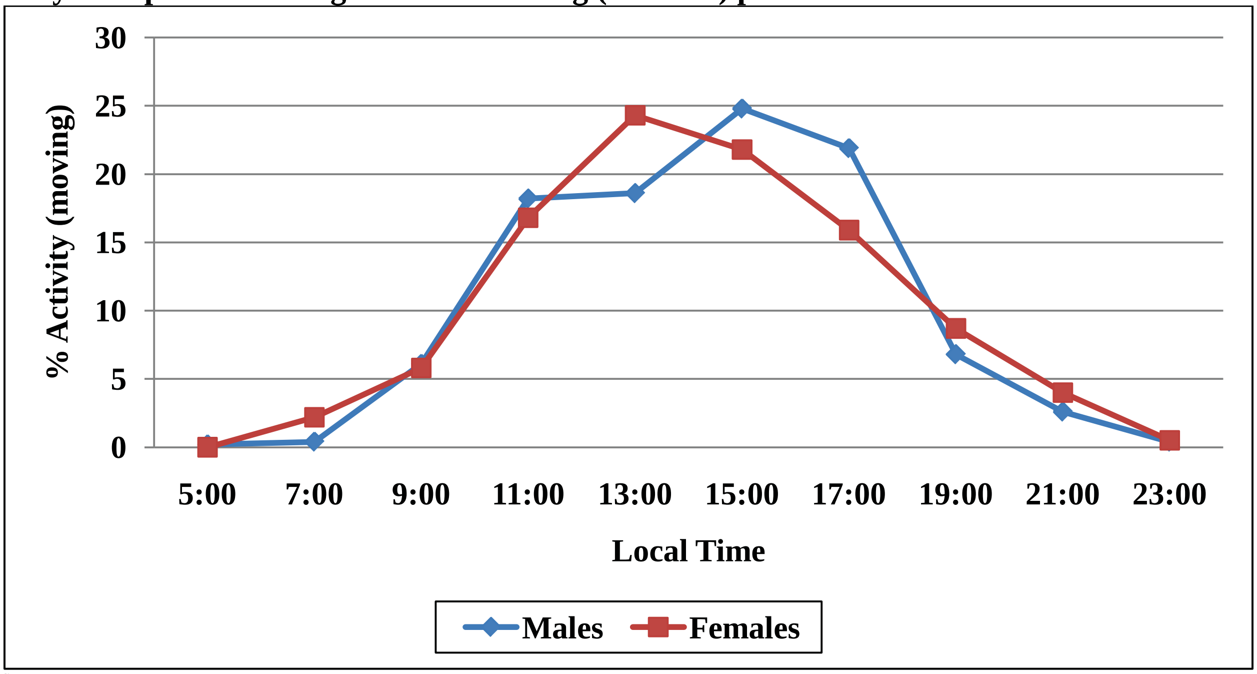


Three dimensional illustration of at-risk balloon locations of Osprey within Langley AFB Imaginary Surfaces during the 2006 breeding period.

During the breeding season female and male adult Ospreys were at-risk for a collision with military aircraft similar amounts of time (females: 2.6 ± 0.37 % vs. males: 2.8 ± 0.44 %). However, clear differences in risk among the two genders were evident when evaluating only those at-risk locations the bird was moving. When only those locations when the birds were actively moving are considered, female Ospreys (15.0 ± 3.73 %) were at-risk more frequently than male Ospreys (8.5 ± 1.07 %).

Our analyses demonstrate that the risk of an Osprey strike is not equally distributed throughout the day, but rather there are clear temporal (daily) patterns in BASH risk potential posed by Ospreys during the breeding season. When considering only those Osprey locations when the birds were at-risk for a collision, 83.5 % of the times male Ospreys were at-risk and 78.8 % of the times female Ospreys were at-risk occurred during 11:00 through 17:00 hr local standard time (Figure 13).

Figure 13. Percentage of male and female Osprey locations classified as at-risk[a] during daily time periods throughout the breeding (summer) period.



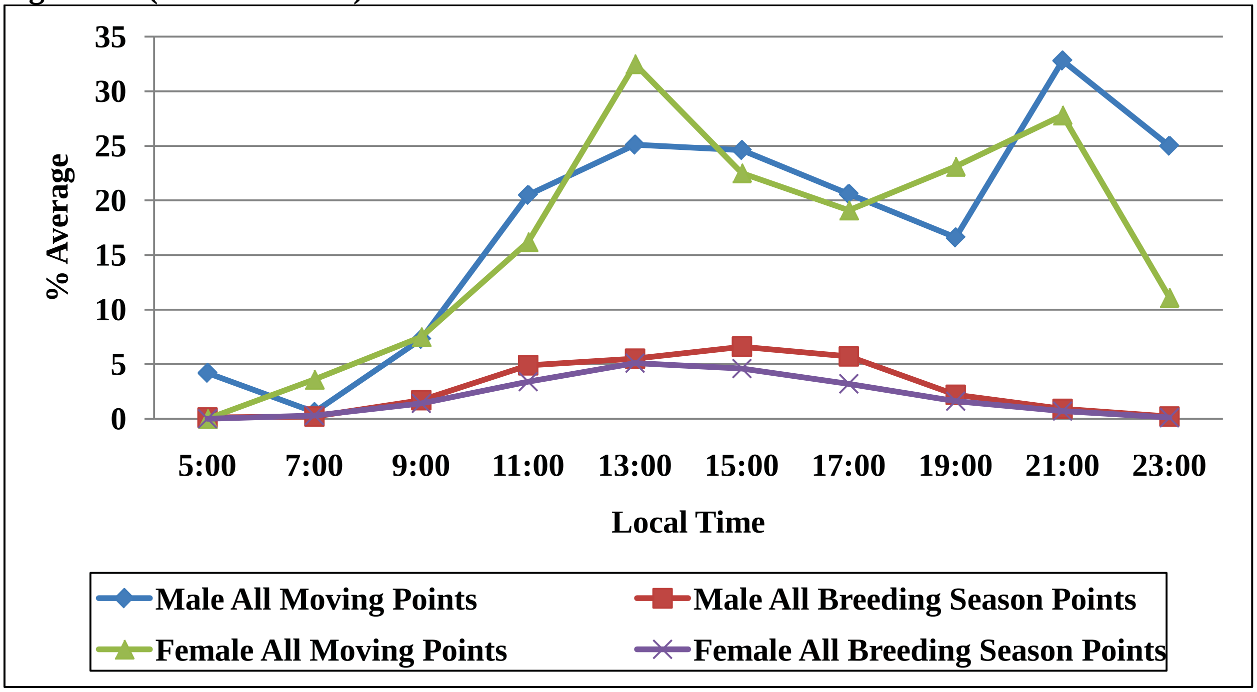
[a] *An Osprey location was classified as at-risk if the bird was flying at an altitude and geographic location near Langley AFB within airspace used by military aircraft.*

For both male and female adult Ospreys, the proportion of times the birds were at-risk for a collision with military aircraft was highest during late morning to mid-day hours, more specifically during 11:00 to 17:00 hr local time (Figure 14). In contrast, the lowest proportion of times Osprey locations were classified as at-risk was during the early morning hours, more specifically from 05:00 through 09:00 hr (Figure 14).

Our analyses demonstrate that patterns of BASH risk posed by breeding Osprey varied between male and female adults throughout the breeding season (i.e., monthly). When considering only those locations when the birds were at-risk for a collision with military aircraft, for male Ospreys the distribution of at-risk points was relatively equal from May through August, although the highest proportion of at-risk locations occurred in June (Figure 15). In contrast, for female Ospreys the proportion of at-risk locations (each month) increased as the breeding season progressed, with approximately 70% of the at-risk locations occurring in the months of July and August (Figure 15).

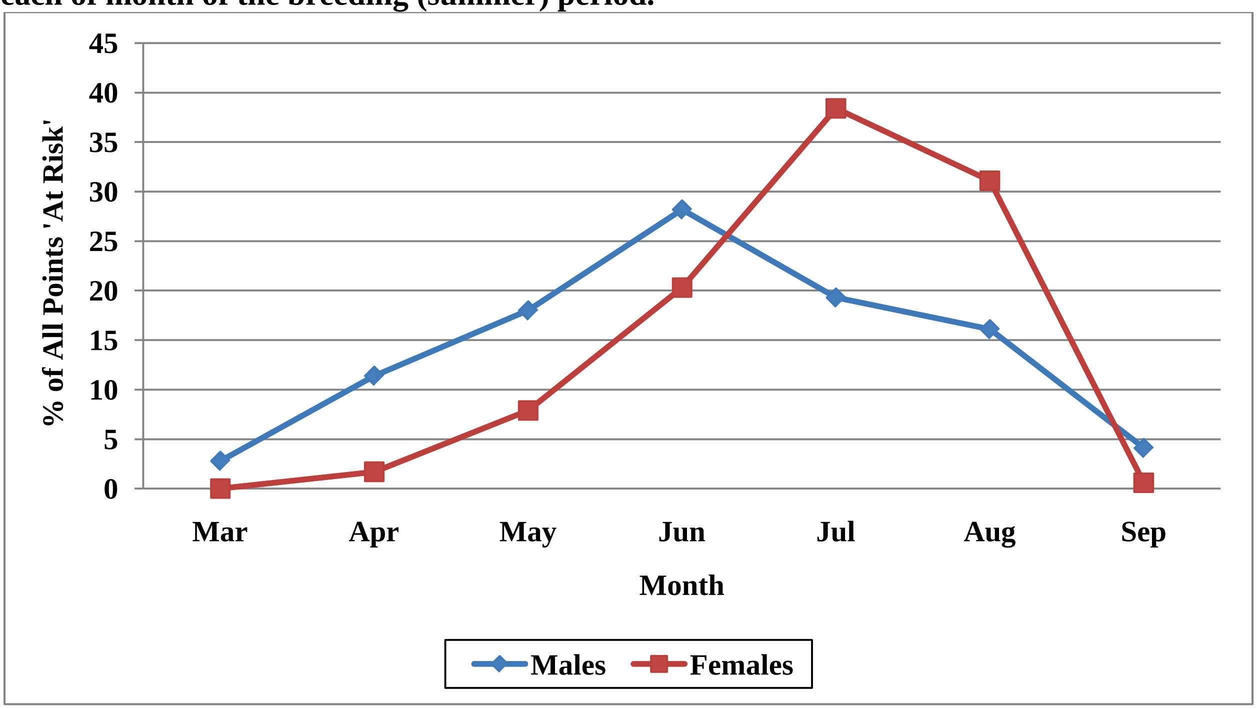
Figure 14. Average percentage of male and female Osprey locations classified as at-risk[a] among all male and female Osprey locations where the birds was moving and all male and female Osprey locations during daily time periods throughout the breeding (summer) period.

Figure 14. (CONTINUED)



[a] An Osprey location was classified as at-risk if the bird was flying at an altitude and geographic location near Langley AFB within airspace used by military aircraft.

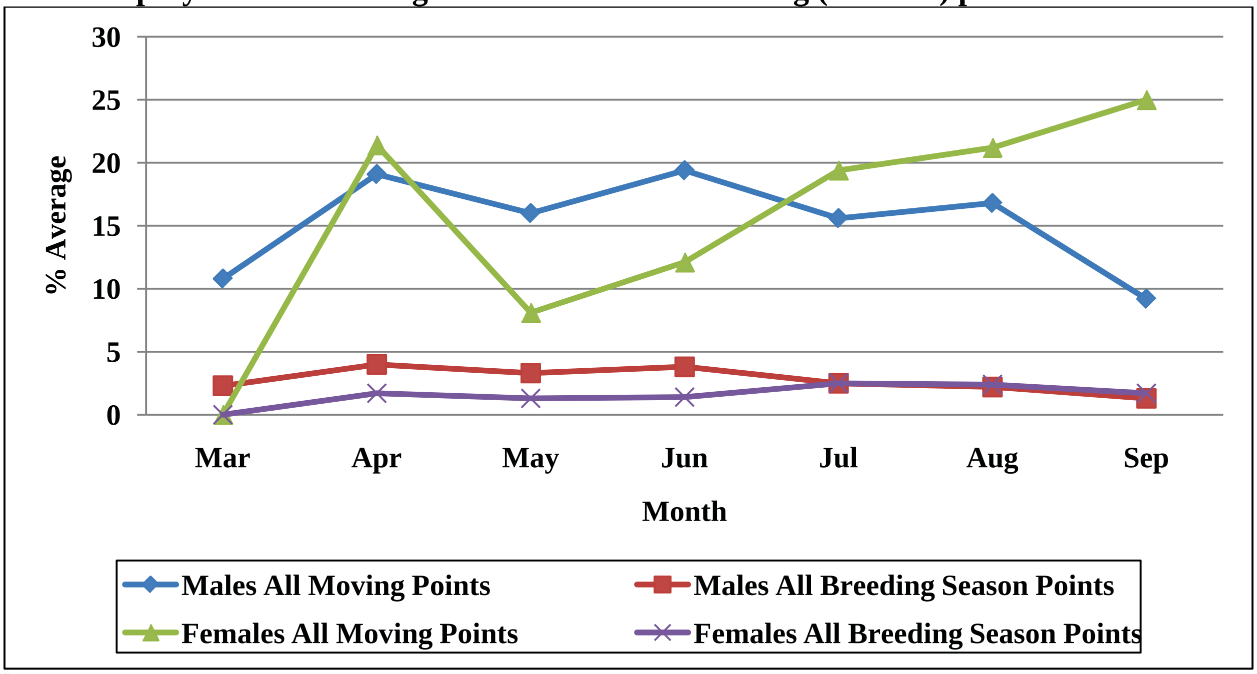
Figure 15. Percentage of male and female Osprey locations classified as at-risk[a] during each of month of the breeding (summer) period.



[a] An Osprey location was classified as at-risk if the bird was flying at an altitude and geographic location near Langley AFB within airspace used by military aircraft. [b] No female Ospreys were tracked during March.

Differences between Osprey genders are very apparent when comparing the proportion of Osprey locations where the bird was at-risk among months. For male Ospreys, the average proportion of times the birds were at-risk for a collision with military aircraft was relatively similar across all months of the breeding season (Figure 16). In contrast, the average proportion of times female Ospreys were at-risk was lowest during May and consistently increased as the breeding season progressed (Figure 16).

Figure 16. Average percentage of male and female Osprey locations classified as at-risk[a] among all male and female Osprey locations where the bird was moving and all male and female Osprey locations during each month of the breeding (summer) period.[b]



[a] An Osprey location was classified as at-risk if the bird was flying at an altitude and geographic location near Langley AFB within airspace used by military aircraft .[b] No female Ospreys were tracked during March.

Our analyses show clear spatially explicit patterns of BASH hazards posed to military aircraft operating in association with Langley AFB by breeding Osprey and these patterns varied between males and females. Not unexpectedly, the geographic location of an individual Osprey nest appeared to have considerable influence on the particular airspaces used by the satellite-tagged Osprey(s) associated with that nest.

When considering only those Osprey locations when the birds were at-risk for a collision, 16.2 % of the at-risk Osprey locations for males and 15.7 % for female Ospreys were within the primary surface, the approach-departure surface, and the transitional surfaces (i.e., those areas closest to the airfield itself) (Table 7). For male Ospreys, on average over half of the at-risk locations were within the conical surface area of critical airspace. The proportion of at-risk locations for female Ospreys was highest within the inner horizontal surface area of critical airspace and decreased within airspaces further from the airfield itself (Table 7).

The location of an Osprey nest (relative to the airfield) was related to the proportion of Osprey locations that were at-risk (that is, Osprey locations within areas of critical airspace). We found significant correlations between the distance of an Osprey nest (satellite-tagged birds) from the airfield and the proportion of at-risk Osprey locations within the approach-departure clearance surface ($r = 0.63$, $P = 0.007$), the inner horizontal surface ($r = -0.69$, $P = 0.002$), and the transitional surfaces ($r = 0.50$, $P = 0.04$) areas of critical airspace. In contrast, the distance of an Osprey nest from the airfield was not related to the proportion of at-risk Osprey locations within the primary surface ($r = 0.18$, $P = 0.49$), the conical surface ($r = -0.08$, $P = 0.76$), or the outer horizontal surface ($r = 0.27$, $P = 0.30$) areas of critical airspace.

Table 7. Percentage of Osprey locations classified as at-risk [a] distributed among the imaginary surfaces components throughout the breeding (summer) period.

Imaginary Surfaces Component	% of All Points At-Risk[a]	
	Males	**Females**
Primary Surface	0.4	1.6
Approach-Departure Surface	11.7	9.4
Transitional Surface	4.1	4.7
Inner Horizontal Surface	16.1	38.1
Conical Surface	56.3	28.0
Outer Horizontal Surface	11.4	18.2

[a] An Osprey location was classified as at-risk if the bird was flying at an altitude and geographic location near Langley AFB within airspace used by military aircraft.

5.5.3. Breeding Period Airspace Risk Polygons

The airspace risk polygons analyses were developed and implemented to quantify and identify areas where breeding Ospreys posed a BASH hazard to military aircraft near Langley AFB (see APPENDIX B for detailed BASH risk maps and illustrations). On average, the size of airspace risk polygons (i.e., spatially explicit models of areas of critical airspace used by Ospreys during the breeding season) was 21.0 ± 3.04 km^2 (range for individual Ospreys = 6.2 km^2 to 48.2 km^2).

Osprey gender did not influence the size of airspace risk polygons for Ospreys near Langley AFB during the breeding season. The average airspace risk polygon size for male Ospreys was similar to the average size of airspace risk polygons for female Ospreys (Table 8). However, the status of an Osprey nest (e.g., success in producing chicks) clearly influenced the size of airspace risk polygons for breeding Ospreys. On average, Ospreys that were associated with a successful nest had airspace risk polygons that were 45 % smaller in size compared to Ospreys associated with unsuccessful nests (Table 8).

Table 8. Average (± 1 SE) airspace risk polygon sizes (km^2) of adult Ospreys during the breeding (summer) periods during 2006, 2007, 2008, and 2009.

Group	*n*	Airspace Risk Polygon ± 1 SE (km^2)
Males	8	23.00 ± 4.57
Females	9	19.20 ± 4.23
Successful Nests	9	15.07 ± 2.96
Unsuccessful Nests	8	27.63 ± 4.66

The portion of the airspace risk polygon that was contained within each area of critical airspace type (i.e., based on IS) varied among individual Ospreys and appeared to be related to the geographic location of individuals nest. Overall, the area of airspace risk polygons for individual Ospreys contained within the primary surface (range = 0 km^2 to 0.7 km^2), approach-departure surfaces (range = 0 km^2 to 7.0 km^2), the transitional surfaces (range = 0 km^2 to 2.0 km^2) was relatively less compared to the inner horizontal surface (range = 0 km^2 to 6.0 km^2), the conical surface (range = 1.3 km^2 to 19.4 km^2) and the outer horizontal surface (range = 0.8 km^2 to 37.5 km^2).

5.6. BASH Risk Potential of Migrating Osprey

5.6.1. Migration Period Points At-Risk

The migration points at-risk analyses were developed and implemented to quantify the BASH hazard that migrating Ospreys pose to military aircraft using SUA and MTR along the Atlantic seaboard (see APPENDIX C, E and G for detailed BASH risk maps and illustrations). Further, we determined if temporal and spatial patterns of BASH risk posed by migrating Ospreys to military aircraft exist and if so, can be identified.

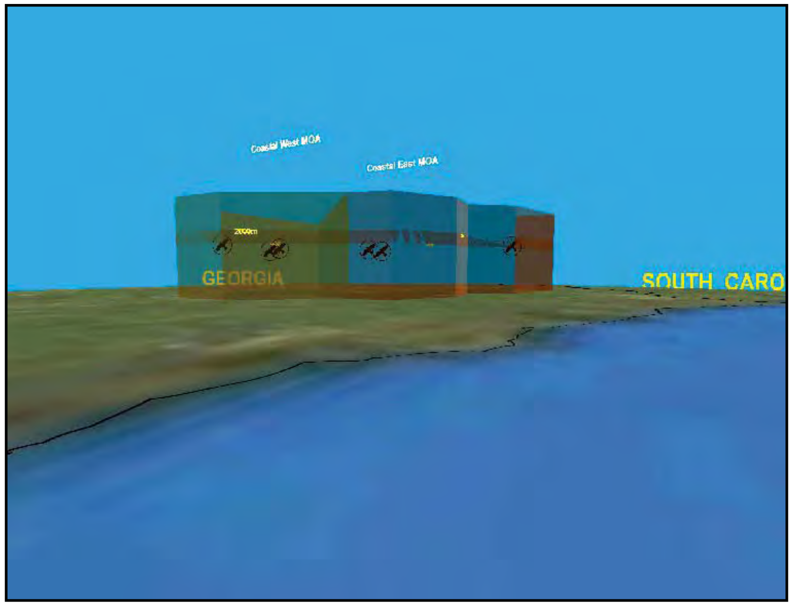
Due to the geographic routes, the altitudes flown, and their movement patterns, during the fall migration period Ospreys pose a hazard to military aircraft operating along the Atlantic seaboard. Although Ospreys pose some BASH risk to military aircraft operating within all of the SUA and MTR airspaces along the Atlantic seaboard, the distribution of Osprey locations at-risk for a collision with military aircraft was not equally distributed among the types of MTA (Table 9). Over 56% of the at-risk locations for migrating Ospreys during fall were associated with MTR, more specifically instrument routes and visual routes. In contrast, less than 3 % of the at-risk Osprey locations were associated with slow routes and alert areas.

Table 9. Total number of adult Osprey point locations classified as at-risk [a] found within military training airspace during the 2006, 2007, and 2008 fall migration periods.

Military Training Airspace	Number of At-Risk[a] Points
Alert Areas	2
Airfields	13
Instrument Routes	34
Visual Routes	47
Slow Routes	1
Military Operating Areas	21
Restricted Areas	11
Warning Areas	15
All Military Airspace (Total)	144

[a] An Osprey location was classified as at-risk if the bird was flying at an altitude and geographic location within airspace used by military aircraft.

On average, during their fall migrations adult Ospreys were at-risk (that is, posed a hazard to military aircraft operating along the Atlantic seaboard) 15.8 ± 1.43 % (range for individual Ospreys = 8.5 % to 27.5 %) of the times they were located within the U.S. by the satellite tracking system during their fall migration period. When only those locations of moving birds are considered, migrating adult Ospreys were at-risk 35.4 ± 2.62 % (range for individual Ospreys = 19.2 % to 58.3 %) of the times they were located within the U.S. by the satellite tracking system.



Three dimensional (side view) illustration of at-risk Osprey locations within Coastal MOA, Georgia during the 2007 fall migration period.

Female and male adult Ospreys were at-risk for a collision with military aircraft similar amounts of time (Females: 16.3 ± 2.18 % vs. Males: 15.1 ± 1.66 %) within the U.S. during the fall migration period (Table 10). When only those locations of moving birds within the U.S. are considered, female Ospreys (38.3 ± 3.73 %) were at-risk with equal frequency to male Ospreys (31.1 ± 2.95 %) during fall migration (Table 10).

Table 10. Average percentage of adult male and female Osprey locations during fall migration classified as at-risk[a] among all Osprey locations within the United States where the bird was moving and all Osprey locations within the United States.

Military Training Airspace	Males		Females	
	All Moving Points in US[b]	All Points in US[c]	All Moving Points in US[b]	All Points in US[c]
Alert Areas	0.8	0.4	0.4	0.2
Airfields	3.6	1.7	2.6	1.1
Instrument Routes	5.5	2.7	10.4	4.5
Visual Routes	11.1	5.4	11.6	4.9
Slow Routes	0	0	0.4	0.2
Military Operations Areas	4.2	2.0	6.1	2.6
Restricted Areas	2.4	1.2	3.0	1.3
Warning Areas	3.6	1.7	3.7	1.6
All Military Airspace (Total)	31.1	15.1	38.3	16.3

[a] An Osprey location was classified as at-risk if the bird was flying at an altitude and geographic location within airspace used by military aircraft. [b] All Osprey locations within the United States during the fall migration period where the bird was classified as moving.[c] All Osprey locations within the United States during the fall migration period.

Based on activity information provided by the satellite transmitters (see Fall Migration section above), it would appear the risk of an Osprey strike posed by migrating Ospreys during the fall migration period is not equally distributed throughout the day. For both male and female adult Ospreys, the frequency of Osprey migratory movements (and consequently the BASH risk potential posed to military aircraft) was highest during late morning to mid-day hours, more specifically during 11:00 to 17:00 hr local time.

Due to the geographic routes, the altitudes flown, and their movement patterns, during the spring migration period Ospreys pose a hazard to military aircraft operating along the Atlantic seaboard. Although Ospreys pose some BASH risk to military aircraft operating within all of the SUA and MTR airspaces along the Atlantic seaboard, the distribution of Osprey locations at-risk for a collision with military aircraft was not equally distributed among the types of MTA (Table 11). Over 63% of the at-risk locations for migrating Ospreys during fall were associated with MTR, more specifically instrument routes and visual routes. In contrast, less than 3% of the at-risk Osprey locations were associated with slow routes and alert areas.

Table 11. Average percentage of adult male and female Osprey locations during spring migration classified as at-risk[a] among all Osprey locations within the United States where the bird was moving and all Osprey locations within the United States.

Military Training Airspace	Males		Females	
	All Moving Points in US[b]	All Points in US[c]	All Moving Points in US[b]	All Points in US[c]
Alert Areas	1.0	0.4	0	0
Airfields	2.7	1.0	1.7	0.5
Instrument Routes	8.9	3.7	5.5	1.7
Visual Routes	17.2	7.2	14.3	4.5
Slow Routes	0	0	0	0
Military Operations Areas	8.5	3.6	5.7	1.8
Restricted Areas	0	0	3.5	1.1
Warning Areas	2.8	1.2	1.7	0.5
All Military Airspace (Total)	41.2	17.1	32.4	10.2

[a] An Osprey location was classified as at-risk if the bird was flying at an altitude and geographic location within airspace used by military aircraft. [b] All Osprey locations within the United States during the spring migration period where the bird was classified as moving. [c] All Osprey locations within the United States during the spring migration period.

On average, during their spring migrations adult Ospreys were at-risk (that is, posed a hazard to military aircraft operating along the Atlantic seaboard) 14.3 ± 2.67 % (range for individual Ospreys = 6.3 % to 22.5 %) of the times they were located by the satellite tracking system in the U.S. during their spring migration period. When only those locations of moving birds are considered, migrating adult Ospreys were at-risk 37.7 ± 5.26 % (range for individual Ospreys = 20.0 % to 47.4 %) of the times they were located in the U.S. by the satellite tracking system.

Female and male adult Ospreys were at-risk for a collision with military aircraft similar amounts of time (Females: 10.2 ± 3.90 % vs. Males: 17.1 ± 3.10 %) within the U.S. during the spring migration period (Table 21).

When only those locations of moving birds within the U.S. are considered, female Ospreys (32.4 ± 12.41%) were at-risk with equal frequently to male Ospreys (41.2 ± 5.03 %) during spring migration (Table 12).

Based on activity information provided by the satellite transmitters (see Spring Migration section above), it would appear the risk of an Osprey strike posed by migrating Ospreys during the spring migration period is not equally distributed throughout the day. For both male and female adult Ospreys, the frequency of Osprey migratory movements (and consequently the BASH risk potential posed to military aircraft) was highest during late morning to mid-day hours, more specifically during 11:00 to 17:00 hr local time.

Table 12. Total number of adult Osprey point locations classified as at-risk[a] found within military training airspace during the 2007, 2008, and 2009 spring migration periods.

Military Training Airspace	Number of At-Risk[a] Points
Alert Areas	1
Airfields	3
Instrument Routes	9
Visual Routes	20
Slow Routes	0
Military Operating Areas	8
Restricted Areas	2
Warning Areas	3
All Military Airspace (Total)	46

[a] *An Osprey location was classified as at-risk if the bird was flying at an altitude and geographic location within airspace used by military aircraft.*

During fall migration in 2006, location and movement information for Osprey J51 was at-risk (that is, when flying within SUA or MTR) during 10.1 % of the times when located within the United States. Further, Osprey J51 was at-risk 25 % of the time when moving with the U.S. during the fall migration period. Individual locations for Osprey J51 during the fall migration where he was at-risk were associated within MTR (75 % of at-risk locations) and warning areas (25 % of at-risk locations).

Our analyses demonstrate that Osprey J54 passed through several SUA and MTR during post-fledging movements northward from the Langley AFB area to Maine. Osprey J54 was at-risk 3.8 % of the times when located by the satellite tracking systems and 15.2 % of the times when only moving points within SUA or MTR were considered. Individual locations for Osprey J54 during his post-fledging movements when he was at-risk were associated with MTR (42.9 % of at-risk locations), military airfields, and restricted airspace areas.

5.6.2. Migration Period Route Risk

The migration route risk analyses were developed and implemented to identify and quantify the BASH hazard that migrating Ospreys pose to military aircraft using SUA and MTR along the U.S. Eastern Seaboard in a spatial context (see APPENDIX C, E and G for detailed BASH risk maps and illustrations).

Our analyses suggest that, on average, during a fall migration an adult Osprey made 61 ± 1.9 incursions (range for individual Ospreys = 49 to 80) into MTA within the southeastern U.S. (thus posing a hazard to military aircraft operating within those airspaces). The number of Osprey incursions was similar between Osprey genders (Females: 63 ± 2.6 incursions per fall migration vs. Males: 58 ± 2.0 incursions per fall migration).

Although Ospreys pose some BASH risk to military aircraft operating within all of the SUA and MTR airspace types along the Atlantic seaboard, Osprey incursions into MTA were not equally distributed among the various types of SUA and MTR (Table 13). Over 75 % of the Osprey incursions into MTA by migrating Ospreys during fall were associated with MTR, more specifically instrument route (24.1 % of all incursions) and visual route (51.8 % of all incursions). In contrast, Osprey incursions into alert areas and warning areas were the least frequent; these types of airspace accounted for less than 4% of total Osprey incursions during the fall migration period.

Our analyses suggest that, on average, during the spring migration period an adult Osprey made 65 ± 5.2 incursions (range for individual Ospreys = 50 to 80) into MTA within the southeastern U.S. (thus posing a hazard to military aircraft operating within those airspaces). The number of Osprey incursions was similar between Osprey genders (females: 74 ± 6.5 incursions per fall migration vs. males: 59 ± 5.9 incursions per fall migration).

Similar to the fall migratory period, Ospreys migrating in spring pose some BASH risk to military aircraft operating within all of the SUA and MTR airspace types along the Atlantic seaboard. During spring migration, Osprey incursions into airspace used for military flight operations were not equally distributed among the various types of MTA (Table 13). Similar to the fall migration period, the majority of Osprey incursions into MTA by Ospreys migrating in spring was associated with MTR, specifically instrument route (22.5 % of Osprey incursions) and visual route (53.1 % of Osprey incursions). Osprey incursions into alert areas and warning areas were the least frequent; these types of airspace accounted for less than 2 % of the total Osprey incursions during the spring migration period.

Table 13. Total number of Osprey incursions into military training airspace by adult Ospreys during the 2006, 2007, and 2008 fall migration periods and the 2007, 2008, and 2009 spring migration periods.

	Number of Osprey Incursions[a]	
Military Training Airspace	**Fall Migration**	**Spring Migration**
Alert Areas	12	3
Airfields	43	12
Instrument Routes	221	73
Visual Routes	475	172
Slow Routes	16	6
Military Operating Areas	60	21
Restricted Areas	74	31
Warning Areas	16	6
All Military Airspace (Total)	917	324

[a] An Osprey incursion is defined as a intersect of an Osprey migration route location (assuming the bird was flying at an altitude of 1,150 feet AGL) and an airspace used by military aircraft.

Using the results from the migration route analyses and considering all fall and spring migrations for all Ospreys in this study (i.e., 13 adults and 2 juveniles), we identified 143 individual SUA and MTR with one of more incursions by migrating Ospreys (Table 14). Within each MTA type, there was considerable variation in the total number of Osprey incursions for individual MTAs. Overall, individual SUA with the highest frequency of incursions by migrating Ospreys were Langley AFB in Virginia (*n* = 17), alert area A291 in Florida (*n* = 15), Beaufort 2 military operations area and Beaufort 3 military operations area in South Carolina (*n* = 9 each), Coastal 1 military operations area in Georgia (*n* = 9), restricted area R2901 in Florida (*n* = 26, and warning area W465 south of Florida (*n* = 18). Instrument routes 62 in Virginia (*n* = 39), 35 in South Carolina (*n* = 27), and 56 in Florida (*n* = 27), slow route 166 in South Carolina (*n* = 14), visual routes 1006 in Florida (*n* = 66), 1043 in South Carolina (*n* = 36), and 1046 in North Carolina (*n* = 35) were the MTR with the highest frequency of Osprey incursions.

F-22 Raptor and F-15 Eagle in flight over Virginia.

Table 14. Listing of military training airspace types and names with one or more Osprey incursions during the 2006, 2007, and 2008 fall migration periods and the 2007, 2008, and 2009 spring migration periods.

Military Training Airspace Types	Total Number with 1 or More Osprey Incursions[a]	Military Training Airspace Names with 1 or More Osprey Incursions[a]
Alert Areas	1	A291 (Miami, FL)
Airfields	16	A. P. Hill AAF, Beaufort MCAS, Camp Blanding AAF, Camp Davis MCOLF, Hunter AAF, Jacksonville NAS, Langley AFB, MCAS Beaufort, MCAS New River, NAS Norfolk, Oak Grove MCOLF, Pope AFB, Seymour Johnson AFB, Whitehouse NOLF, Wright AAF
Visual Routes	49	VR058, VR073, VR083, VR084, VR085, VR086, VR087, VR088, VR092, VR094, VR095, VR096, VR097, VR704, VR705, VR707, VR1001, VR1002, VR1003, VR1004, VR1005, VR1006, VR1007, VR1008, VR1009, VR1010, VR1040, VR1041, VR1043, VR1046, VR1059, VR1061, VR1066, VR1087, VR1088, VR1089, VR1098, VR1631, VR1713, VR1721, VR1722, VR1752, VR1753, VR1754, VR1755, VR1758, VR1759, VR1800, VR1801
Instrument Routes	26	IR002, IR012, IR018, IR022, IR023, IR034, IR035, IR036, IR046, IR047, IR048, IR049, IR050, IR051, IR053, IR055, IR056, IR062, IR074, IR082, IR083, IR089, IR090, IR721, IR800, IR804
Slow Routes	10	SR101, SR102, SR104, SR105, SR119, SR166, SR820, SR821, SR835, SR867
Restricted Areas	15	Fort A.P. Hill (VA), Quantico (VA), Camp LeJeune (NC), Pointsett-Sumter (SC), Fort Stewart (GA), Townsend (GA), Avon Park West (FL), Avon Park (FL), Lake George (FL), Pinecastle (FL), Rodman (FL), Starke (FL), Stevens Lake (FL), West Palm Beach (FL), Cudjoe Key (FL)

Table 14. (CONTINUED)

Military Training Airspace Types	Total Number with 1 or More Osprey Incursions[a]	Military Training Airspace Names with 1 or More Osprey Incursions[a]
Military Operations Area	24	Farmville MOA (VA), Hill MOA (VA), Pickett 2 MOA (VA), Fort Bragg South Area A MOA (NC), Gamecock C MOA (SC), Gamecock I MOA (SC), Beaufort 1 MOA (SC), Beaufort 2 MOA (SC), Beaufort 3 MOA (SC), Poinsett MOA (SC), Fort Stewart B1 MOA (GA), Fort Stewart C1 MOA (GA), Moody 2 North MOA (GA), Moody 2 South MOA (GA), Bulldog A MOA (GA), Bulldog D MOA (GA), Coastal 1 East MOA (GA), Coastal 1 West MOA (GA), Coastal 2 MOA (GA), Coastal 5 MOA (GA), Quick Thrust I MOA (GA), Avon East MOA (FL), Basinger MOA (FL), Marian MOA (FL)
Warning Areas	2	W174 (Key West , FL), W456 (Key West, FL)
All Military Training Airspace (Total)	143	

[a] *An Osprey incursion is defined as an intersect of an Osprey migration route location (assuming the bird was flying at an altitude of 1,150 feet AGL) and an airspace used by military aircraft.*

6. CONCLUSIONS

Recent advancements in satellite tracking technologies, most notably the availability of flight speed and altitude information, has allowed researchers to gain an unprecedented understanding of the ecology of wildlife species, in particular birds that migrate long distances. Prior to the availability of these technologies, such information was nearly impossible to obtain. Using the newest generation of satellite transmitters, this project has provided new and detailed information and thus a greater understanding of the ecology of Ospreys during all parts of their annual cycle, including breeding, migration, and wintering periods. Such information is essential for natural resource managers to make effective decisions regarding the conservation and management of this species in North America.

This project has enhanced our understanding of Ospreys during the breeding season and provided important information regarding the activity and spatial ecology of Ospreys during this time period. During the breeding season, Ospreys exhibited a diurnal activity pattern with most movements occurring during daylight hours. Overall, Osprey activity during summer varied among months and between genders. Female Ospreys exhibited very little movement during the incubation and chick-rearing phases of the breeding season, whereas males were active throughout the summer months.

The size of Osprey home ranges during the breeding season did not vary by gender, but was clearly influenced by reproductive success. Ospreys that were unsuccessful during reproductive efforts utilized a much larger area compared to successfully breeding birds.

The wintering ecology of Ospreys is relatively unknown, although previous research has provided information regarding the winter range of North American Ospreys. Similar to Ospreys in other studies, the Ospreys we tracked spent the winter months in various parts of the Caribbean and South America. This project has enhanced our understanding of Ospreys in winter and provided the first information regarding the movement patterns and spatial ecology of wintering North American Ospreys. During their winter period, Ospreys were relatively sedentary and had relatively small home ranges.

As evidenced by many research studies in recent years, satellite tracking technologies have been particularly useful for studying long distance migrations of birds. Detailed information gained from this research effort further demonstrates the utility of GPS−capable satellite telemetry for studying bird migration patterns, in particular raptors and other birds that migrate very long distances. Migrating Ospreys (in fall and spring) used similar geographic routes along the Eastern seaboard and primarily made migratory movements during a defined period (11:00−17:00 hr local standard time) each day. Migrating Ospreys typically roosted at night within stopover areas along their migration routes.

We developed a series of novel methods for documenting, quantifying, and assessing the BASH risk potential that breeding and migrating Ospreys pose to military aircraft operating in association with an airfield and during flight operations within military training airspace. These risk assessment methods are based on advanced operational risk management processes and incorporate Osprey movement and activity information and military aircraft flight information within a temporal and spatial context. The control area, breeding points at-risk, and airspace risk polygon analyses were developed for assessing BASH risk potential associated with military flight operations in association with an airfield. These analyses will be most effective when applied to situations where bird movements are localized within a general area (such as a breeding or wintering period). The migration points at-risk and migration route risk analyses were developed for assessing BASH risk potential associated with military flight operations within military training airspace. These analyses will be most effective when applied to situations where birds are making long distance movements across the landscape (such as migrations). Although these novel risk assessment models are very useful for documenting, quantifying, and ultimately reducing the BASH risk potential that Osprey and other birds pose to safe military aircraft flight operations, we believe they represent a critical first step in the development of more refined models (i.e., USAF Bird Avoidance Model and Avian Hazard Advisory System) and methods to more effectively assess BASH risk potential. We encourage those in the scientific community who possess bird movement information to consider providing that information for BASH risk assessment modeling efforts with the goal of reducing BASH incidents and the associated negative consequences to natural and human resources.

By developing and employing the novel analytical methods, we conducted a quantitative risk assessment that considered both temporal and spatial patterns in the hazard that breeding Ospreys pose to military aircraft operating from Langley AFB. Our findings from this research effort clearly demonstrate that during the breeding season Ospreys nesting near Langley AFB pose a safety hazard to military aircraft operating in the vicinity of the airfield. We identified the times of day and portions of the breeding season (i.e., months) when the risk of an Osprey-aircraft collision was highest for both male and female Ospreys. This detailed information will allow military flight planners to consider this safety factor and reduce the risk of Osprey–aircraft collisions at or near Langley AFB. In addition, the risk assessment methods could be effectively used at other airfields and with other species if detailed bird movement, activity, and location information is available for analysis.

We conducted a quantitative risk assessment that considered both temporal and spatial patterns in the hazard that migrating Ospreys pose to military aircraft operating within MTA along the U.S. Eastern Seaboard. We demonstrated that during their fall and spring migrations, Ospreys pose a risk to military aircraft operating along the Atlantic seaboard. By developing and employing the novel analytical methods, we found that time of day, season (timing), geographic location, and altitude (of both birds and aircraft) are important factors influencing the risk posed Our findings suggest that this risk is highest during late-morning to afternoon hours and lowest during early morning and evening hours. Ultimately, using information provided by this research effort, the timing and routing of military training flights might be scheduled during times of low Osprey activity to reduce the risk of Osprey–aircraft collisions.


Fledgling Osprey perched on a nest in the Back River.

The deliverable products resulting from this project expanded current bird-strike avoidance systems while determining effective solutions for reducing Osprey-strike risks implemented through the combined partnerships of flight safety officers, airspace managers, natural resource managers, wildlife biologists, and geospatial analysts. The execution and achievements for this project support the USAF mission. Through active participation (i.e., oral presentations, professional interactions) at scientific meetings and other outreach efforts (i.e., feature articles), the project team has provided information to various members of the scientific community and the general public about this research effort. Additionally, through these activities the project team has highlighted the role the DoD Legacy Resources Management Program, Langley AFB, and other involved parties have in natural resources conservation and management, in particular related to Ospreys. This project will serve as a technical reference for managing Osprey conflicts to military aviation for professional wildlife management agencies, natural resource managers, and flight safety officers. This research effort has applications for measuring the effectiveness of current management practices, developing long-term management strategies and supporting legal requirements that would allow Osprey and military aircraft to co-exist in a safer flying environment.

7. LITERATURE CITED

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APPENDIX A.

Summary of Delivered Products

Delivery Date	Category	Title
2006 August	Project Report	DoD Legacy Resource Management Program: 2006 Progress Report
2006 June	News Article Publication	The Langley Flyer: "Scientists track Ospreys to reduce bird strikes, protects pilots and saves birds".
2007 April	Poster Presentation	Vertebrate Pest Management Conference, Berkley CA: "Assessing BASH risk potential of migrating and breeding Osprey in the mid-Atlantic Chesapeake Bay region"
2007 August	Poster Presentation	DoD Sustaining Military Readiness Conference, Orlando FL: "Assessing BASH risk potential of migrating and breeding Osprey in the mid-Atlantic Chesapeake Bay region"
2007 December	Magazine Publication	USAF Flying Safety: "Tracking raptors in raptor land"
2007 February	Project Report	DoD Legacy Resource Management Program: 2006 Technical Report
2007 February	Project Report	DoD Legacy Resource Management Program: 2007 Progress Report
2007 June	News Article	Air Combat Command News Archive: "Langley monitors Osprey population".
2007 March	Poster Presentation	USAF Environmental Training Symposium, Nashville, TN: "Assessing BASH risk potential of migrating and breeding Osprey in the mid-Atlantic Chesapeake Bay region"
2007 March	Website	NASA/LaRC Osprey Tracker: http://gis.larc.nasa.gov/osprey/tracking.htm
2007 March	Poster Presentation	4th International Partners-In-Flight Conference, McAllen, TX: "Assessing BASH risk associated with breeding and migrating Osprey".
2007 April	Poster Presentation	Annual Conference of the Southeastern Association of Fish and Wildlife Agencies, Morgantown, WV: "Assessing BASH risk associated with breeding and migrating Ospreys".
2007 August	Poster Presentation	2007 Sustaining Military Readiness Conference, Lake Buena Vista, FL: "Assessing BASH risk associated with breeding and migrating Ospreys".
2008 February	Project Report	DoD Legacy Resource Management Program: 2007 Technical Report.

APPENDIX A. (CONTINUED)

Delivery Date	Category	Title
2008 March	Poster Presentation	23rd Vertebrate Pest Conference, San Diego, CA: "Assessing bird-aircraft strike hazard (BASH) risk associated with breeding and migrating Osprey."
2008 April	Poster Presentation	64th Annual Northeast Fish and Wildlife Conference, Galloway, NJ: "Assessing bird-aircraft strike hazard risk associated with breeding and migrating Ospreys".
2008 August	Poster Presentation	10th Joint Meeting of Bird Strike Committee USA/Canada, Lake St. Mary's, FL: "Assessing BASH risk of breeding and migrating Ospreys".
2008 August	Oral Presentation	126th Joint Meeting of the American Ornithologists' Union / Cooper Ornithological Society / Canadian Society of Ornithologists, Portland, OR: "South for the winter: wintering ecology of North American Osprey."
2008 August	Oral Presentation	126th Joint Meeting of the American Ornithologists' Union / Cooper Ornithological Society / Canadian Society of Ornithologists, Portland, OR: "The spring migration of ospreys to North America as revealed by satellite telemetry."
2008 August	Oral Presentation	126th Joint Meeting of the American Ornithologists' Union / Cooper Ornithological Society / Canadian Society of Ornithologists, Portland, OR: "North American ospreys in the human landscape: conflicts, contaminants, and benefits."
2008 November	Digital Photos	DoD Legacy Resource Management Program: Collection of project photos.
2008 November	Oral Presentation	15th Annual Conference of The Wildlife Society Meeting, Miami, FL: "Moving right along: assessing migration patterns of Ospreys using satellite telemetry".
2008 December	Oral Presentation	69th Midwest Fish and Wildlife Conference, Columbus, OH: "Assessing migration patterns of Osprey using satellite telemetry".
2009 February	Newsletter Publication	Microwave Telemetry, Inc., Tracker News. "Using satellite telemetry to reduce risk of Osprey collisions with military aircraft".
2009 March	Oral Presentation	Environmental Systems Research Institute Federal User Conference, Washington D.C.: "Monitoring Osprey using GIS".
2009 March	Fact Sheet	DoD Legacy Resource Management Program: "Techniques for capturing and marking Osprey"

APPENDIX A. (CONTINUED)

Delivery Date	Category	Title
2009 April	Oral Presentation	65th Annual Northeast Fish and Wildlife Conference, Lancaster, PA: "Assessing fall migration patterns of Ospreys using satellite telemetry."
2009 May	Project Report	DoD Legacy Resource Management Program: 2008 Progress Report
2009 July	News Article	The Langley Flyer: "Bird strike avoidance– high tech risk mitigation".
2009 August	Poster Presentation	2009 Sustaining Military Readiness Conference, Phoenix, AZ: "Do migrating Osprey pose a risk to military aircraft?"
2009 August	Wall Poster	DoD Legacy Resource Management Program: "Satellite tracking Osprey and assessing movement patterns within military airspace".
2009 October	Poster Presentation	16th Annual Conference of The Wildlife Society, Monterey, CA: "Do migrating Osprey pose a risk to military aircraft?"
2009 December	Poster Presentation	70th Midwest Fish and Wildlife Conf., Springfield, IL: "Do migrating Osprey pose a risk to military aircraft?"
2010 March	Project Report	DoD Legacy Resource Management Program: 2008 Technical Report
2010 September	Oral Presentation	2010 Raptor Research Foundation Conference, Fort Collins, CO: "Assessing BASH risk potential of breeding and migrating Ospreys"
2010 November	Newsletter Publication	ARGOS Forum, No. 71, "Using satellite telemetry to reduce risk of Osprey collisions with military aircraft".
2011 March	Project Report	DoD Legacy Resource Management Program: Final Scientific Report
2011 March	Fact Sheet	DoD Legacy Resource Management Program: Project over, 06/07/08-292.
2011 March	GIS Data	DoD Legacy Resource Management Program: Argos Osprey location data.
2011 March	GIS Data	USAF BASH Team: Osprey bird aircraft strike hazard data.
2011 August	Magazine Publication	The Combat Edge, Air Combat Command: "Satellite tracking bird hazards".
In Coordination	Journal Publication	Ornithological Monographs, "Wintering ecology of adult North American Ospreys".

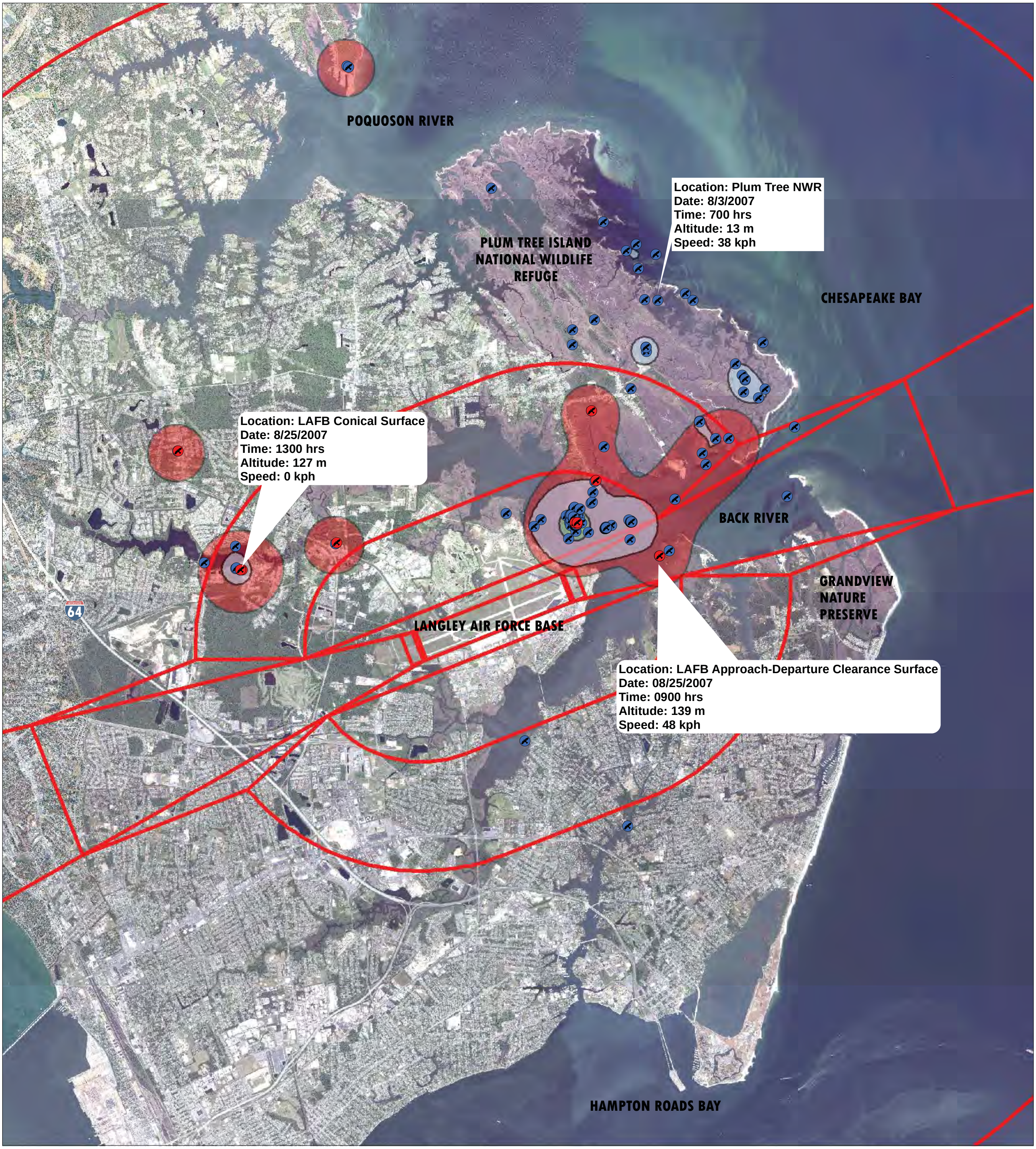
APPENDIX B.

Breeding (Summer) Period Maps

Appendix B features 18 high-quality reference maps illustrating point locations, estimated home-range sizes, airspace hazard locations, and airspace risk polygons of satellite-tagged Osprey during the breeding period.

Osprey F27 Breeding Period

Date Range: 1 Jun - 30 Aug 2007



Legend

- F27_Point Locations
- F27_50% KHR (0.30 km2)
- F27_95% KHR (4.21 km2)
- F27_Airspace Risk Locations
- F27_Airspace Risk Polygon (15.70 km2)
- LAFB Imaginary Surfaces

N, W, E, S

Scale: 1:24,000

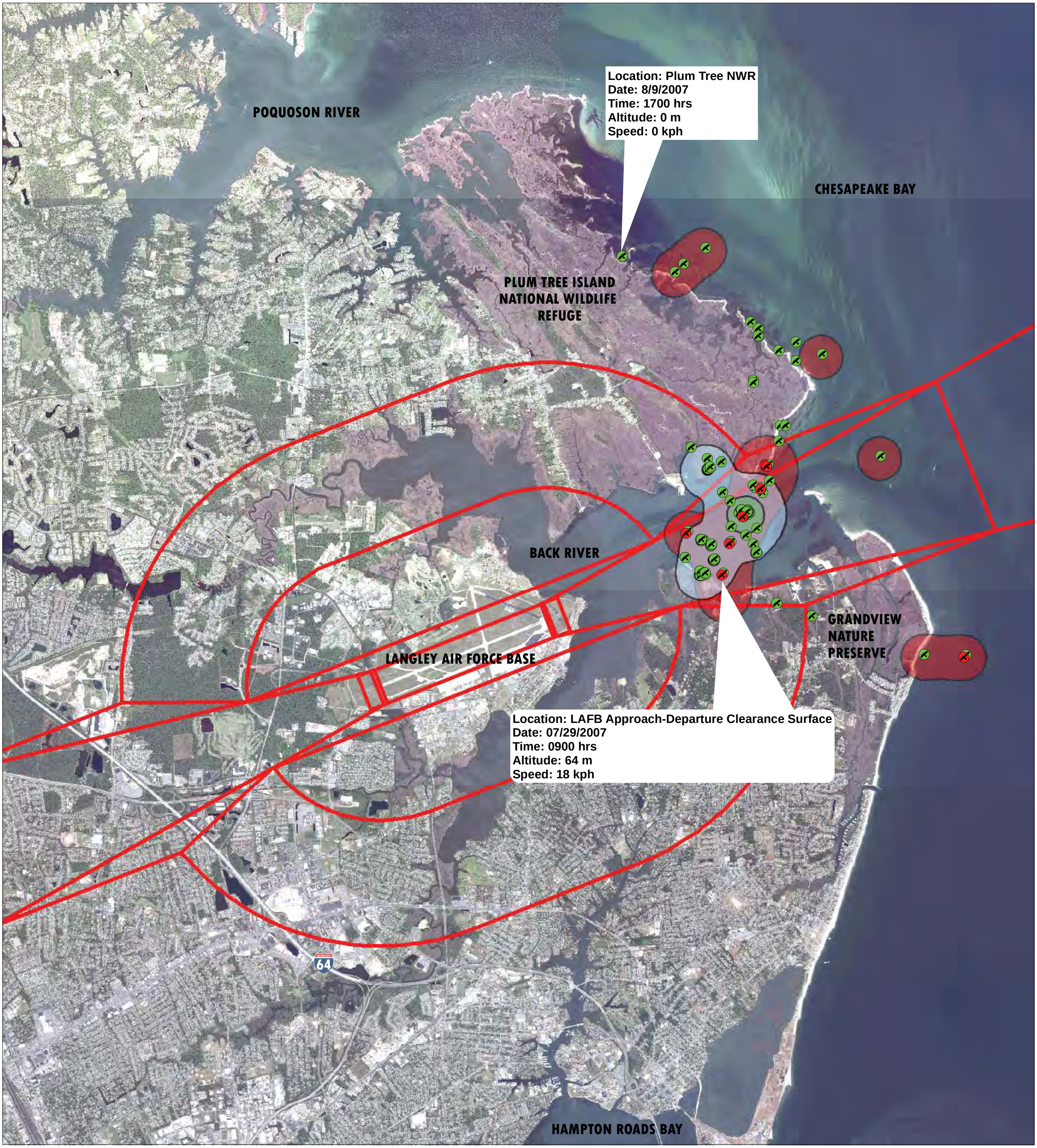
0 | 875 | 1,750 | 3,500 Meters

DoD Legacy Project 06/07/08-292

Coordinate System:
WGS 84 UTM 18N
Vertical Datum:
GEOID 88

Data Provided By:
633 ABW Installation Geospatial Information and Services
Produced By: 1 FW Flight Safety

Osprey F28 Breeding Period



Date Range: 1 Jun - 25 Aug 2007

Legend

- F28_Point Locations
- F28_50% KHR (0.31 km2)
- F28_95% KHR (3.20 km2)
- F28_Airspace Hazard Locations
- F28_Airspace Risk Polygon (6.37 km2)
- LAFB Imaginary Surfaces

DoD Legacy Project 06/07/08-292

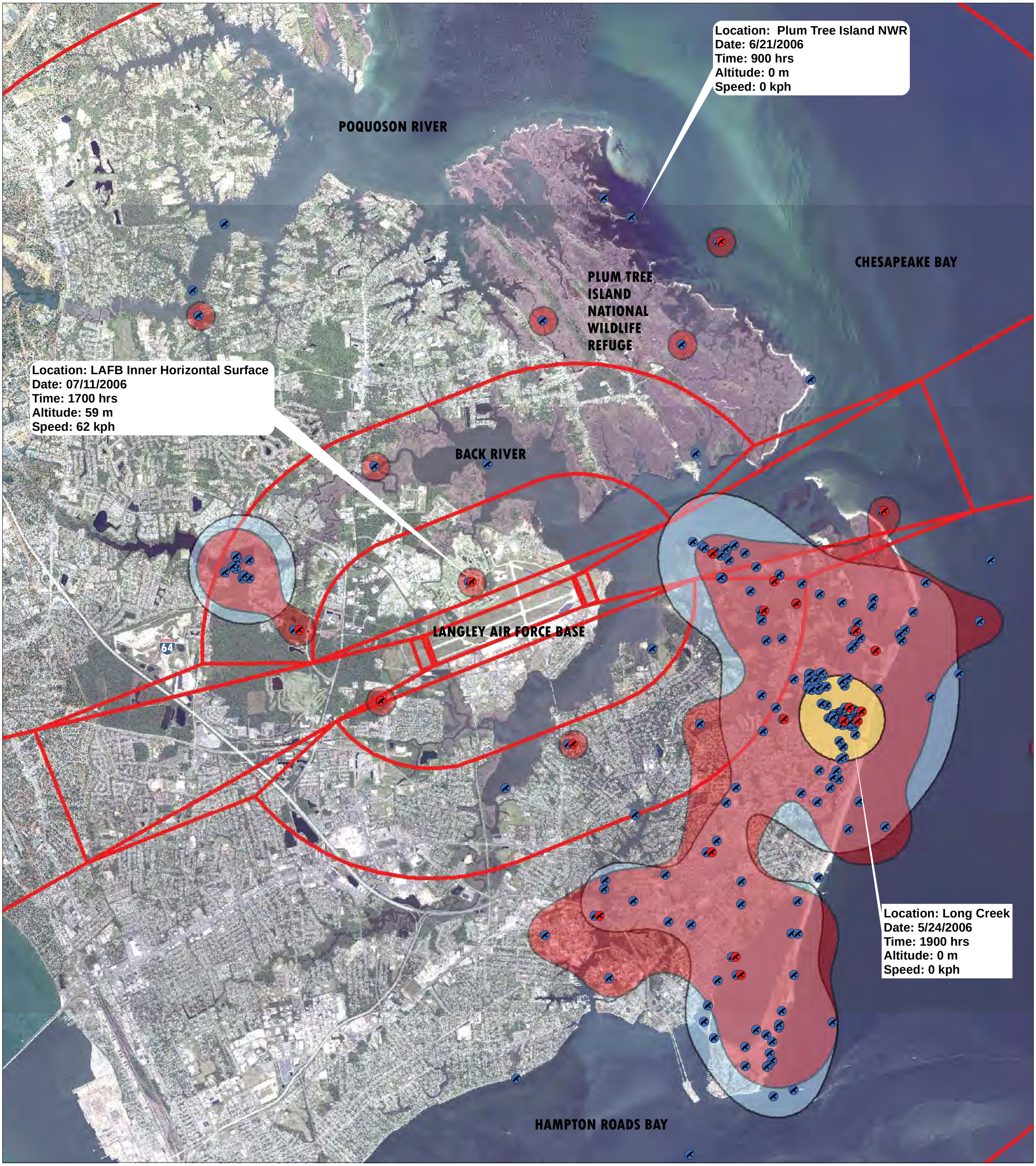
Coordinate System:
WGS 84 UTM 18N
Vertical Datum:
GEOID 88

Data Provided By:
633 ABW Installation Geospatial Information and Services
Produced By: 1 FW Flight Safety

N W E S

Scale: 1:20,888

0 750 1,500 3,000 Meters



DoD Legacy Project 06/07/08-292

Coordinate System:
WGS 84 UTM 18N
Vertical Datum:
GEOID 88

Data Provided By:
633 ABW Installation Geospatial Information and Services
Produced By: 1 FW Flight Safety

Osprey F46 Breeding Period

Date Range: 16 May - 29 Aug 2006

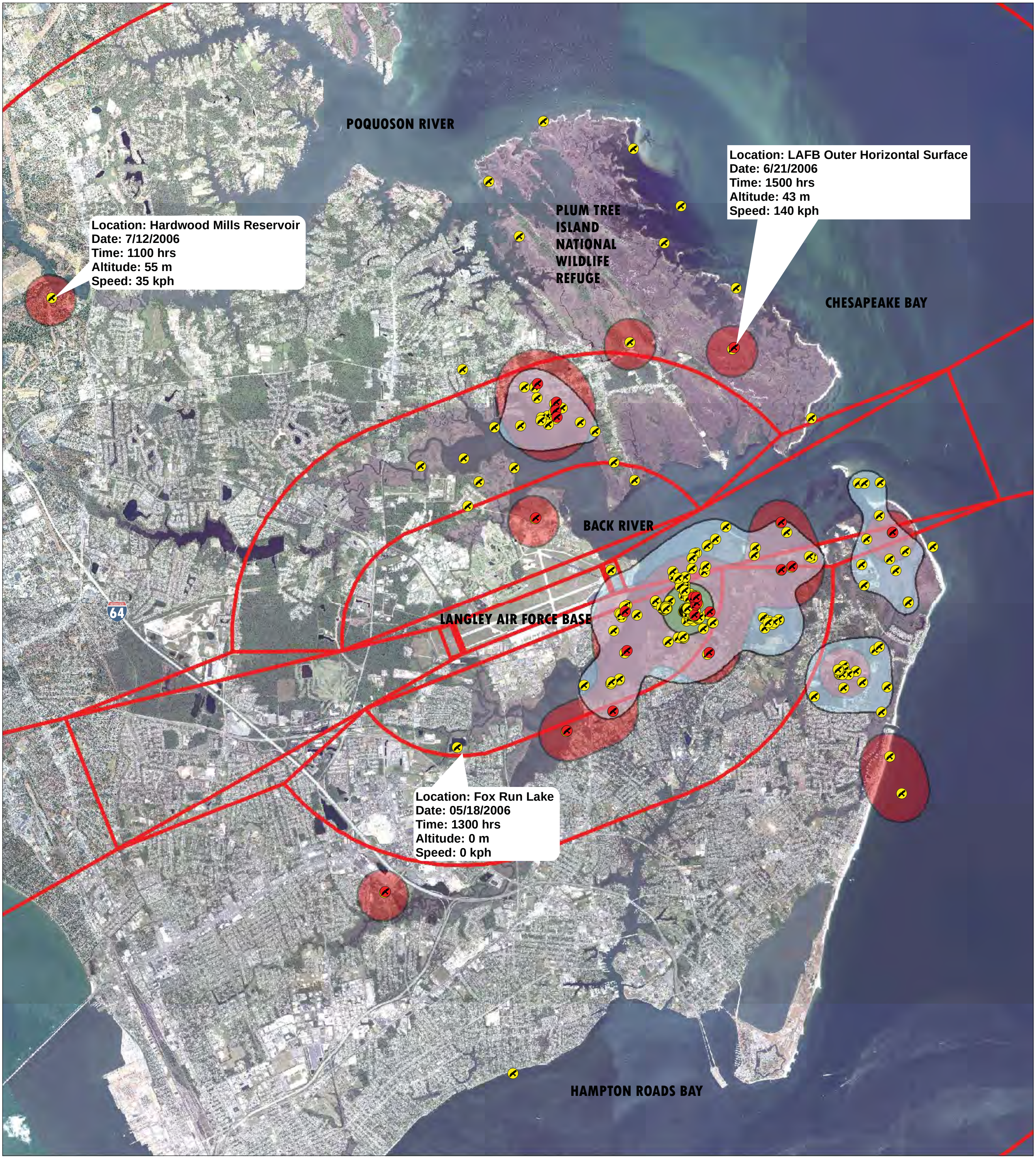
Legend

- F46_Point Locations
- F46_50% KHR (2.14 km2)
- F46_95% KHR (45.38 km2)
- F46_Airspace Hazard Locations
- F46_Airspace Risk Polygon (48.22 km2)
- LAFB Imaginary Surfaces

N
W E
S

Scale: 1:24,000

0 850 1,700 3,400 Meters



Osprey F48A Breeding Period

Date Range: 16 May - 15 Aug 2006

Legend

- F48A_Point Locations
- F48A_Airspace Hazard Locations
- F48A_50% KHR (0.77 km2)
- F48A_Airspace Risk Polygon (21.14 km2)
- F48A_95% KHR (18.02 km2)
- LAFB Imaginary Surfaces

DoD Legacy Project 06/07/08-292

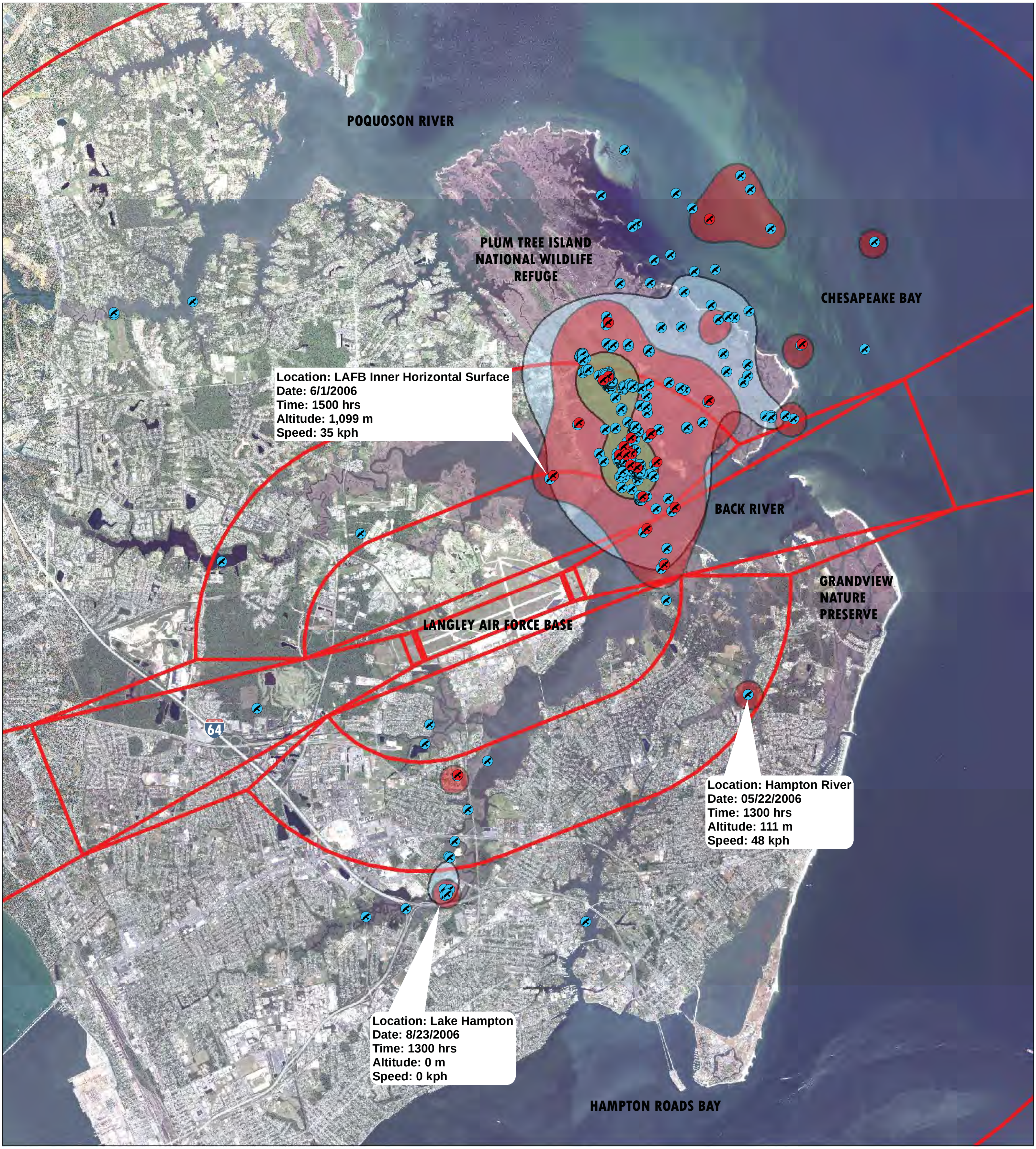
Coordinate System: WGS 84 UTM 18N
Vertical Datum: GEOID 88

Data Provided By: 633 ABW Installation Geospatial Information and Services
Produced By: 1 FW Flight Safety

N W E S

Scale: 1:24,000

0 875 1,750 3,500 Meters



Osprey M52 Breeding Period

Date Range: 21 May - 6 Sep 2006

DoD Legacy Project 06/07/08-292

Coordinate System: WGS 84 UTM 18N
Vertical Datum: GEOID 88

Data Provided By:
633 ABW Installation Geospatial Information and Services
Produced By: 1 FW Flight Safety

Legend

- M52_Point Locations
- M52_Airspace Hazard Locations
- M52_50% KHR (2.64 km2)
- M52_Airspace Risk Polygon (18.13 km2)
- M52_95% KHR (19.51 km2)
- LAFB Imaginary Surfaces

N
W E
S

Scale: 1:24,000

0 900 1,800 3,600 Meters

DoD Legacy Project 06/07/08-292

Coordinate System:
WGS 84 UTM 18N
Vertical Datum:
GEOID 88

Data Provided By:
633 ABW Installation Geospatial Information and Services
Produced By: 1 FW Flight Safety

Osprey M47 Breeding Period

Time Period: 16 May - 9 Sep 2006

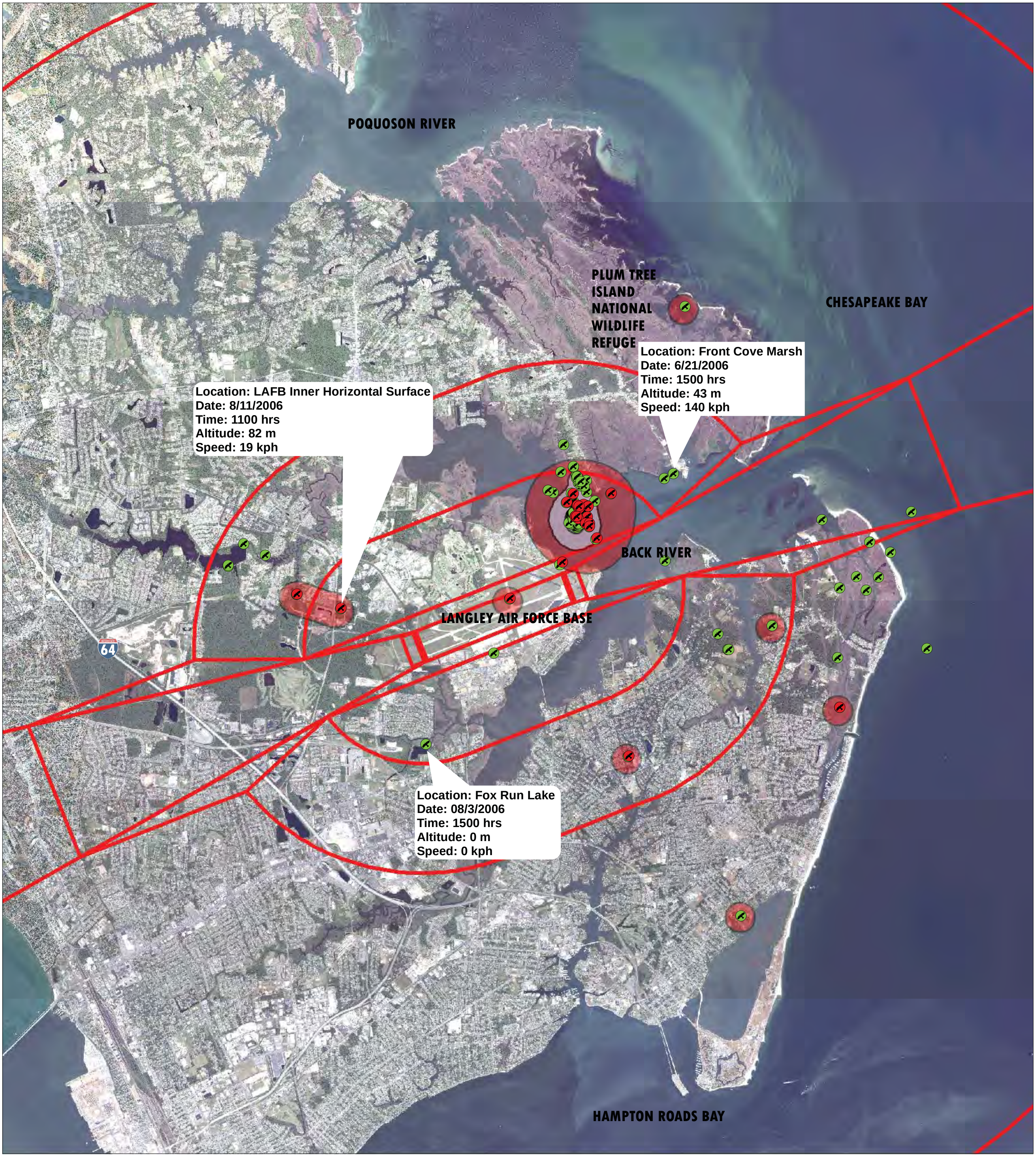
Legend

- M47_Point Locations
- M47_50% KHR (1.20 km2)
- M47_95% KHR (19.77 km2)
- M47_Airspace Risk Polygon (31.07 km2)
- M47_Airspace Hazard Locations
- LAFB Imaginary Surfaces

N
W E
S

Scale: 1:24,000

0 900 1,800 3,600 Meters



DoD Legacy Project 06/07/08-292

Coordinate System: WGS 84 UTM 18N
Vertical Datum: GEOID 88

Data Provided By: 633 ABW Installation Geospatial Information and Services
Produced By: 1 FW Flight Safety

Osprey F49 Breeding Period

Date Range: 17 May - 22 Aug 2006

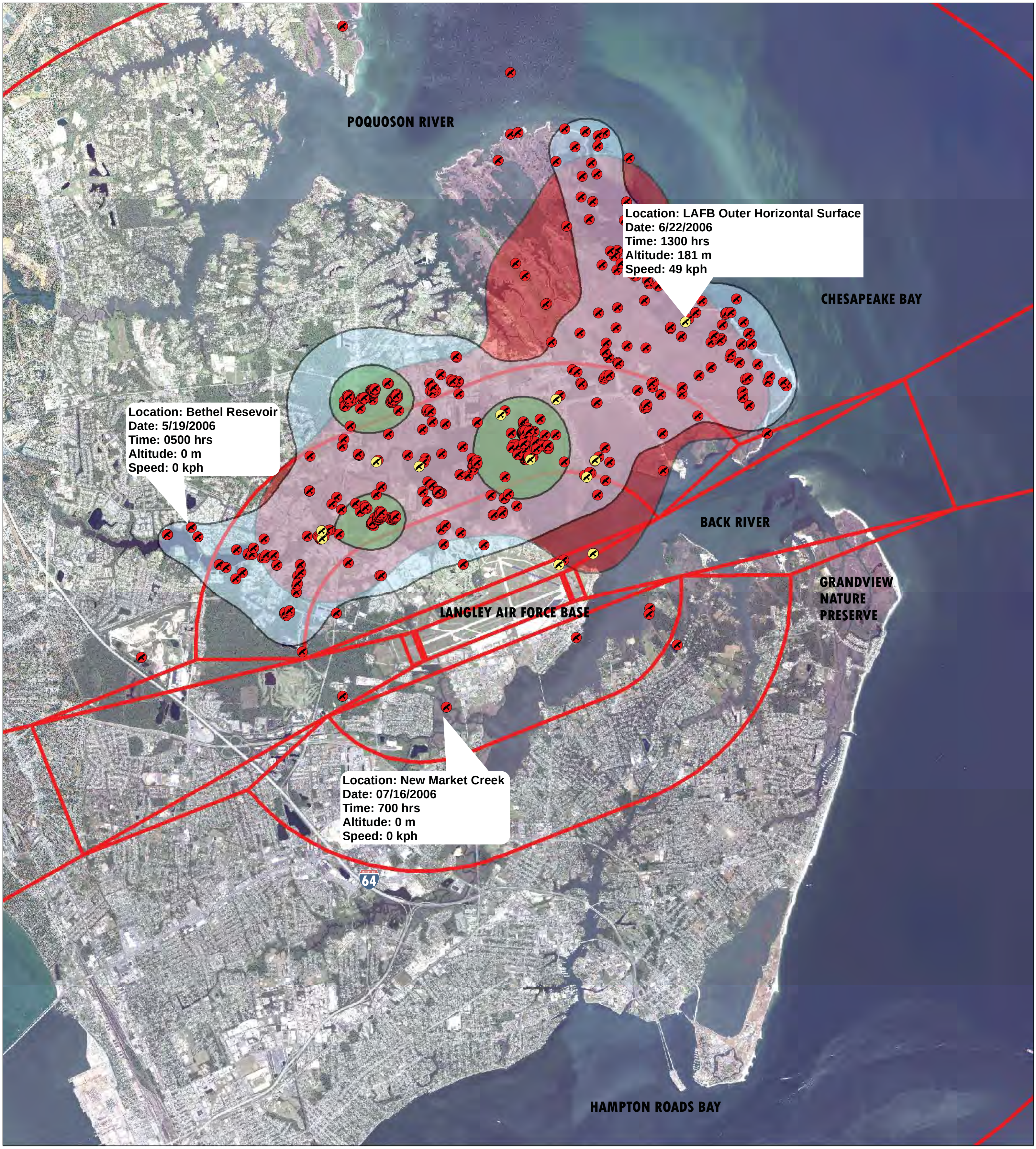
Legend

- F49_Point Locations
- F94_50% KHR (0.13 km2)
- F94_95% KHR (1.05 km2)
- F49_Airspace Hazard Locations
- F94_Airspace Hazard Polygon (6.20 km2)
- LAFB Imaginary Surfaces

N W E S

Scale: 1:24,000

0 900 1,800 3,600 Meters



DoD Legacy Project 06/07/08-292

Coordinate System:
WGS 84 UTM 18N
Vertical Datum:
GEOID 88

Data Provided By:
633 ABW Installation Geospatial
Information and Services
Produced By: 1 FW Flight Safety

Osprey M50 Breeding Period

Date Range: 17 May - 26 Sep 2006

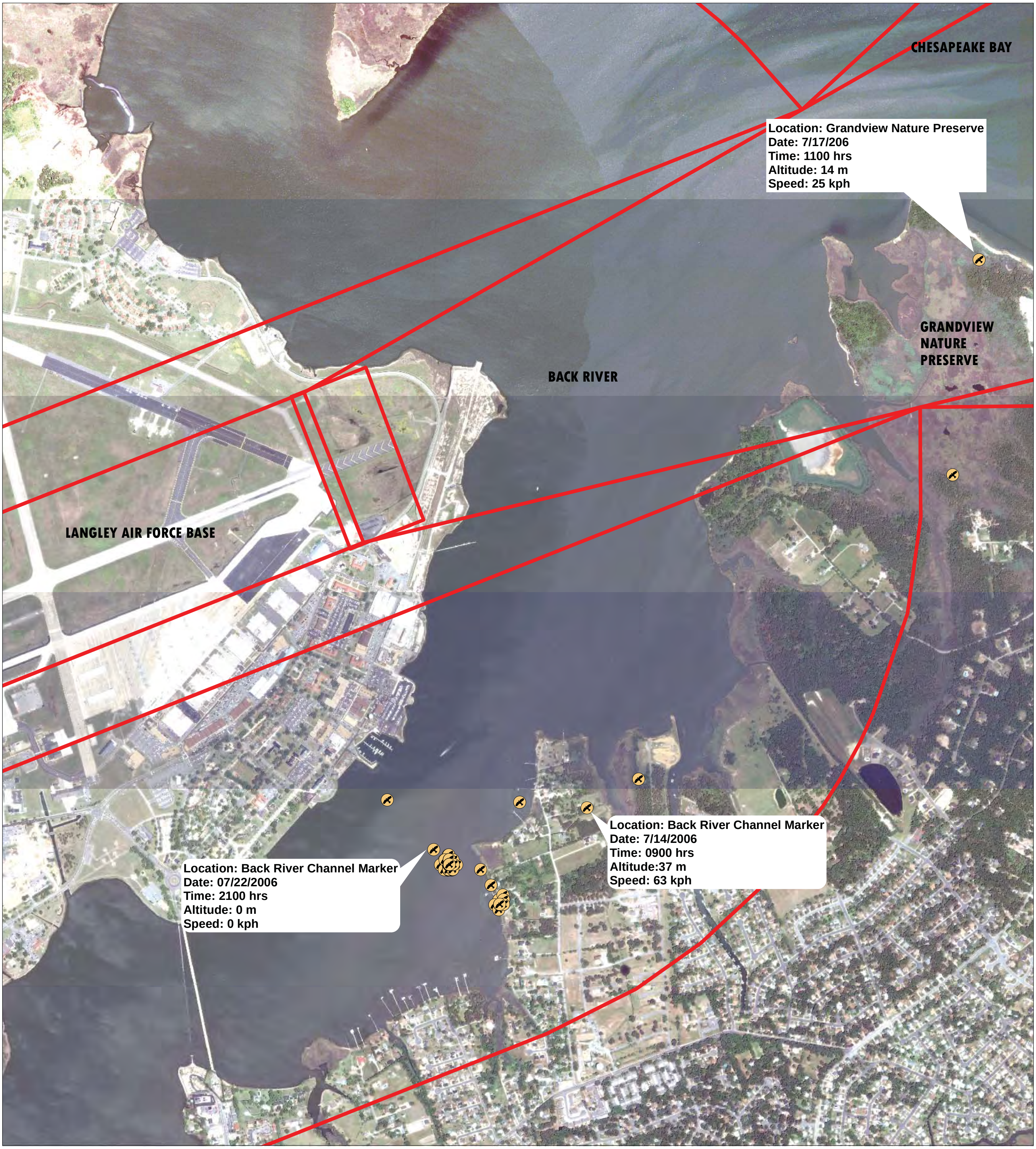
Legend

- M50_Point Locations
- M50_Airspace Hazard Locations
- M50_50% KHR (5.88 km2)
- M50_Airspace Risk Polygon (45.62 km2)
- M50_95% KHR (48.52 km2)
- LAFB Imaginary Surfaces

N
W E
S

Scale: 1:24,000

0 875 1,750 3,500
Meters



DoD Legacy Project 06/07/08-292

Coordinate System: WGS 84 UTM 18N
Vertical Datum: GEOID 88

Data Provided By: 633 ABW Installation Geospatial Information and Services
Produced By: 1 FW Flight Safety

Osprey J54 Breeding Period

Date Range: 21 Jun - 25 Jul 2006

Legend

- J54_Point Locations
- LAFB Imaginary Surfaces

N W E S

Scale: 1:4,260

0 170 340 680 Meters

DoD Legacy Project 06/07/08-292

Coordinate System:
WGS 84 UTM 18N
Vertical Datum:
GEOID 88

Data Provided By:
633 ABW Installation Geospatial Information and Services
Produced By: 1 FW Flight Safety

Osprey M52 Breeding Period

Date Range: 12 Mar - 25 Aug 2007

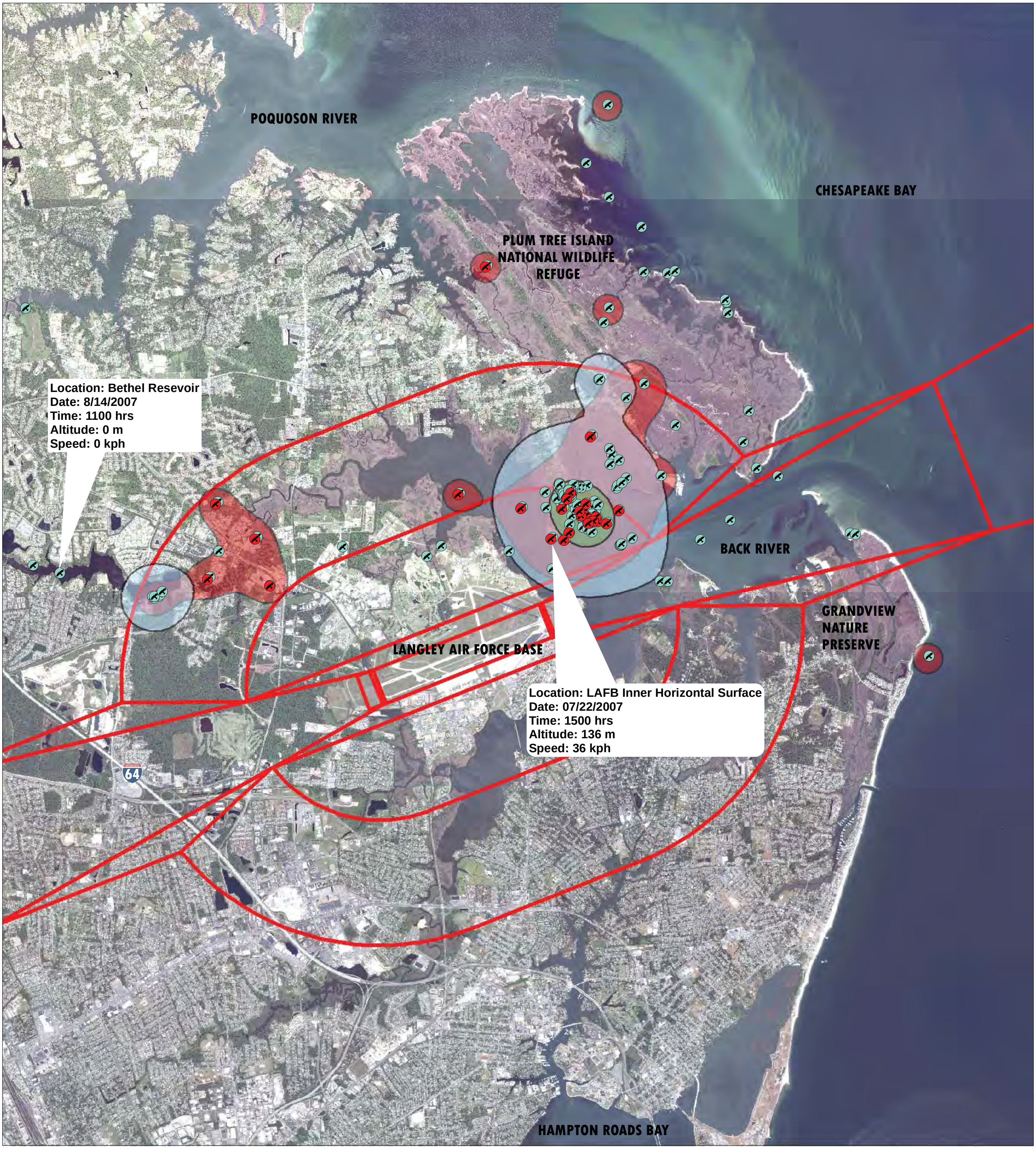
Legend

- M52_Point Locations
- M52_50% KHR (2.96 km2)
- M52_95% KHR (23.15 km2)
- M52_Airspace Risk Polygon (17.29 km2)
- M52_Airspace Hazard Locations
- LAFB Imaginary Surfaces

N W E S

Scale: 1:24,000

0 875 1,750 3,500 Meters



Osprey F48B Breeding Period

Date Range: 2 Jun - 3 Sep 2007

DoD Legacy Project 06/07/08-292

Coordinate System: WGS 84 UTM 18N
Vertical Datum: GEOID 88

Data Provided By: 633 ABW Installation Geospatial Information and Services
Produced By: 1 FW Flight Safety

Legend

- F48B_Point Locations
- F48B_50% KHR (0.96 km2)
- F48B_95% KHR (9.46 km2)
- F48B_Airspace Hazard Locations
- F48B_Airspace Risk Polygon (10.55 km2)
- LAFB Imaginary Surfaces

N
W E
S

Scale: 1:20,940

0 750 1,500 3,000 Meters

DoD Legacy Project 06/07/08-292

Coordinate System: WGS 84 UTM 18N
Vertical Datum: GEOID 88

Data Provided By: 633 ABW Installation Geospatial Information and Services
Produced By: 1 FW Flight Safety

Osprey F53 Breeding Period

Date Range: 31 May - 3 Sep 2007

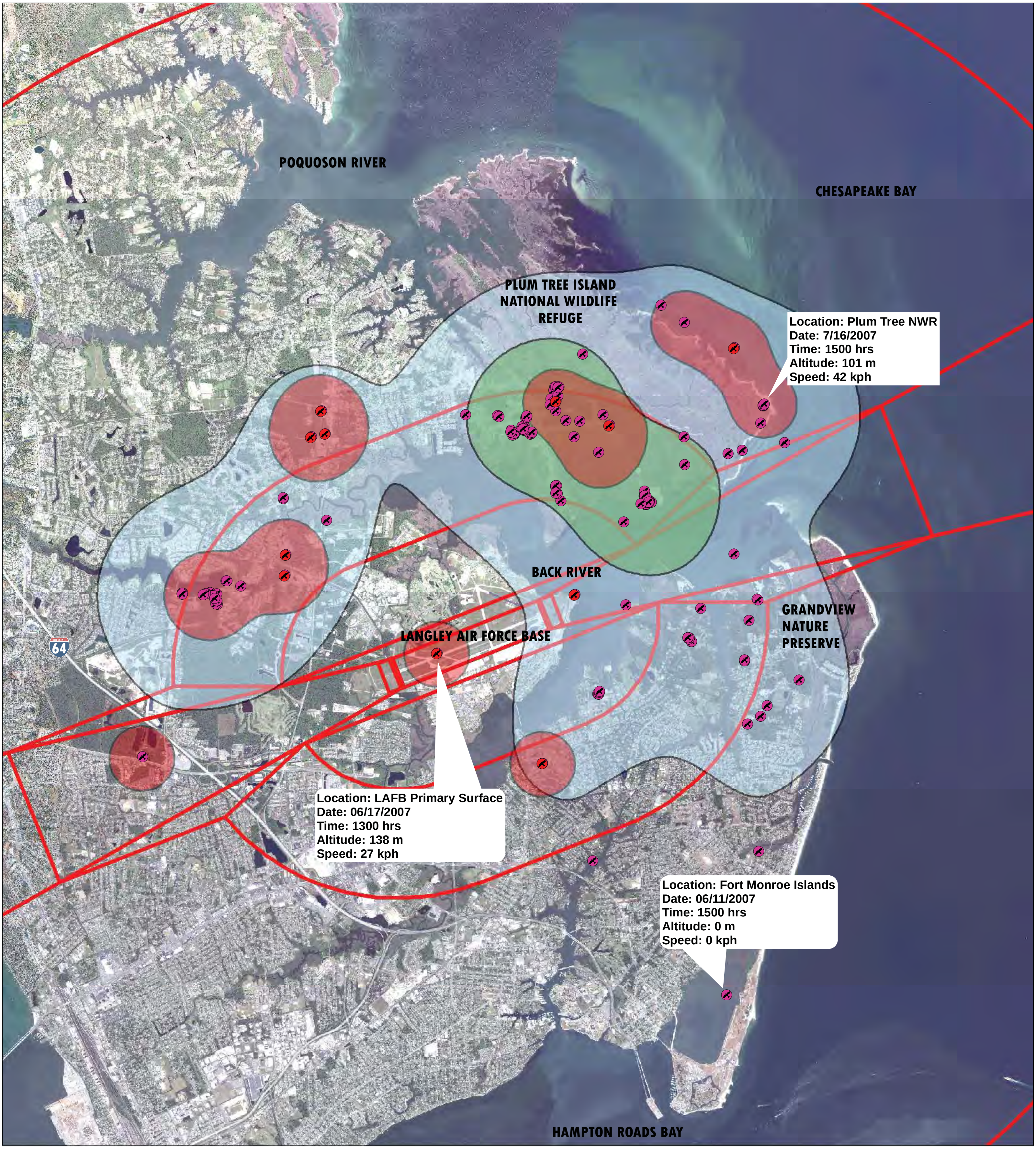
Legend

- F53_Point Locations
- F53_Airspace Hazard Locations
- F53_50% KHR (1.85 km2)
- F53_Airspace Risk Polygon (21.45 km2)
- F53_95% KHR (21.20 km2)
- LAFB Imaginary Surfaces

N
W E
S

Scale: 1:24,000

0 900 1,800 3,600 Meters



DoD Legacy Project 06/07/08-292

Coordinate System: WGS 84 UTM 18N
Vertical Datum: GEOID 88

Data Provided By: 633 ABW Installation Geospatial Information and Services
Produced By: 1 FW Flight Safety

Osprey F94 Breeding Period

Date Range: 1 Jun - 12 Aug 2007

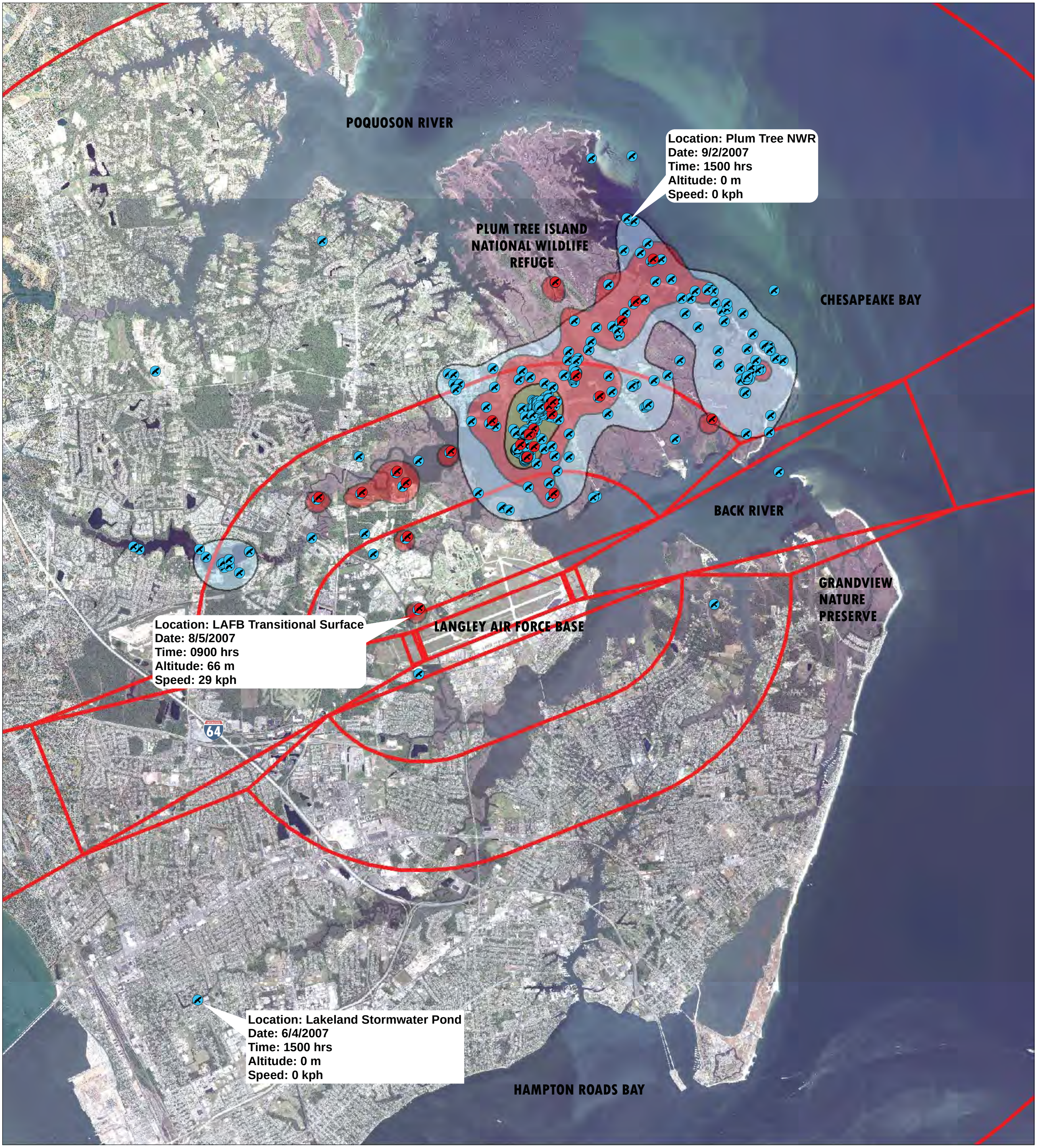
Legend

- F94_Point Locations
- F94_Airspace Hazard Locations
- F94_50% KHR (14.16 km2)
- F94_Airspace Risk Polygon (20.25 km2)
- F94_95% KHR (105.59 km2)
- LAFB Imaginary Surfaces

N W E S

Scale: 1:20,888

0 900 1,800 3,600 Meters



Osprey M54 Breeding Period

Date Range: 31 May - 11 Sep 2007

Legend

- M54_Point Locations
- M54_50% KHR (1.39 km2)
- M54_95% KHR (20.31 km2)
- M54_Airspace Hazard Locations
- M54_Airspace Risk Polygon (10.36 km2)
- LAFB Imaginary Surfaces

DoD Legacy Project 06/07/08-292

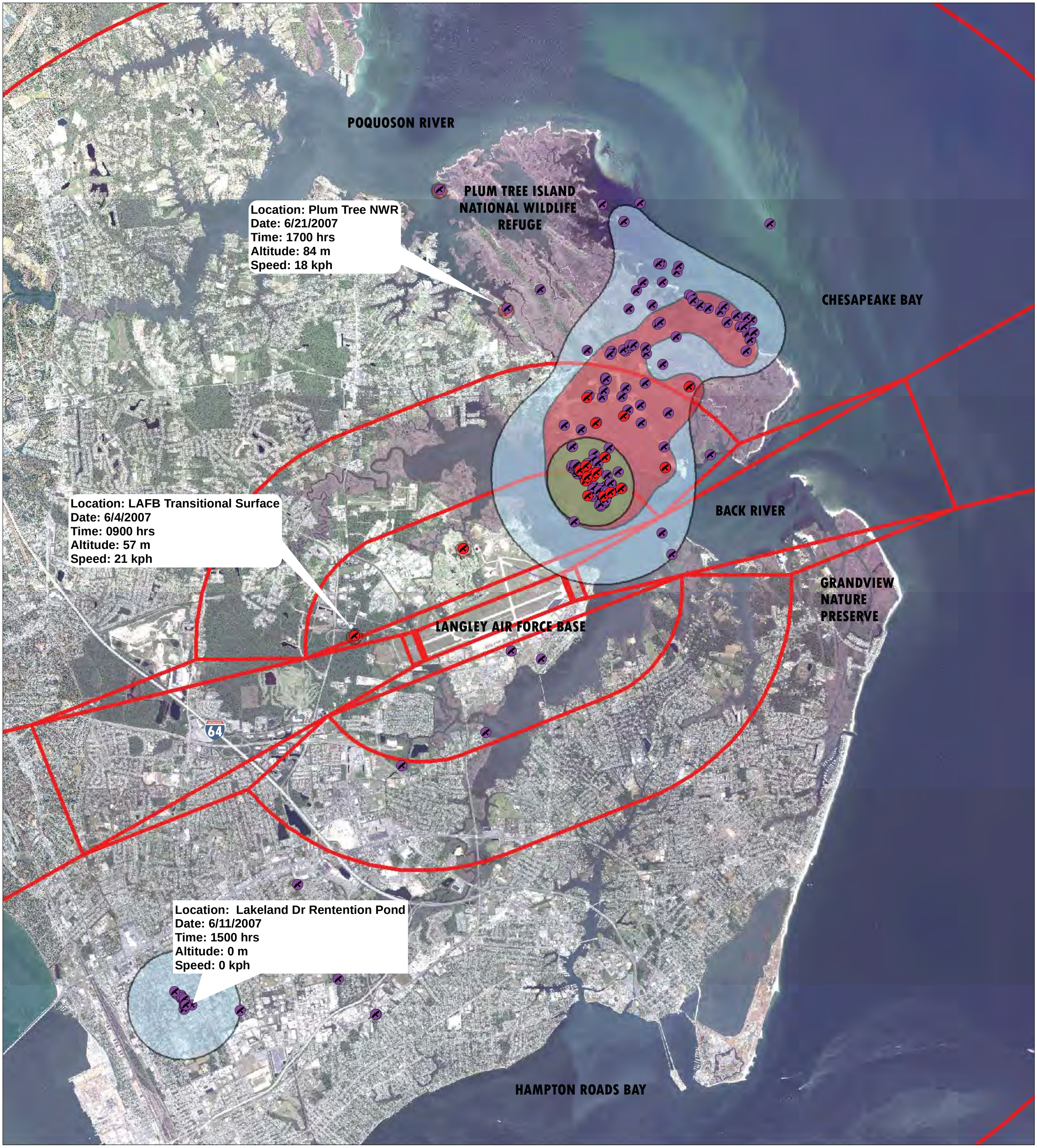
Coordinate System:
WGS 84 UTM 18N
Vertical Datum:
GEOID 88

Data Provided By:
633 ABW Installation Geospatial
Information and Services
Produced By: 1 FW Flight Safety

N S W E

Scale: 1:24,000

0 875 1,750 3,500 Meters



DoD Legacy Project 06/07/08-292

Coordinate System:
WGS 84 UTM 18N
Vertical Datum:
GEOID 88

Data Provided By:
633 ABW Installation Geospatial
Information and Services
Produced By: 1 FW Flight Safety

Osprey M98 Breeding Period

Date Range: 2 Jun - 13 Aug 2007

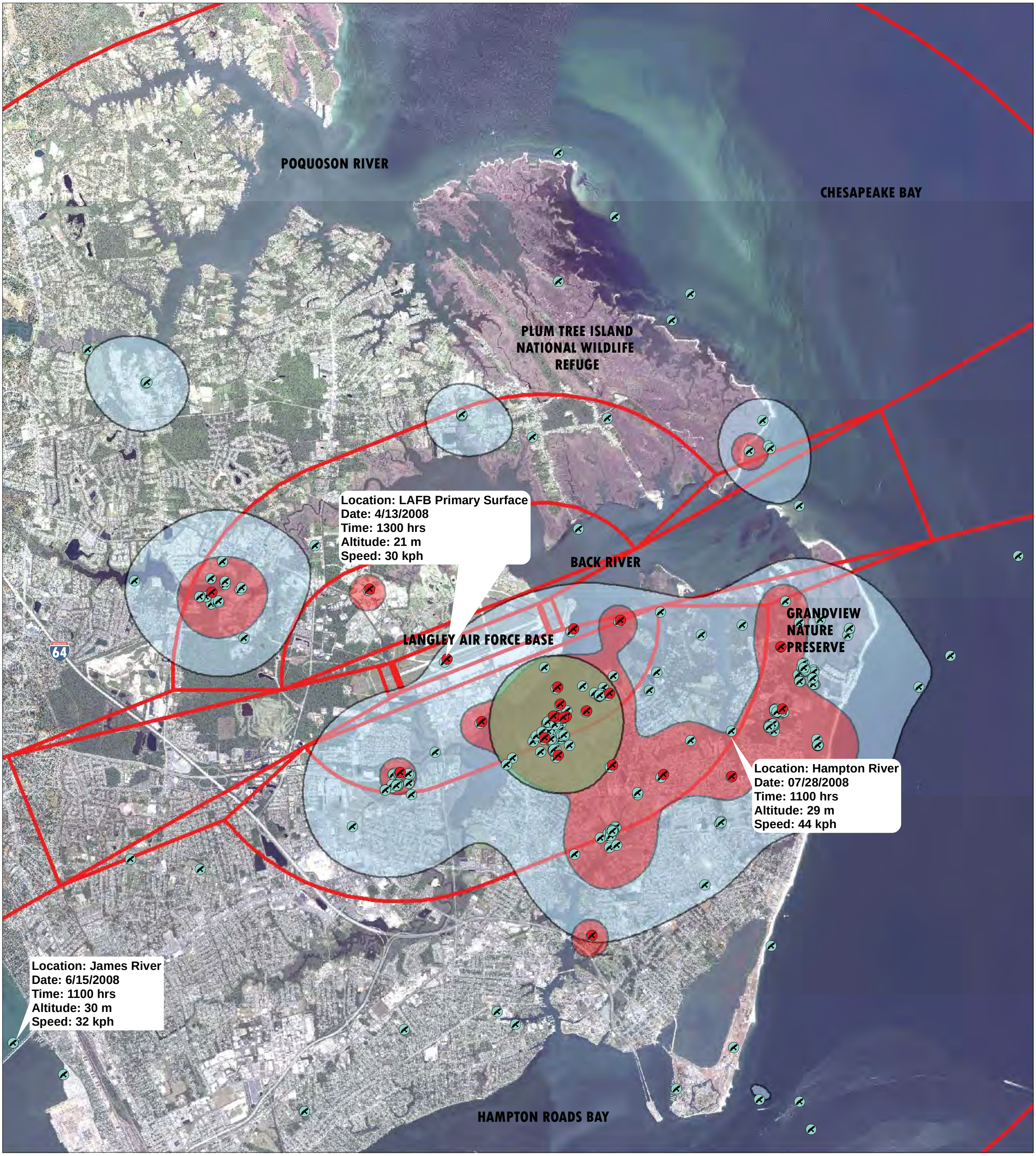
Legend

- M98_Point Locations
- M98_Airspace Hazard Locations
- M98_50% KHR (2.30 km2)
- M98_Airspace Risk Polygon (10.02 km2)
- M98_95% KHR (27.12 km2)
- LAFB Imaginary Surfaces

N
W E
S

Scale: 1:24,000

0 900 1,800 3,600 Meters



DoD Legacy Project 06/07/08-292

Coordinate System:
WGS 84 UTM 18N
Vertical Datum:
GEOID 88

Data Provided By:
633 ABW Installation Geospatial Information and Services
Produced By: 1 FW Flight Safety

Osprey F94 Breeding Period

Date Range: 18 Apr - 18 Aug 2008

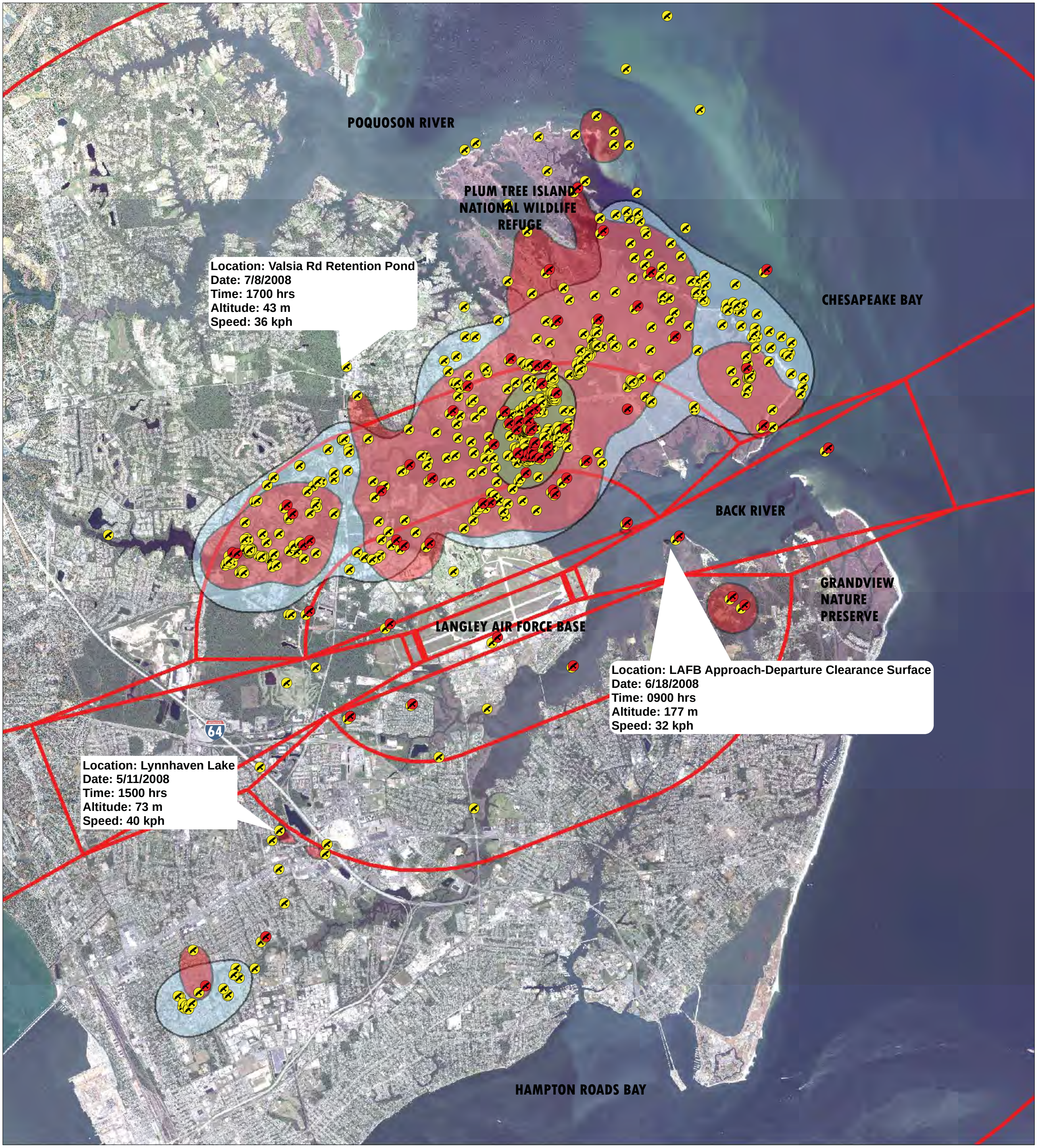
Legend

- F94_Point Locations
- F94_Airspace Hazard Locations
- F94_50% KHR (5.59 km2)
- F94_Airspace Risk Polygon (22.96 km2)
- F94_95% KHR (76.87 km2)
- LAFB Imaginary Surfaces

N W E S

Scale: 1:20,888

0 900 1,800 3,600 Meters



Osprey M54 Breeding Period

Date Range: 20 Mar - 14 Sep 2008

Legend

- M54_Point Location
- M54_50% KHR (2.81 km2)
- M54_95% KHR (44.02 km2)
- M54_Airspace Hazard Locations
- M54_Airspace Risk Polygon (35.48 km2)
- LAFB Imaginary Surfaces

DoD Legacy Project 06/07/08-292

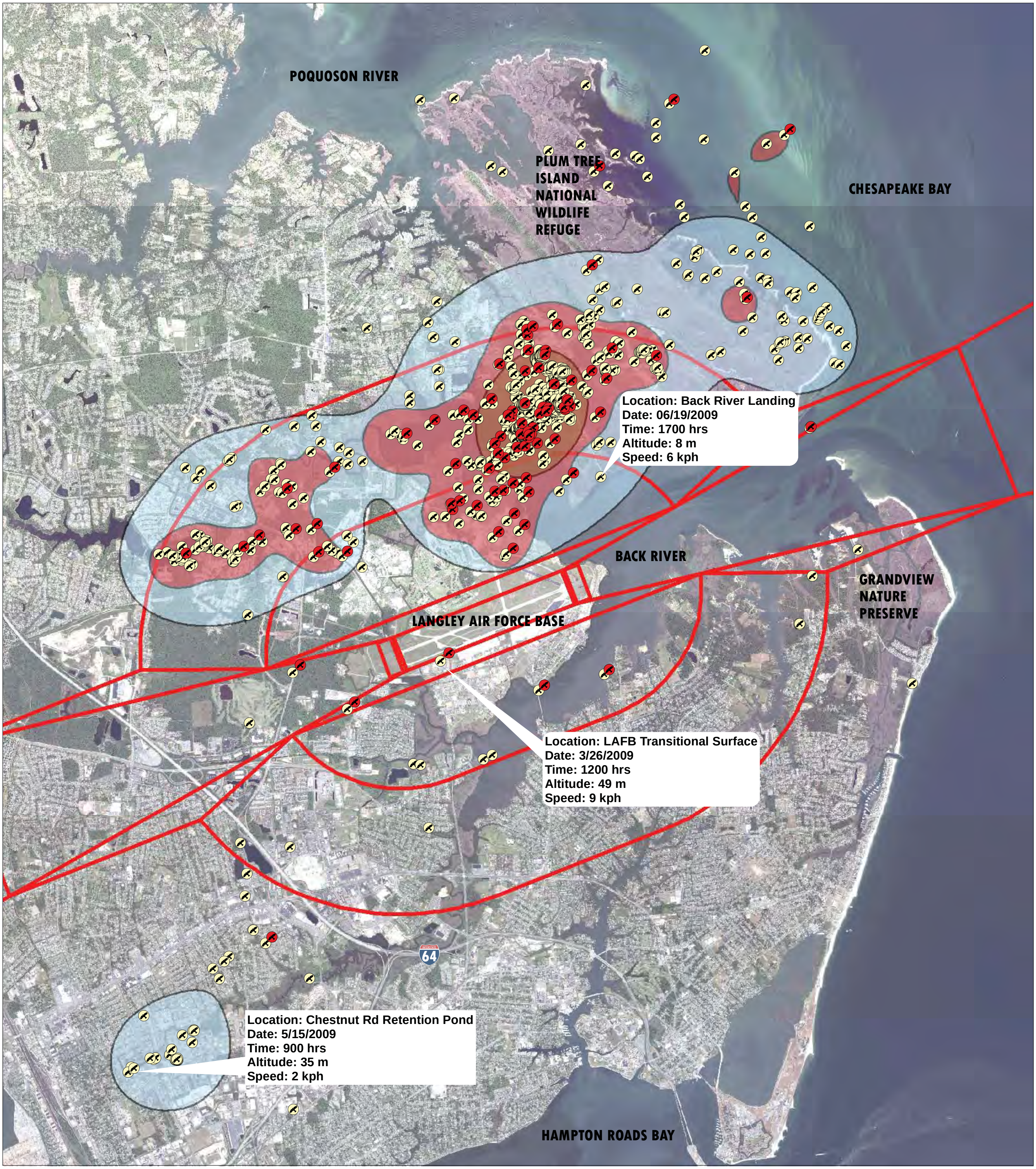
Coordinate System: WGS 84 UTM 18N
Vertical Datum: GEOID 88

Data Provided By: 633 ABW Installation Geospatial Information and Services
Produced By: 1 FW Flight Safety

N W E S

Scale: 1:24,000

0 875 1,750 3,500 Meters



DoD Legacy Project 06/07/08-292

Coordinate System:
WGS 84 UTM 18N
Vertical Datum:
GEOID 88

Data Provided By:
633 ABW Installation Geospatial Information and Services
Produced By: 1 FW Flight Safety

Osprey M54 Breeding Period

Date Range: 20 Mar - 29 Sep 2009

Legend
- M54_Point Locations
- M54_50% KHR (3.13 km2)
- M54_95% KHR (44.31 km2)
- M54_Airspace Hazard Locations
- M54_Airspace Risk Polygon (15.91 km2)
- LAFB Imaginary Surfaces

N
W E
S

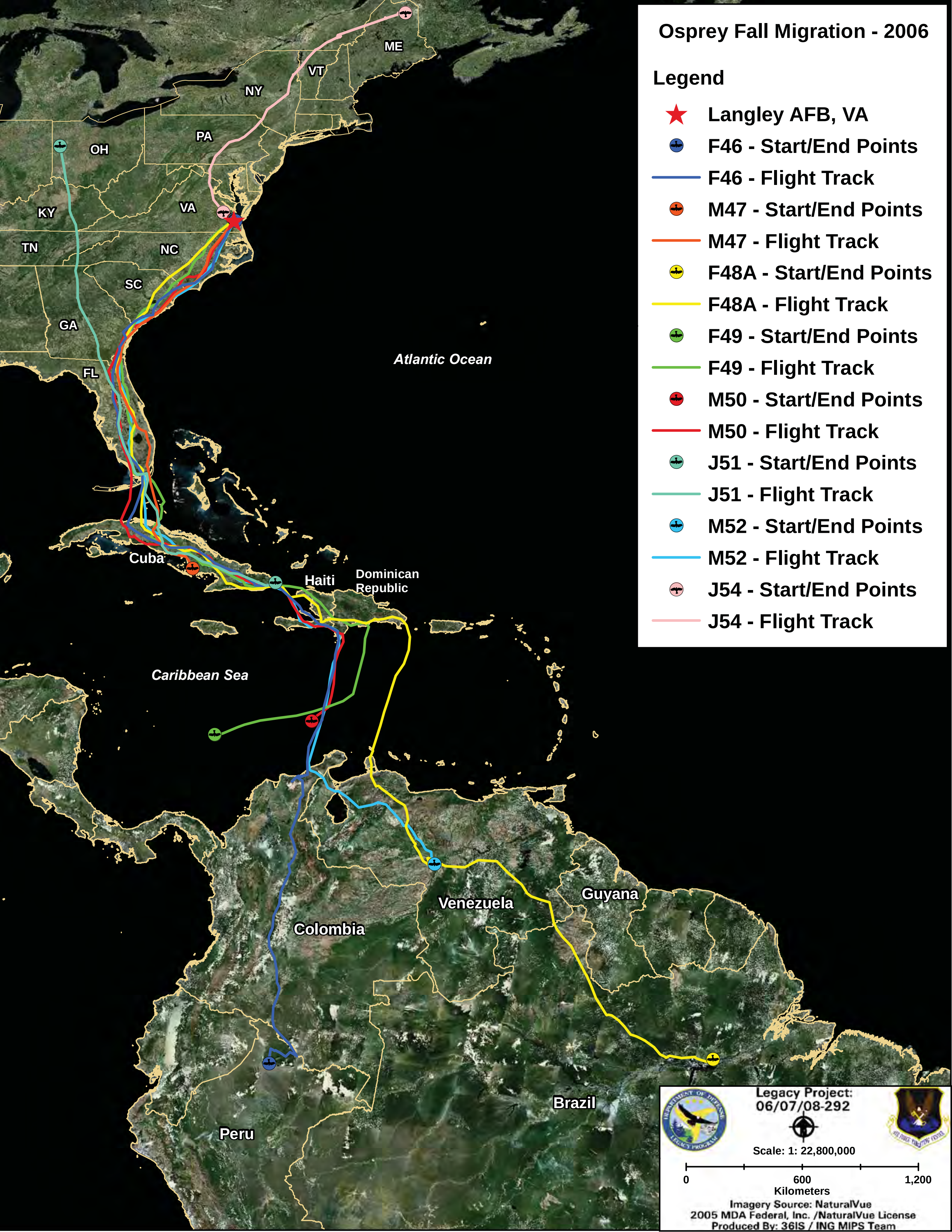
Scale: 1:21.131

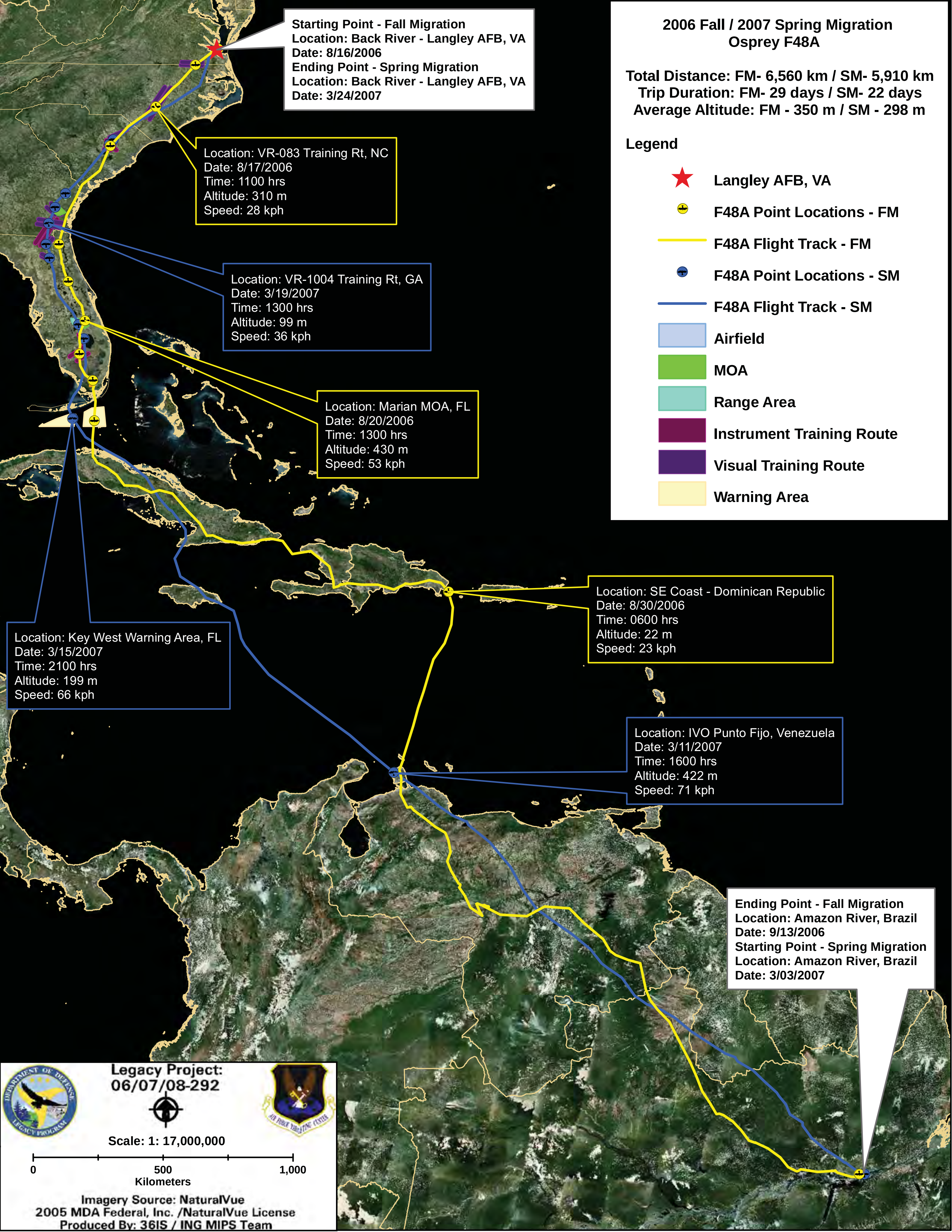
0 750 1,500 3,000 Meters

APPENDIX C.

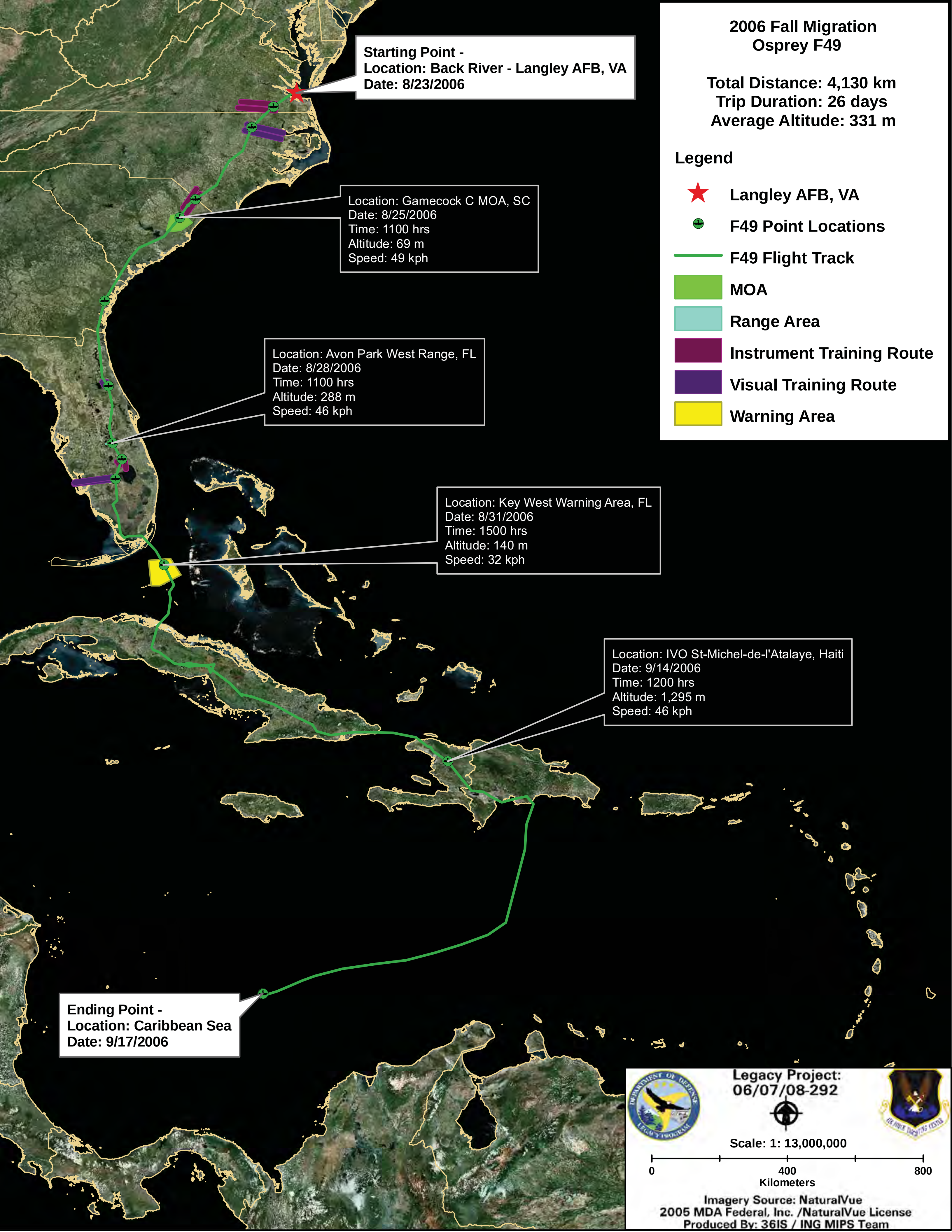
Fall Migration Maps

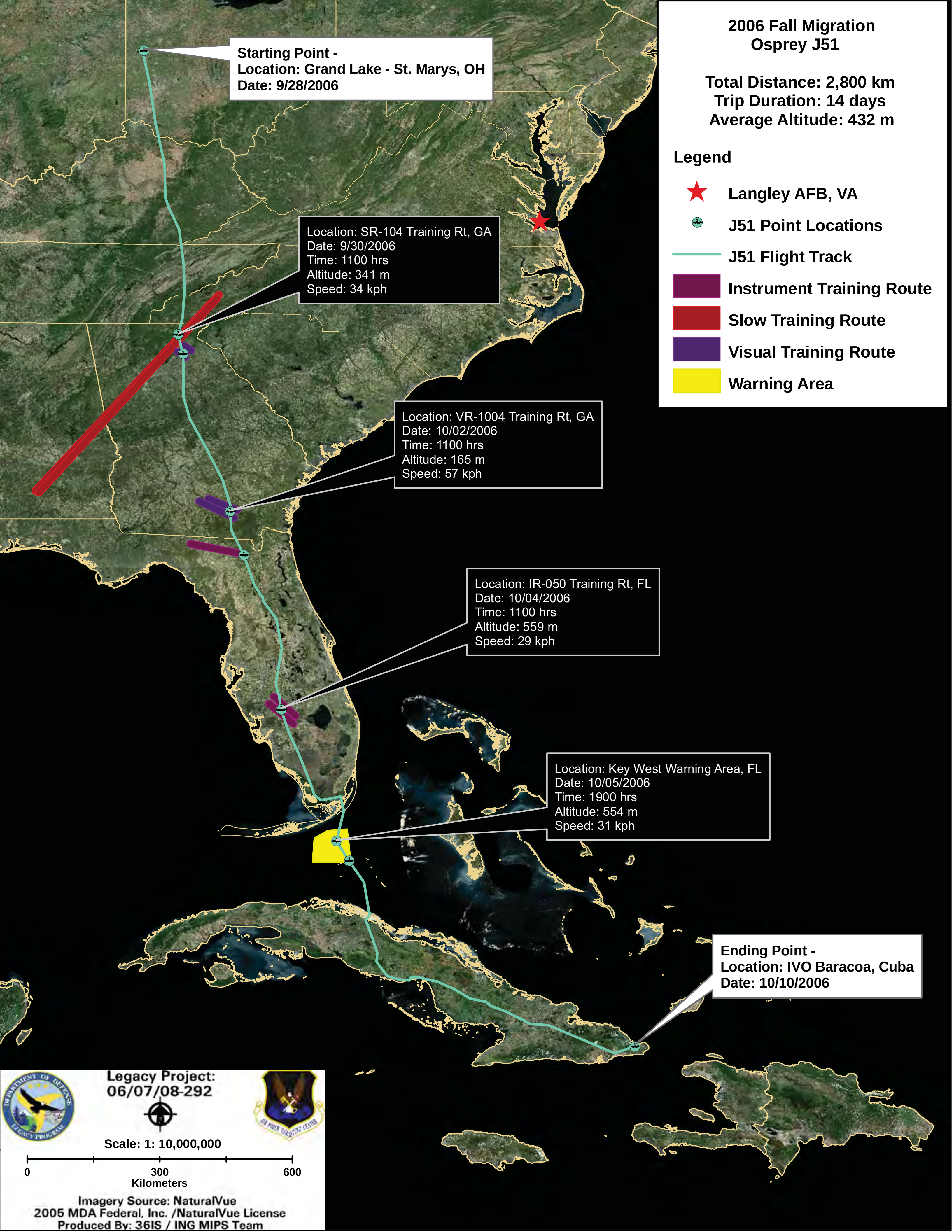
Appendix C features 20 high-quality reference maps illustrating flight tracks, point locations, distance traveled, duration of trip, average altitude, and military training airspace intersects of satellite-tagged Osprey during the fall migration period.

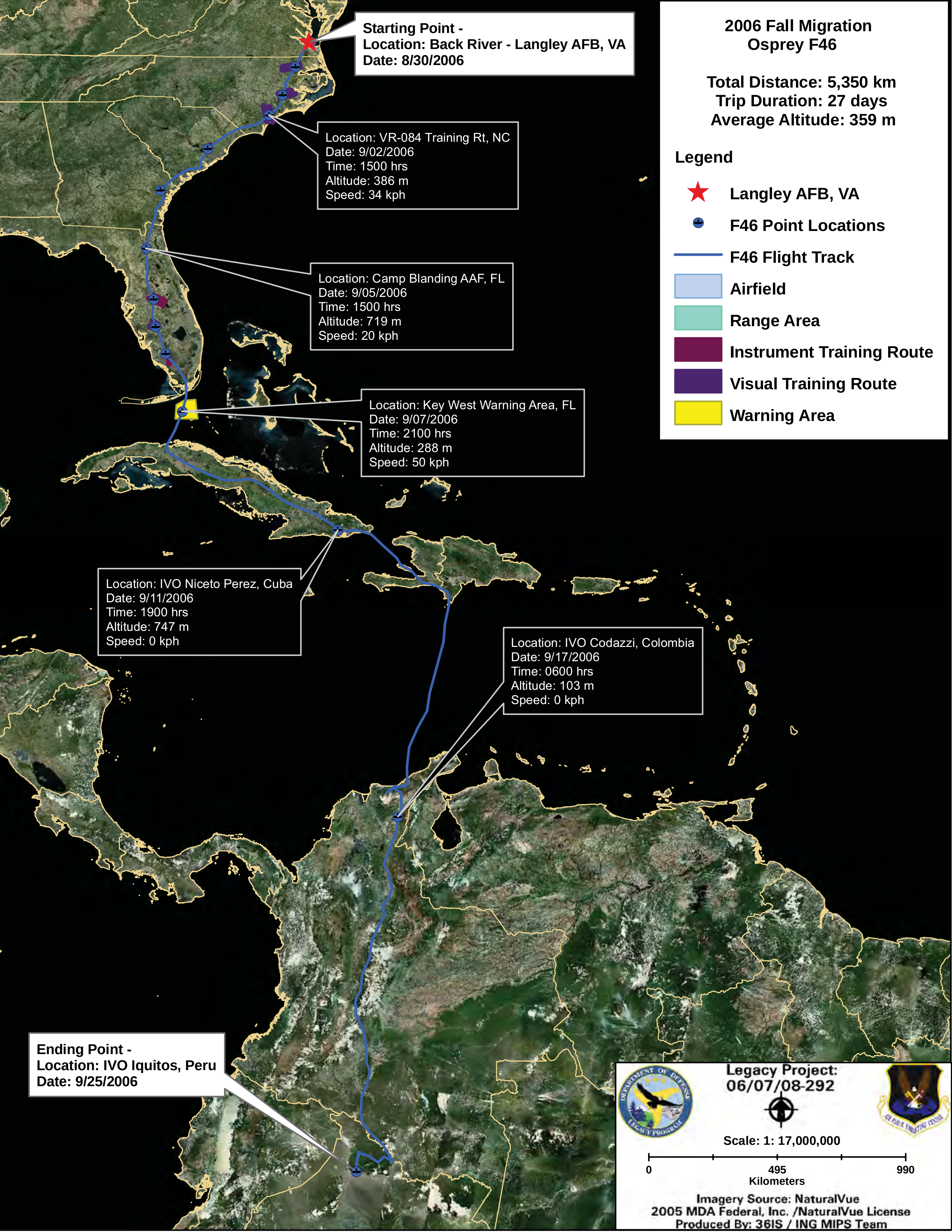

Osprey Fall Migration - 2006
Legend
Langley AFB, VA
F46 - Start/End Points
F46 - Flight Track
M47 - Start/End Points
M47 - Flight Track
F48A - Start/End Points
F48A - Flight Track
F49 - Start/End Points
F49 - Flight Track
M50 - Start/End Points
M50 - Flight Track
J51 - Start/End Points
J51 - Flight Track
M52 - Start/End Points
M52 - Flight Track
J54 - Start/End Points
J54 - Flight Track
ME
VT
NY
PA
OH
KY
VA
TN
NC
SC
GA
FL
Atlantic Ocean
Cuba
Haiti
Dominican Republic
Caribbean Sea
Venezuela
Guyana
Colombia
Brazil
Peru
Legacy Project:
06/07/08-292
Scale: 1: 22,800,000
0
600
1,200
Kilometers
Imagery Source: NaturalVue
2005 MDA Federal, Inc. /NaturalVue License
Produced By: 36IS / ING MIPS Team

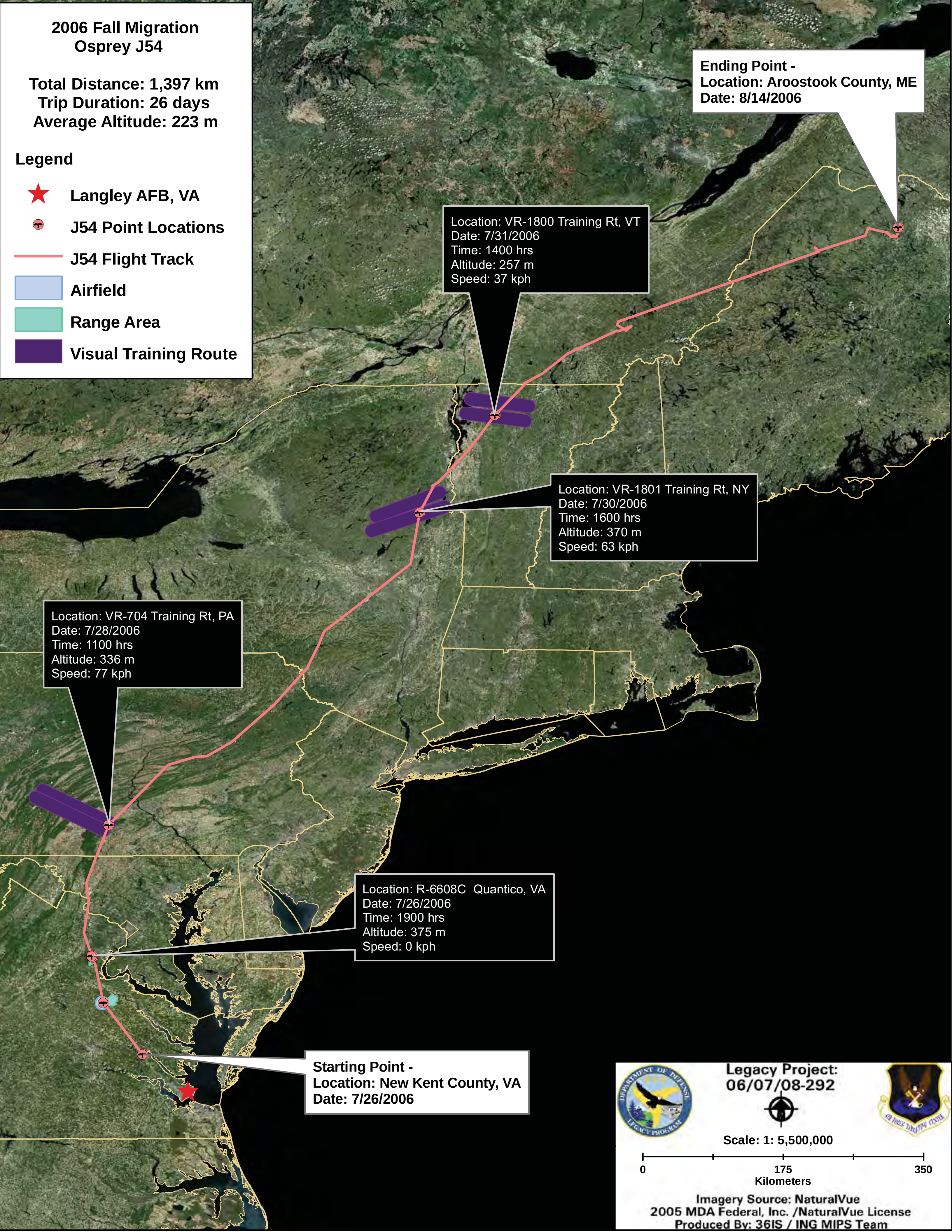


2006 Fall / 2007 Spring Migration
Osprey F48A
Total Distance: FM- 6,560 km / SM- 5,910 km
Trip Duration: FM- 29 days / SM- 22 days
Average Altitude: FM - 350 m / SM - 298 m
Legend
Langley AFB, VA
F48A Point Locations - FM
F48A Flight Track - FM
F48A Point Locations - SM
F48A Flight Track - SM
Airfield
MOA
Range Area
Instrument Training Route
Visual Training Route
Warning Area
Starting Point - Fall Migration
Location: Back River - Langley AFB, VA
Date: 8/16/2006
Ending Point - Spring Migration
Location: Back River - Langley AFB, VA
Date: 3/24/2007
Location: VR-083 Training Rt, NC
Date: 8/17/2006
Time: 1100 hrs
Altitude: 310 m
Speed: 28 kph
Location: VR-1004 Training Rt, GA
Date: 3/19/2007
Time: 1300 hrs
Altitude: 99 m
Speed: 36 kph
Location: Marian MOA, FL
Date: 8/20/2006
Time: 1300 hrs
Altitude: 430 m
Speed: 53 kph
Location: SE Coast - Dominican Republic
Date: 8/30/2006
Time: 0600 hrs
Altitude: 22 m
Speed: 23 kph
Location: Key West Warning Area, FL
Date: 3/15/2007
Time: 2100 hrs
Altitude: 199 m
Speed: 66 kph
Location: IVO Punto Fijo, Venezuela
Date: 3/11/2007
Time: 1600 hrs
Altitude: 422 m
Speed: 71 kph
Ending Point - Fall Migration
Location: Amazon River, Brazil
Date: 9/13/2006
Starting Point - Spring Migration
Location: Amazon River, Brazil
Date: 3/03/2007
Legacy Project:
06/07/08-292
Scale: 1: 17,000,000
0
500
1,000
Kilometers
Imagery Source: NaturalVue
2005 MDA Federal, Inc. /NaturalVue License
Produced By: 36IS / ING MIPS Team

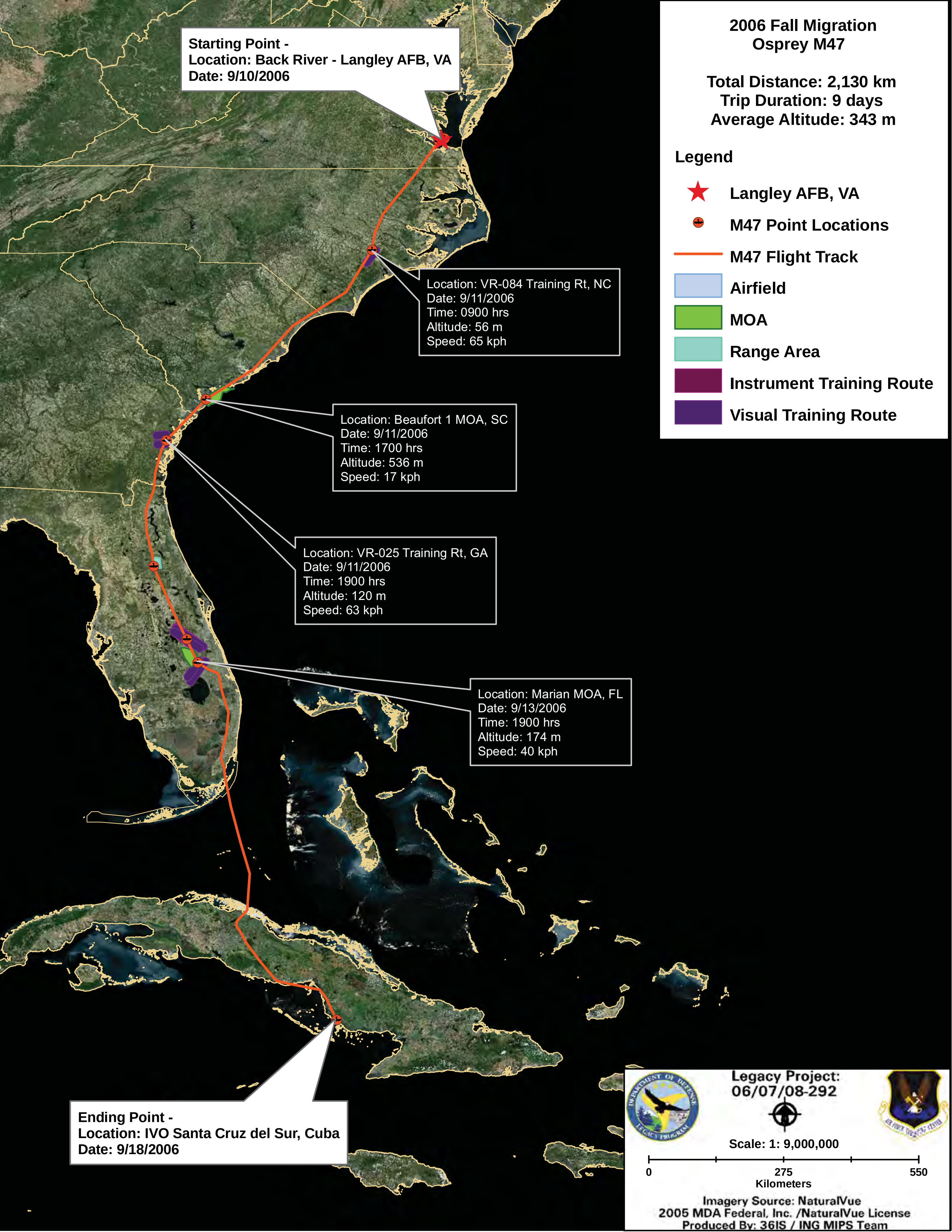

2006 Fall Migration
Osprey F49
Total Distance: 4,130 km
Trip Duration: 26 days
Average Altitude: 331 m
Legend
Langley AFB, VA
F49 Point Locations
F49 Flight Track
MOA
Range Area
Instrument Training Route
Visual Training Route
Warning Area
Starting Point -
Location: Back River - Langley AFB, VA
Date: 8/23/2006
Location: Gamecock C MOA, SC
Date: 8/25/2006
Time: 1100 hrs
Altitude: 69 m
Speed: 49 kph
Location: Avon Park West Range, FL
Date: 8/28/2006
Time: 1100 hrs
Altitude: 288 m
Speed: 46 kph
Location: Key West Warning Area, FL
Date: 8/31/2006
Time: 1500 hrs
Altitude: 140 m
Speed: 32 kph
Location: IVO St-Michel-de-l'Atalaye, Haiti
Date: 9/14/2006
Time: 1200 hrs
Altitude: 1,295 m
Speed: 46 kph
Ending Point -
Location: Caribbean Sea
Date: 9/17/2006
Legacy Project:
06/07/08-292
Scale: 1: 13,000,000
0
400
800
Kilometers
Imagery Source: NaturalVue
2005 MDA Federal, Inc. /NaturalVue License
Produced By: 36IS / ING MIPS Team

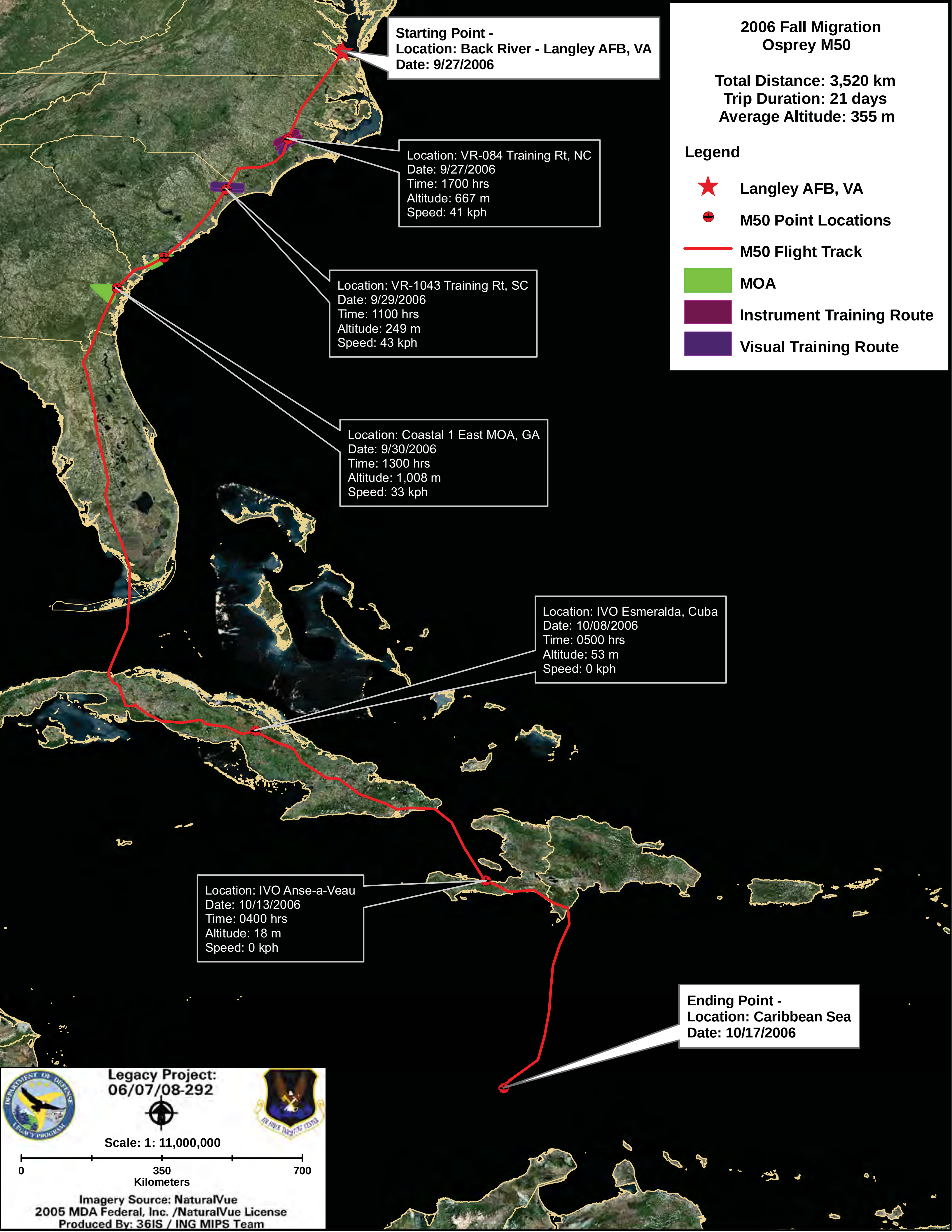

2006 Fall Migration
Osprey J51
Total Distance: 2,800 km
Trip Duration: 14 days
Average Altitude: 432 m
Legend
Langley AFB, VA
J51 Point Locations
J51 Flight Track
Instrument Training Route
Slow Training Route
Visual Training Route
Warning Area
Starting Point -
Location: Grand Lake - St. Marys, OH
Date: 9/28/2006
Location: SR-104 Training Rt, GA
Date: 9/30/2006
Time: 1100 hrs
Altitude: 341 m
Speed: 34 kph
Location: VR-1004 Training Rt, GA
Date: 10/02/2006
Time: 1100 hrs
Altitude: 165 m
Speed: 57 kph
Location: IR-050 Training Rt, FL
Date: 10/04/2006
Time: 1100 hrs
Altitude: 559 m
Speed: 29 kph
Location: Key West Warning Area, FL
Date: 10/05/2006
Time: 1900 hrs
Altitude: 554 m
Speed: 31 kph
Ending Point -
Location: IVO Baracoa, Cuba
Date: 10/10/2006
Legacy Project:
06/07/08-292
Scale: 1: 10,000,000
0
300
600
Kilometers
Imagery Source: NaturalVue
2005 MDA Federal, Inc. /NaturalVue License
Produced By: 36IS / ING MIPS Team


Starting Point -
Location: Back River - Langley AFB, VA
Date: 8/30/2006
2006 Fall Migration
Osprey F46
Total Distance: 5,350 km
Trip Duration: 27 days
Average Altitude: 359 m
Legend
Langley AFB, VA
F46 Point Locations
F46 Flight Track
Airfield
Range Area
Instrument Training Route
Visual Training Route
Warning Area
Location: VR-084 Training Rt, NC
Date: 9/02/2006
Time: 1500 hrs
Altitude: 386 m
Speed: 34 kph
Location: Camp Blanding AAF, FL
Date: 9/05/2006
Time: 1500 hrs
Altitude: 719 m
Speed: 20 kph
Location: Key West Warning Area, FL
Date: 9/07/2006
Time: 2100 hrs
Altitude: 288 m
Speed: 50 kph
Location: IVO Niceto Perez, Cuba
Date: 9/11/2006
Time: 1900 hrs
Altitude: 747 m
Speed: 0 kph
Location: IVO Codazzi, Colombia
Date: 9/17/2006
Time: 0600 hrs
Altitude: 103 m
Speed: 0 kph
Ending Point -
Location: IVO Iquitos, Peru
Date: 9/25/2006
Legacy Project:
06/07/08-292
Scale: 1: 17,000,000
0
495
990
Kilometers
Imagery Source: NaturalVue
2005 MDA Federal, Inc. /NaturalVue License
Produced By: 36IS / ING MIPS Team

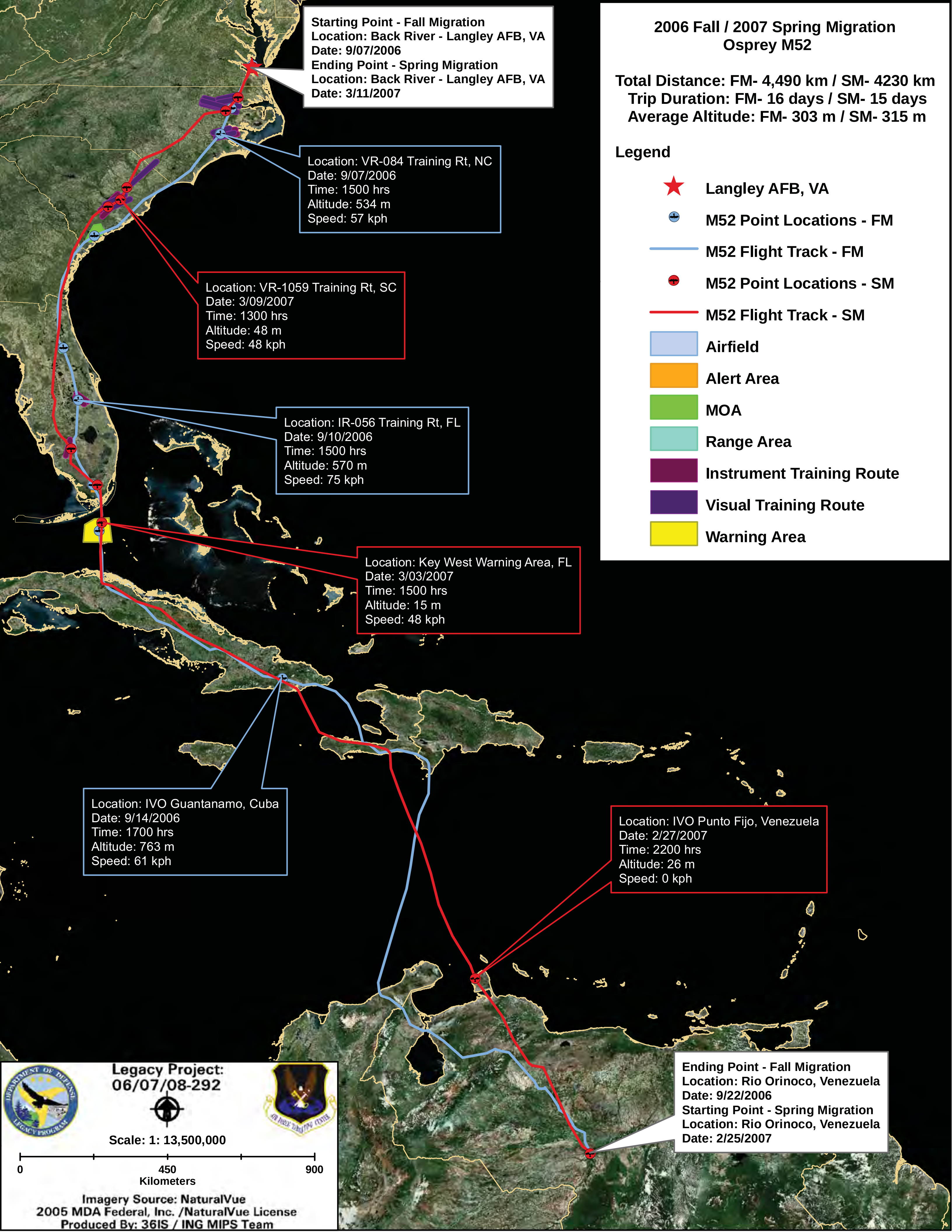


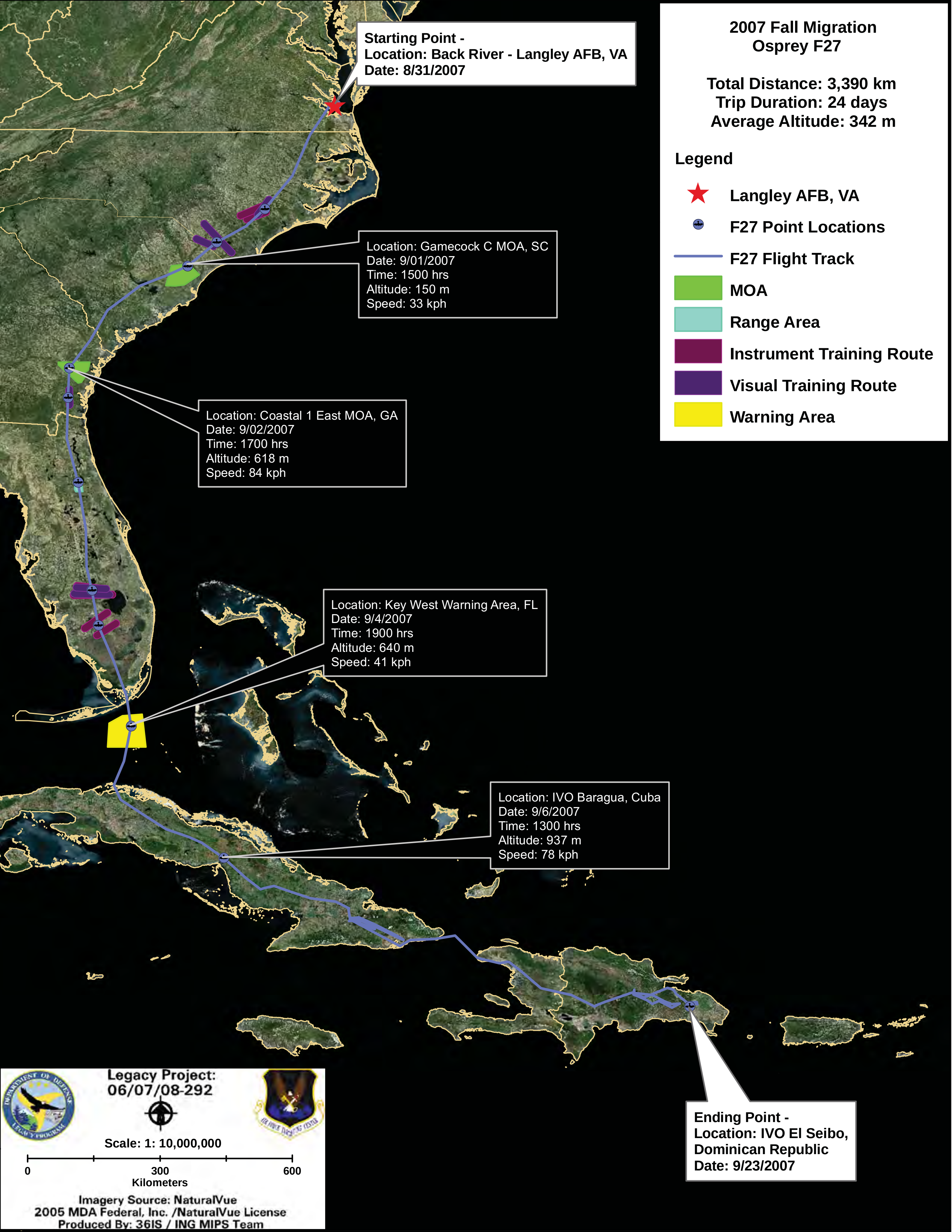
2006 Fall Migration
Osprey J54
Total Distance: 1,397 km
Trip Duration: 26 days
Average Altitude: 223 m
Legend
Langley AFB, VA
J54 Point Locations
J54 Flight Track
Airfield
Range Area
Visual Training Route
Ending Point -
Location: Aroostook County, ME
Date: 8/14/2006
Location: VR-1800 Training Rt, VT
Date: 7/31/2006
Time: 1400 hrs
Altitude: 257 m
Speed: 37 kph
Location: VR-1801 Training Rt, NY
Date: 7/30/2006
Time: 1600 hrs
Altitude: 370 m
Speed: 63 kph
Location: VR-704 Training Rt, PA
Date: 7/28/2006
Time: 1100 hrs
Altitude: 336 m
Speed: 77 kph
Location: R-6608C Quantico, VA
Date: 7/26/2006
Time: 1900 hrs
Altitude: 375 m
Speed: 0 kph
Starting Point -
Location: New Kent County, VA
Date: 7/26/2006
Legacy Project:
06/07/08-292
Scale: 1: 5,500,000
0
175
350
Kilometers
Imagery Source: NaturalVue
2005 MDA Federal, Inc. /NaturalVue License
Produced By: 36IS / ING MIPS Team


2006 Fall Migration
Osprey M47
Total Distance: 2,130 km
Trip Duration: 9 days
Average Altitude: 343 m
Legend
Langley AFB, VA
M47 Point Locations
M47 Flight Track
Airfield
MOA
Range Area
Instrument Training Route
Visual Training Route
Starting Point -
Location: Back River - Langley AFB, VA
Date: 9/10/2006
Location: VR-084 Training Rt, NC
Date: 9/11/2006
Time: 0900 hrs
Altitude: 56 m
Speed: 65 kph
Location: Beaufort 1 MOA, SC
Date: 9/11/2006
Time: 1700 hrs
Altitude: 536 m
Speed: 17 kph
Location: VR-025 Training Rt, GA
Date: 9/11/2006
Time: 1900 hrs
Altitude: 120 m
Speed: 63 kph
Location: Marian MOA, FL
Date: 9/13/2006
Time: 1900 hrs
Altitude: 174 m
Speed: 40 kph
Ending Point -
Location: IVO Santa Cruz del Sur, Cuba
Date: 9/18/2006
Legacy Project:
06/07/08-292
Scale: 1: 9,000,000
0
275
550
Kilometers
Imagery Source: NaturalVue
2005 MDA Federal, Inc. /NaturalVue License
Produced By: 36IS / ING MIPS Team

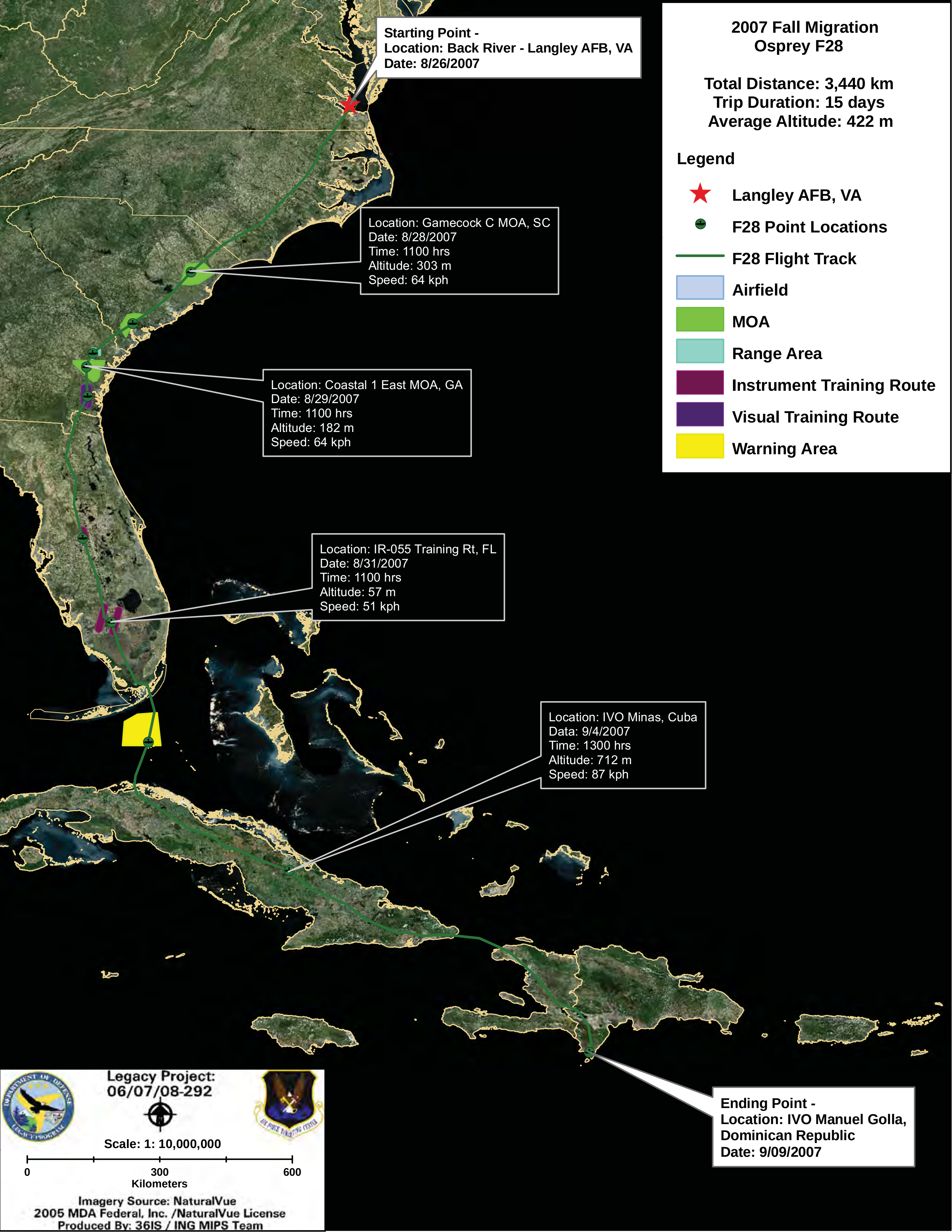


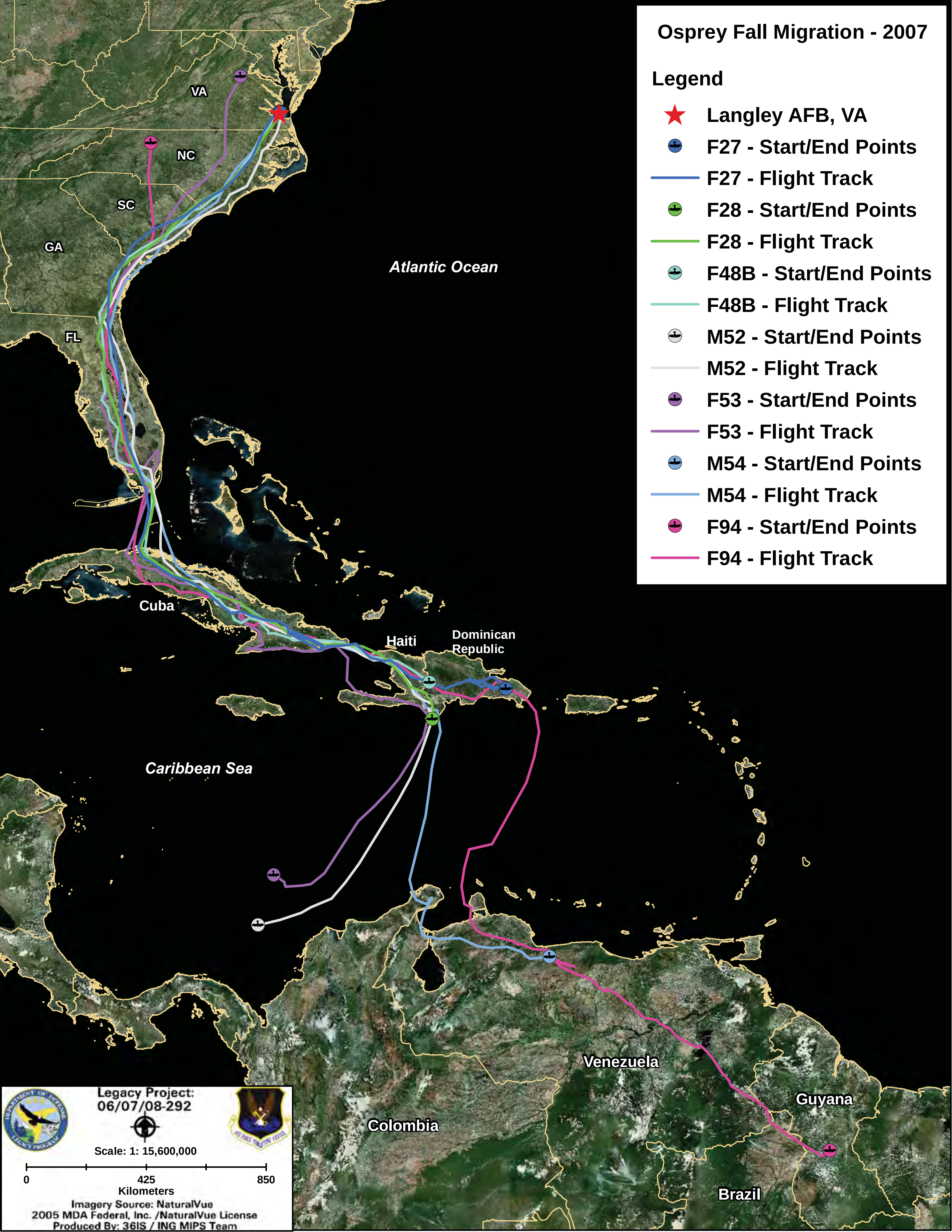
2006 Fall Migration
Osprey M50
Total Distance: 3,520 km
Trip Duration: 21 days
Average Altitude: 355 m
Legend
Langley AFB, VA
M50 Point Locations
M50 Flight Track
MOA
Instrument Training Route
Visual Training Route
Starting Point -
Location: Back River - Langley AFB, VA
Date: 9/27/2006
Location: VR-084 Training Rt, NC
Date: 9/27/2006
Time: 1700 hrs
Altitude: 667 m
Speed: 41 kph
Location: VR-1043 Training Rt, SC
Date: 9/29/2006
Time: 1100 hrs
Altitude: 249 m
Speed: 43 kph
Location: Coastal 1 East MOA, GA
Date: 9/30/2006
Time: 1300 hrs
Altitude: 1,008 m
Speed: 33 kph
Location: IVO Esmeralda, Cuba
Date: 10/08/2006
Time: 0500 hrs
Altitude: 53 m
Speed: 0 kph
Location: IVO Anse-a-Veau
Date: 10/13/2006
Time: 0400 hrs
Altitude: 18 m
Speed: 0 kph
Ending Point -
Location: Caribbean Sea
Date: 10/17/2006
Legacy Project:
06/07/08-292
Scale: 1: 11,000,000
0
350
700
Kilometers
Imagery Source: NaturalVue
2005 MDA Federal, Inc. /NaturalVue License
Produced By: 36IS / ING MIPS Team


2006 Fall / 2007 Spring Migration
Osprey M52
Total Distance: FM- 4,490 km / SM- 4230 km
Trip Duration: FM- 16 days / SM- 15 days
Average Altitude: FM- 303 m / SM- 315 m
Legend
Langley AFB, VA
M52 Point Locations - FM
M52 Flight Track - FM
M52 Point Locations - SM
M52 Flight Track - SM
Airfield
Alert Area
MOA
Range Area
Instrument Training Route
Visual Training Route
Warning Area
Starting Point - Fall Migration
Location: Back River - Langley AFB, VA
Date: 9/07/2006
Ending Point - Spring Migration
Location: Back River - Langley AFB, VA
Date: 3/11/2007
Location: VR-084 Training Rt, NC
Date: 9/07/2006
Time: 1500 hrs
Altitude: 534 m
Speed: 57 kph
Location: VR-1059 Training Rt, SC
Date: 3/09/2007
Time: 1300 hrs
Altitude: 48 m
Speed: 48 kph
Location: IR-056 Training Rt, FL
Date: 9/10/2006
Time: 1500 hrs
Altitude: 570 m
Speed: 75 kph
Location: Key West Warning Area, FL
Date: 3/03/2007
Time: 1500 hrs
Altitude: 15 m
Speed: 48 kph
Location: IVO Guantanamo, Cuba
Date: 9/14/2006
Time: 1700 hrs
Altitude: 763 m
Speed: 61 kph
Location: IVO Punto Fijo, Venezuela
Date: 2/27/2007
Time: 2200 hrs
Altitude: 26 m
Speed: 0 kph
Ending Point - Fall Migration
Location: Rio Orinoco, Venezuela
Date: 9/22/2006
Starting Point - Spring Migration
Location: Rio Orinoco, Venezuela
Date: 2/25/2007
Legacy Project:
06/07/08-292
Scale: 1: 13,500,000
0
450
900
Kilometers
Imagery Source: NaturalVue
2005 MDA Federal, Inc. /NaturalVue License
Produced By: 36IS / ING MIPS Team

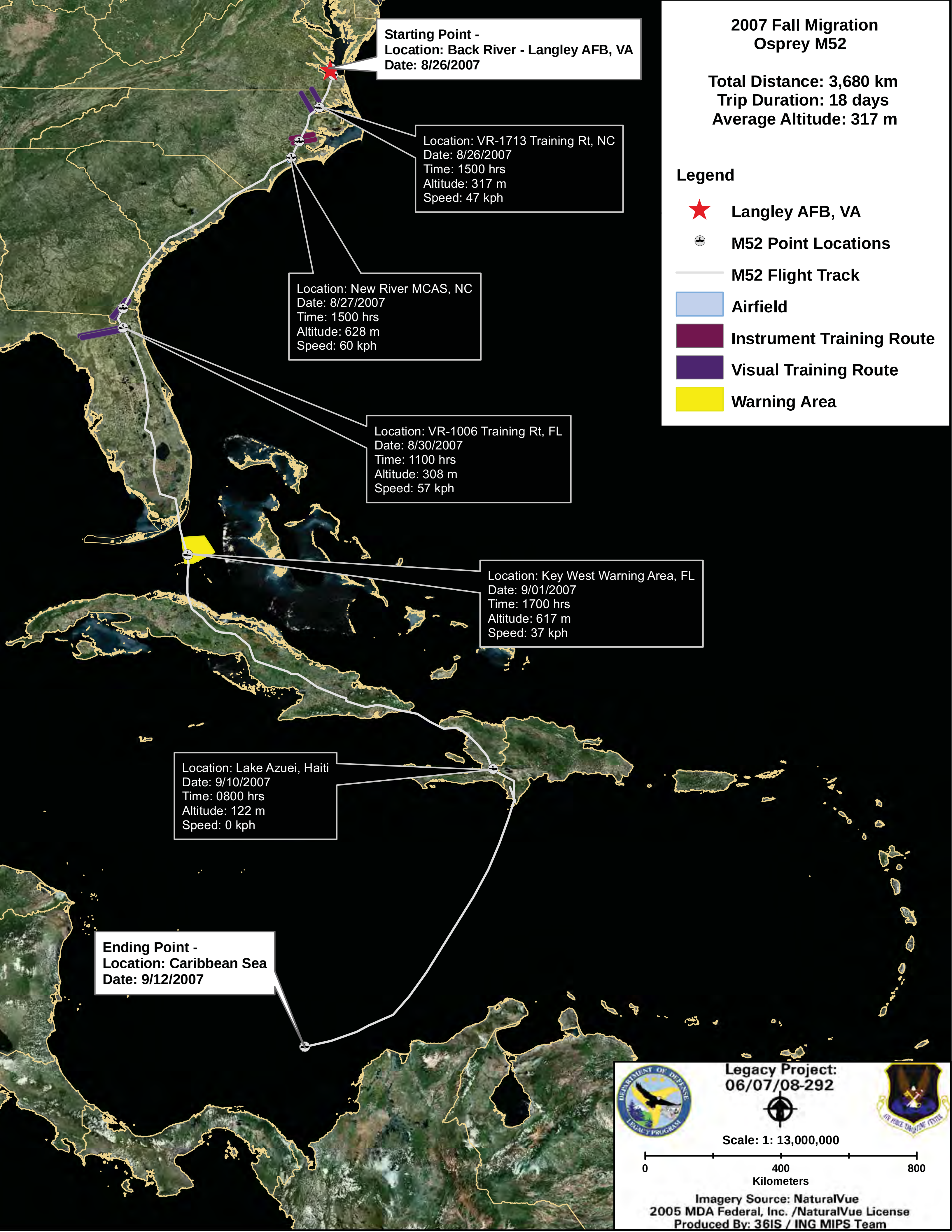


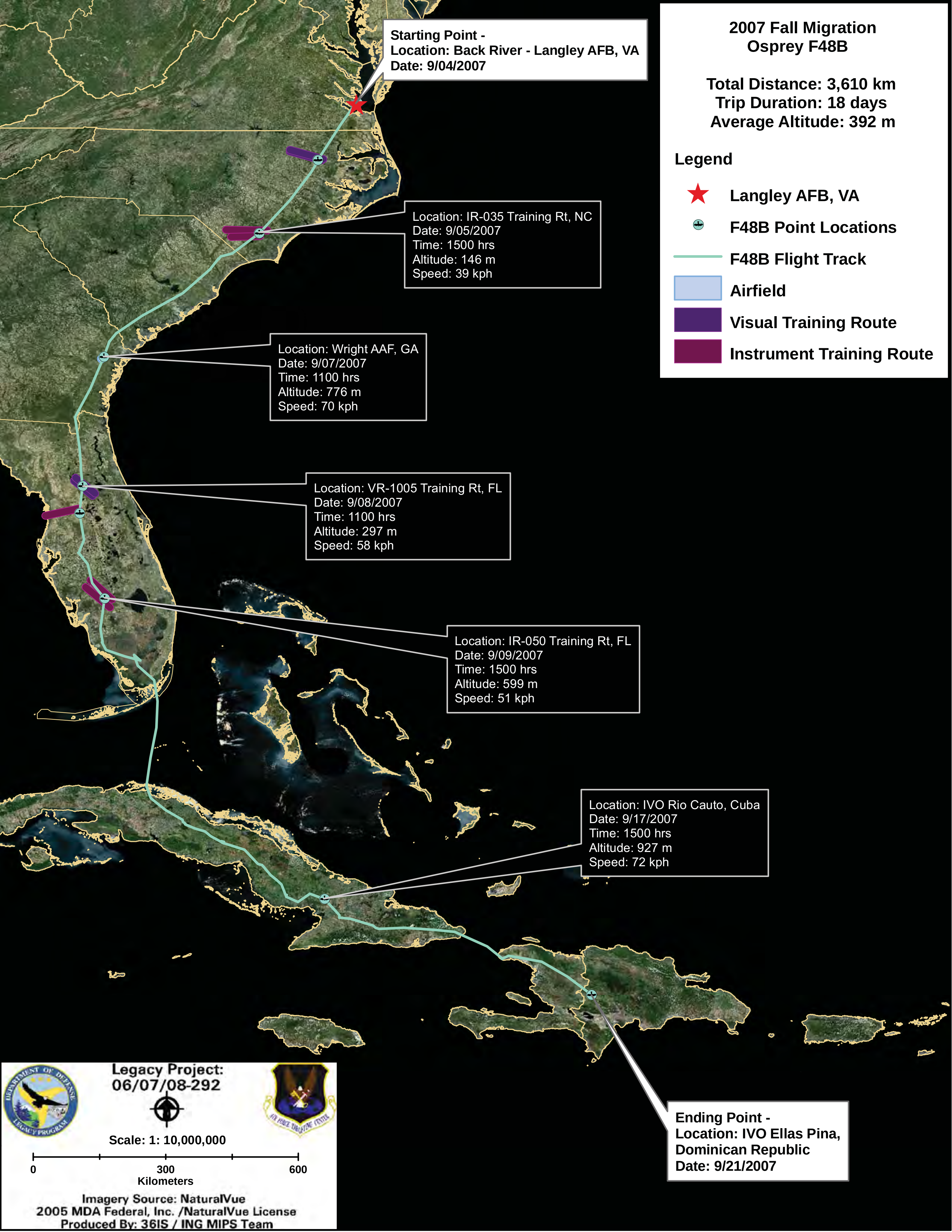
2007 Fall Migration
Osprey F27
Total Distance: 3,390 km
Trip Duration: 24 days
Average Altitude: 342 m
Legend
Langley AFB, VA
F27 Point Locations
F27 Flight Track
MOA
Range Area
Instrument Training Route
Visual Training Route
Warning Area
Starting Point -
Location: Back River - Langley AFB, VA
Date: 8/31/2007
Location: Gamecock C MOA, SC
Date: 9/01/2007
Time: 1500 hrs
Altitude: 150 m
Speed: 33 kph
Location: Coastal 1 East MOA, GA
Date: 9/02/2007
Time: 1700 hrs
Altitude: 618 m
Speed: 84 kph
Location: Key West Warning Area, FL
Date: 9/4/2007
Time: 1900 hrs
Altitude: 640 m
Speed: 41 kph
Location: IVO Baragua, Cuba
Date: 9/6/2007
Time: 1300 hrs
Altitude: 937 m
Speed: 78 kph
Ending Point -
Location: IVO El Seibo,
Dominican Republic
Date: 9/23/2007
Legacy Project:
06/07/08-292
Scale: 1: 10,000,000
0
300
600
Kilometers
Imagery Source: NaturalVue
2005 MDA Federal, Inc. /NaturalVue License
Produced By: 36IS / ING MIPS Team


2007 Fall Migration
Osprey F28
Total Distance: 3,440 km
Trip Duration: 15 days
Average Altitude: 422 m
Legend
Langley AFB, VA
F28 Point Locations
F28 Flight Track
Airfield
MOA
Range Area
Instrument Training Route
Visual Training Route
Warning Area
Starting Point -
Location: Back River - Langley AFB, VA
Date: 8/26/2007
Location: Gamecock C MOA, SC
Date: 8/28/2007
Time: 1100 hrs
Altitude: 303 m
Speed: 64 kph
Location: Coastal 1 East MOA, GA
Date: 8/29/2007
Time: 1100 hrs
Altitude: 182 m
Speed: 64 kph
Location: IR-055 Training Rt, FL
Date: 8/31/2007
Time: 1100 hrs
Altitude: 57 m
Speed: 51 kph
Location: IVO Minas, Cuba
Data: 9/4/2007
Time: 1300 hrs
Altitude: 712 m
Speed: 87 kph
Ending Point -
Location: IVO Manuel Golla,
Dominican Republic
Date: 9/09/2007
Legacy Project:
06/07/08-292
Scale: 1: 10,000,000
0
300
600
Kilometers
Imagery Source: NaturalVue
2005 MDA Federal, Inc. /NaturalVue License
Produced By: 36IS / ING MIPS Team

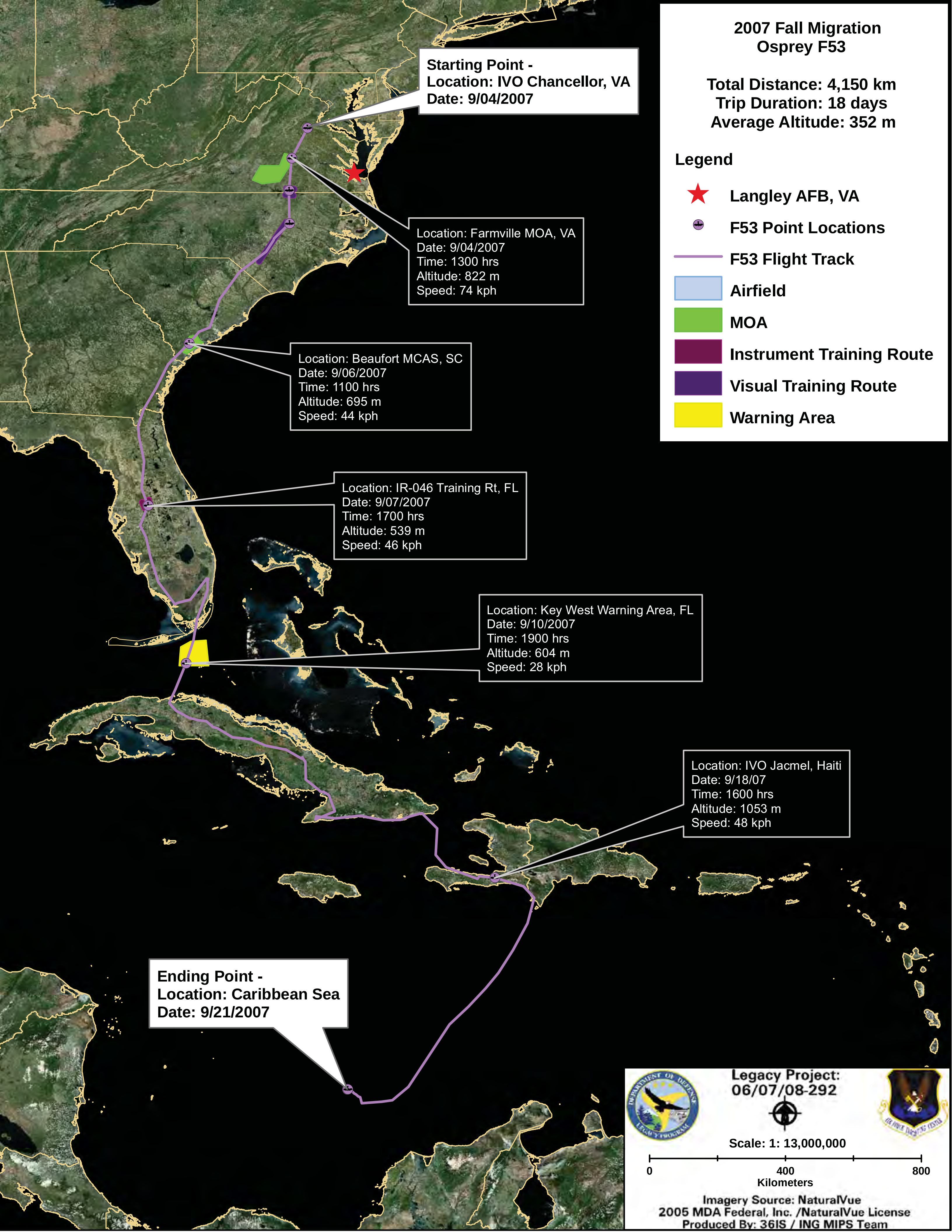


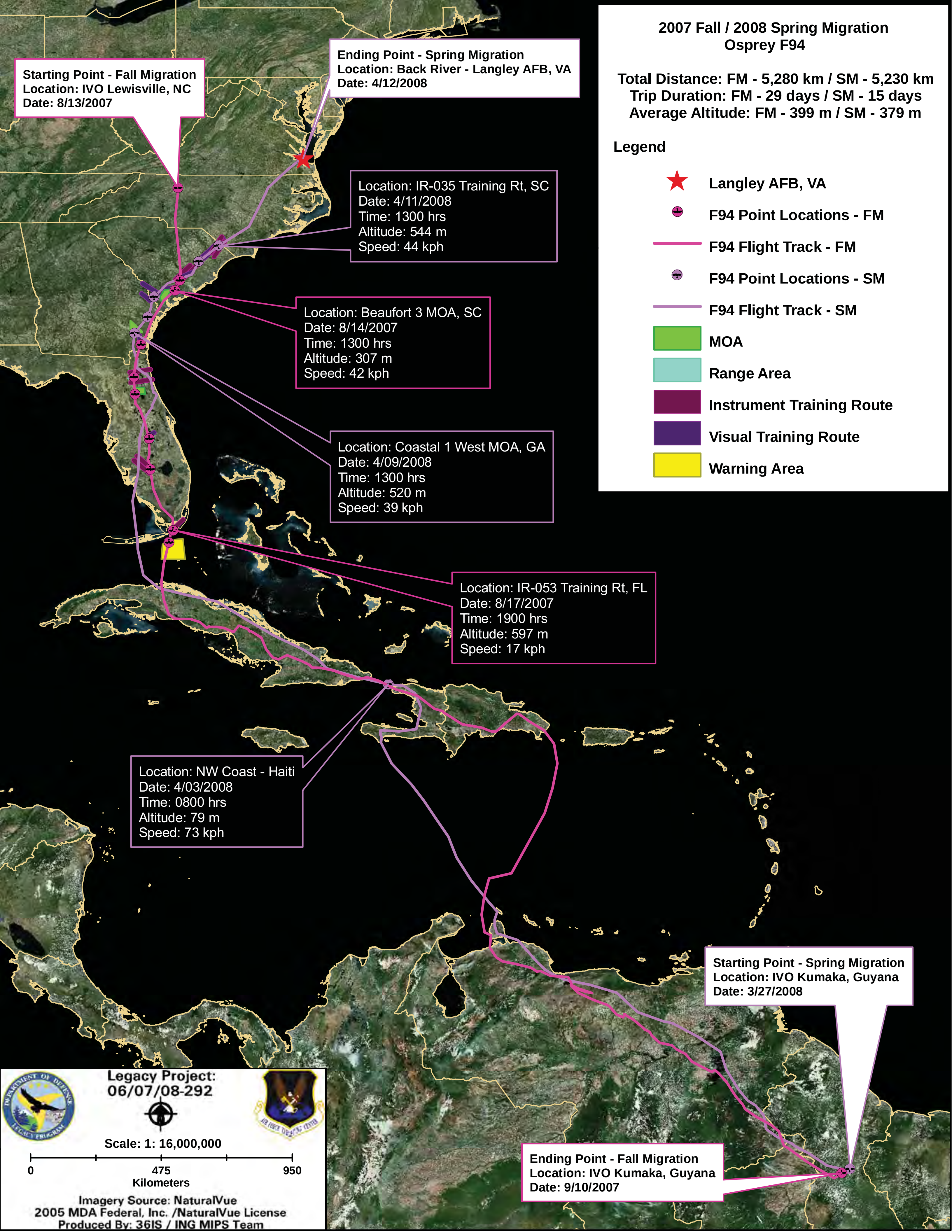
Osprey Fall Migration - 2007
Legend
Langley AFB, VA
F27 - Start/End Points
F27 - Flight Track
F28 - Start/End Points
F28 - Flight Track
F48B - Start/End Points
F48B - Flight Track
M52 - Start/End Points
M52 - Flight Track
F53 - Start/End Points
F53 - Flight Track
M54 - Start/End Points
M54 - Flight Track
F94 - Start/End Points
F94 - Flight Track
VA
NC
SC
GA
FL
Atlantic Ocean
Cuba
Haiti
Dominican Republic
Caribbean Sea
Venezuela
Guyana
Colombia
Brazil
Legacy Project:
06/07/08-292
Scale: 1: 15,600,000
0
425
850
Kilometers
Imagery Source: NaturalVue
2005 MDA Federal, Inc. /NaturalVue License
Produced By: 36IS / ING MIPS Team

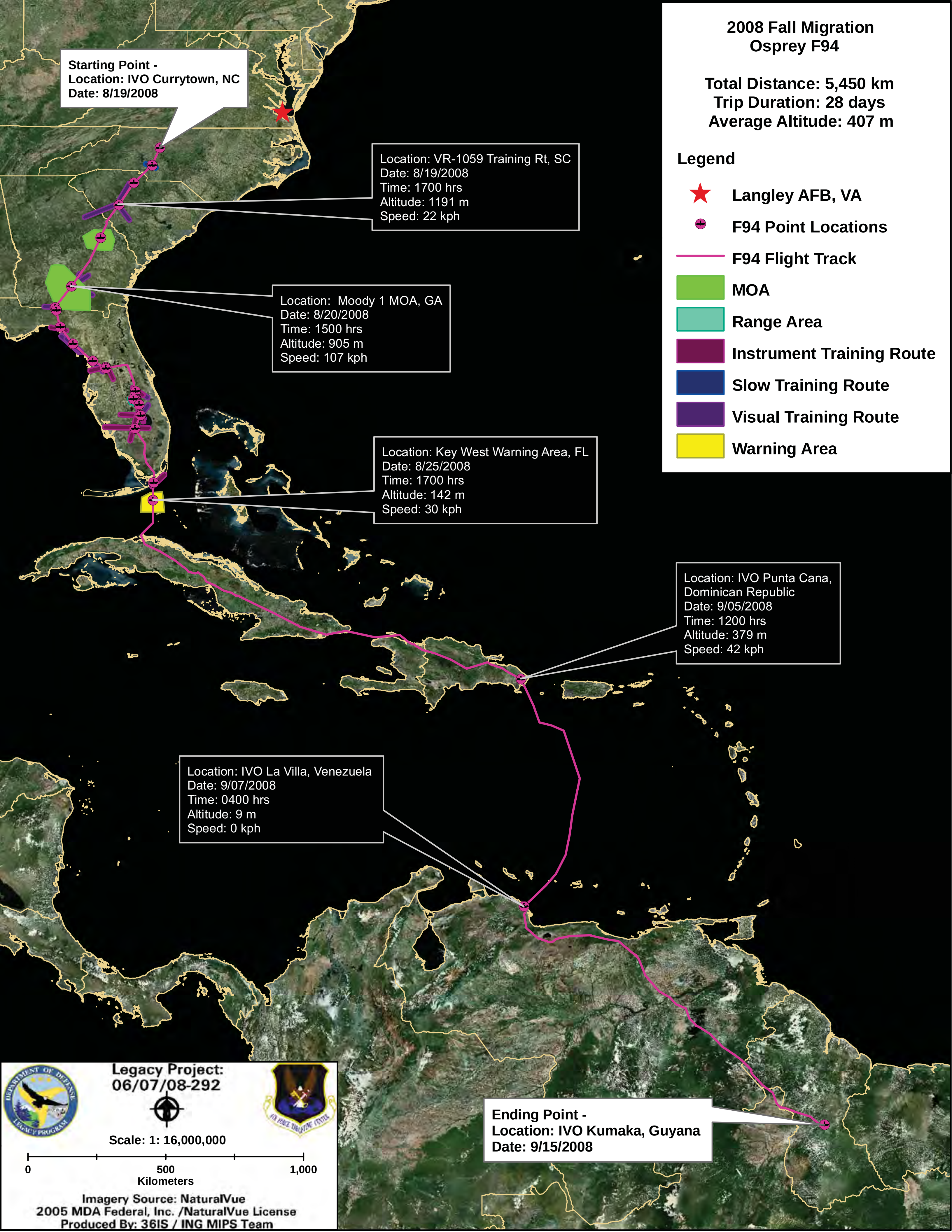

2007 Fall Migration
Osprey M52
Total Distance: 3,680 km
Trip Duration: 18 days
Average Altitude: 317 m
Legend
Langley AFB, VA
M52 Point Locations
M52 Flight Track
Airfield
Instrument Training Route
Visual Training Route
Warning Area
Starting Point -
Location: Back River - Langley AFB, VA
Date: 8/26/2007
Location: VR-1713 Training Rt, NC
Date: 8/26/2007
Time: 1500 hrs
Altitude: 317 m
Speed: 47 kph
Location: New River MCAS, NC
Date: 8/27/2007
Time: 1500 hrs
Altitude: 628 m
Speed: 60 kph
Location: VR-1006 Training Rt, FL
Date: 8/30/2007
Time: 1100 hrs
Altitude: 308 m
Speed: 57 kph
Location: Key West Warning Area, FL
Date: 9/01/2007
Time: 1700 hrs
Altitude: 617 m
Speed: 37 kph
Location: Lake Azuei, Haiti
Date: 9/10/2007
Time: 0800 hrs
Altitude: 122 m
Speed: 0 kph
Ending Point -
Location: Caribbean Sea
Date: 9/12/2007
Legacy Project:
06/07/08-292
Scale: 1: 13,000,000
0
400
800
Kilometers
Imagery Source: NaturalVue
2005 MDA Federal, Inc. /NaturalVue License
Produced By: 36IS / ING MIPS Team

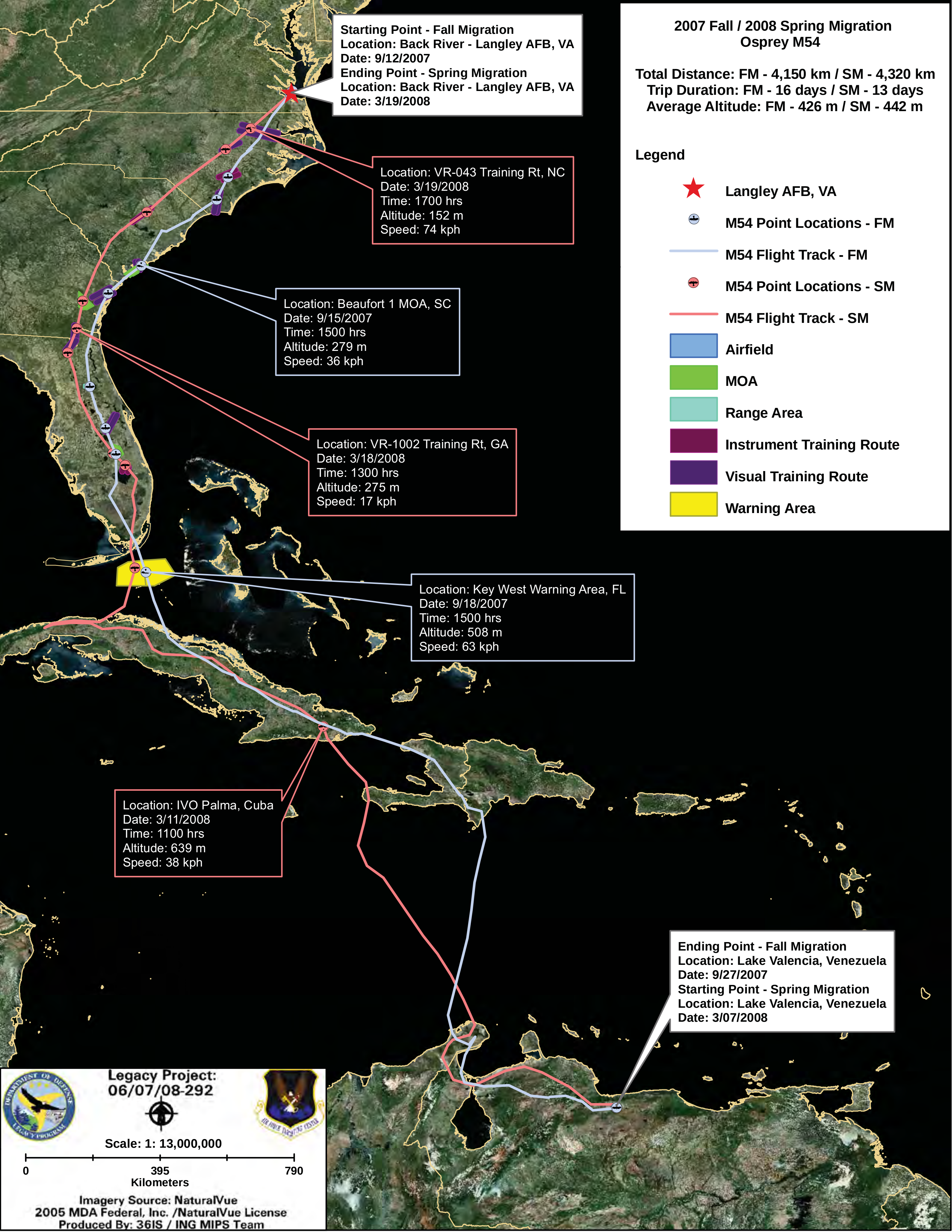


2007 Fall Migration
Osprey F48B
Total Distance: 3,610 km
Trip Duration: 18 days
Average Altitude: 392 m
Legend
Langley AFB, VA
F48B Point Locations
F48B Flight Track
Airfield
Visual Training Route
Instrument Training Route
Starting Point -
Location: Back River - Langley AFB, VA
Date: 9/04/2007
Location: IR-035 Training Rt, NC
Date: 9/05/2007
Time: 1500 hrs
Altitude: 146 m
Speed: 39 kph
Location: Wright AAF, GA
Date: 9/07/2007
Time: 1100 hrs
Altitude: 776 m
Speed: 70 kph
Location: VR-1005 Training Rt, FL
Date: 9/08/2007
Time: 1100 hrs
Altitude: 297 m
Speed: 58 kph
Location: IR-050 Training Rt, FL
Date: 9/09/2007
Time: 1500 hrs
Altitude: 599 m
Speed: 51 kph
Location: IVO Rio Cauto, Cuba
Date: 9/17/2007
Time: 1500 hrs
Altitude: 927 m
Speed: 72 kph
Ending Point -
Location: IVO Ellas Pina, Dominican Republic
Date: 9/21/2007
Legacy Project:
06/07/08-292
Scale: 1: 10,000,000
0
300
600
Kilometers
Imagery Source: NaturalVue
2005 MDA Federal, Inc. /NaturalVue License
Produced By: 36IS / ING MIPS Team

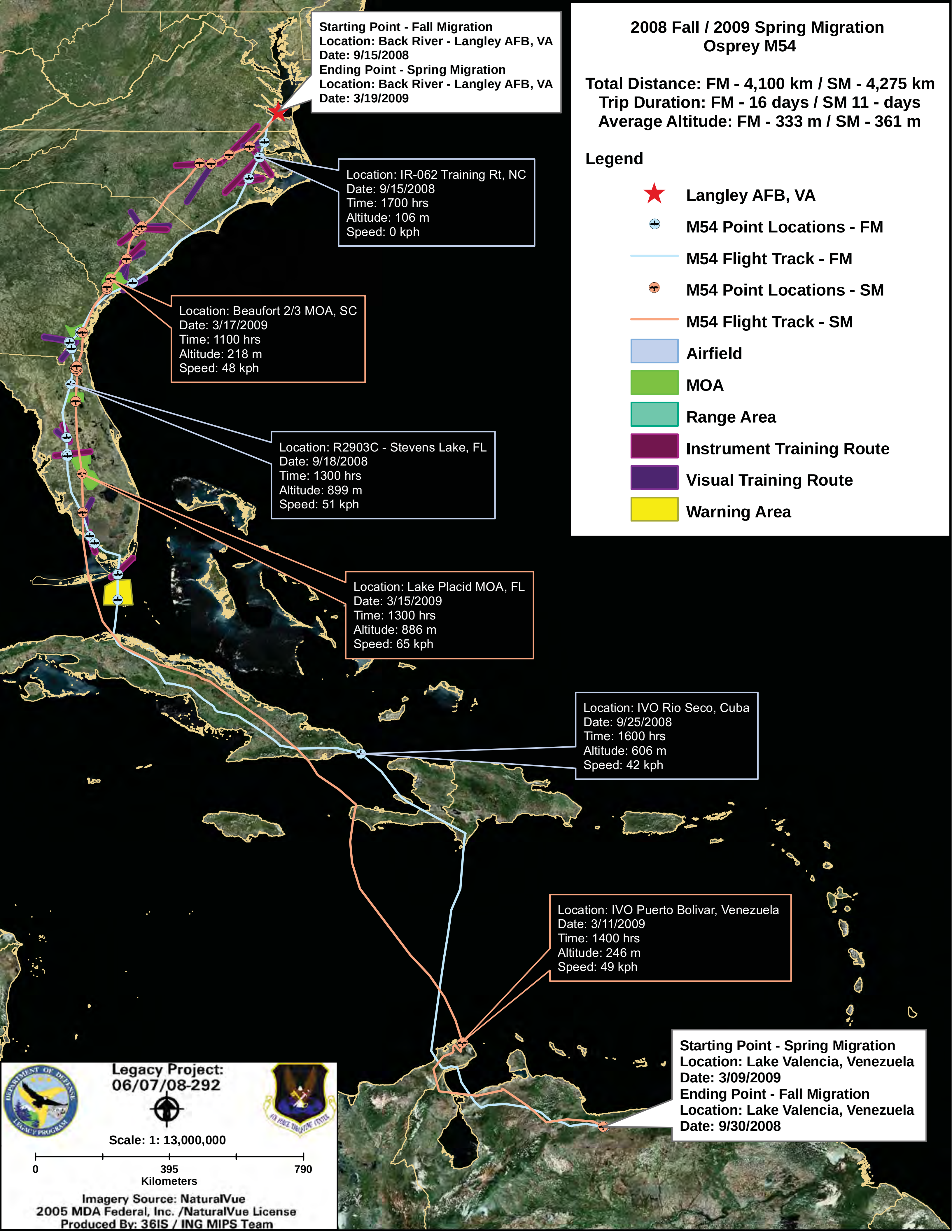

2007 Fall Migration
Osprey F53
Total Distance: 4,150 km
Trip Duration: 18 days
Average Altitude: 352 m
Legend
Langley AFB, VA
F53 Point Locations
F53 Flight Track
Airfield
MOA
Instrument Training Route
Visual Training Route
Warning Area
Starting Point -
Location: IVO Chancellor, VA
Date: 9/04/2007
Location: Farmville MOA, VA
Date: 9/04/2007
Time: 1300 hrs
Altitude: 822 m
Speed: 74 kph
Location: Beaufort MCAS, SC
Date: 9/06/2007
Time: 1100 hrs
Altitude: 695 m
Speed: 44 kph
Location: IR-046 Training Rt, FL
Date: 9/07/2007
Time: 1700 hrs
Altitude: 539 m
Speed: 46 kph
Location: Key West Warning Area, FL
Date: 9/10/2007
Time: 1900 hrs
Altitude: 604 m
Speed: 28 kph
Location: IVO Jacmel, Haiti
Date: 9/18/07
Time: 1600 hrs
Altitude: 1053 m
Speed: 48 kph
Ending Point -
Location: Caribbean Sea
Date: 9/21/2007
Legacy Project:
06/07/08-292
Scale: 1: 13,000,000
0
400
800
Kilometers
Imagery Source: NaturalVue
2005 MDA Federal, Inc. /NaturalVue License
Produced By: 36IS / ING MIPS Team


2007 Fall / 2008 Spring Migration
Osprey F94
Total Distance: FM - 5,280 km / SM - 5,230 km
Trip Duration: FM - 29 days / SM - 15 days
Average Altitude: FM - 399 m / SM - 379 m
Legend
Langley AFB, VA
F94 Point Locations - FM
F94 Flight Track - FM
F94 Point Locations - SM
F94 Flight Track - SM
MOA
Range Area
Instrument Training Route
Visual Training Route
Warning Area
Starting Point - Fall Migration
Location: IVO Lewisville, NC
Date: 8/13/2007
Ending Point - Spring Migration
Location: Back River - Langley AFB, VA
Date: 4/12/2008
Location: IR-035 Training Rt, SC
Date: 4/11/2008
Time: 1300 hrs
Altitude: 544 m
Speed: 44 kph
Location: Beaufort 3 MOA, SC
Date: 8/14/2007
Time: 1300 hrs
Altitude: 307 m
Speed: 42 kph
Location: Coastal 1 West MOA, GA
Date: 4/09/2008
Time: 1300 hrs
Altitude: 520 m
Speed: 39 kph
Location: IR-053 Training Rt, FL
Date: 8/17/2007
Time: 1900 hrs
Altitude: 597 m
Speed: 17 kph
Location: NW Coast - Haiti
Date: 4/03/2008
Time: 0800 hrs
Altitude: 79 m
Speed: 73 kph
Starting Point - Spring Migration
Location: IVO Kumaka, Guyana
Date: 3/27/2008
Ending Point - Fall Migration
Location: IVO Kumaka, Guyana
Date: 9/10/2007
Legacy Project:
06/07/08-292
Scale: 1: 16,000,000
0
475
950
Kilometers
Imagery Source: NaturalVue
2005 MDA Federal, Inc. /NaturalVue License
Produced By: 36IS / ING MIPS Team

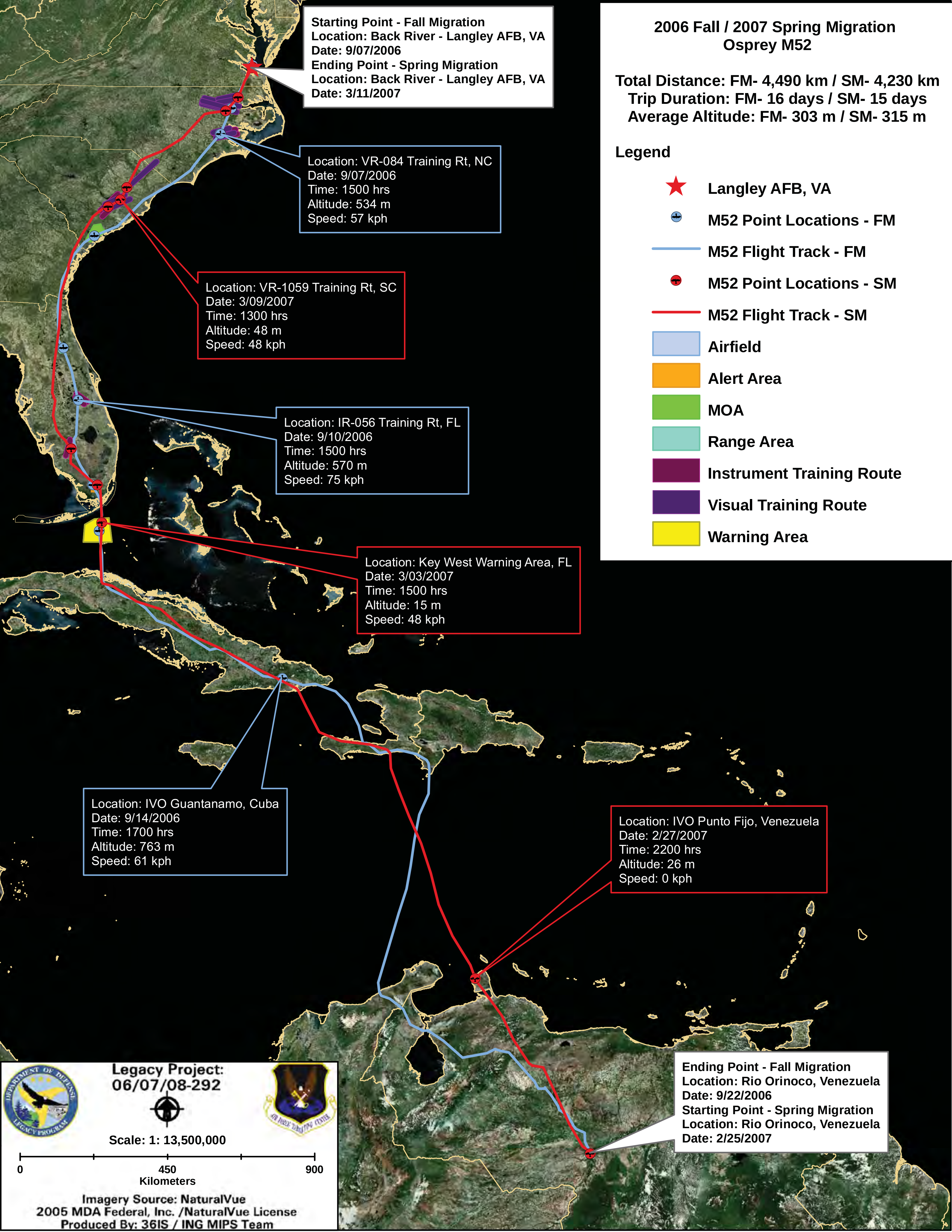

2008 Fall Migration
Osprey F94
Total Distance: 5,450 km
Trip Duration: 28 days
Average Altitude: 407 m
Legend
Langley AFB, VA
F94 Point Locations
F94 Flight Track
MOA
Range Area
Instrument Training Route
Slow Training Route
Visual Training Route
Warning Area
Starting Point -
Location: IVO Currytown, NC
Date: 8/19/2008
Location: VR-1059 Training Rt, SC
Date: 8/19/2008
Time: 1700 hrs
Altitude: 1191 m
Speed: 22 kph
Location: Moody 1 MOA, GA
Date: 8/20/2008
Time: 1500 hrs
Altitude: 905 m
Speed: 107 kph
Location: Key West Warning Area, FL
Date: 8/25/2008
Time: 1700 hrs
Altitude: 142 m
Speed: 30 kph
Location: IVO Punta Cana,
Dominican Republic
Date: 9/05/2008
Time: 1200 hrs
Altitude: 379 m
Speed: 42 kph
Location: IVO La Villa, Venezuela
Date: 9/07/2008
Time: 0400 hrs
Altitude: 9 m
Speed: 0 kph
Ending Point -
Location: IVO Kumaka, Guyana
Date: 9/15/2008
Legacy Project:
06/07/08-292
Scale: 1: 16,000,000
0
500
1,000
Kilometers
Imagery Source: NaturalVue
2005 MDA Federal, Inc. /NaturalVue License
Produced By: 36IS / ING MIPS Team



2007 Fall / 2008 Spring Migration
Osprey M54
Total Distance: FM - 4,150 km / SM - 4,320 km
Trip Duration: FM - 16 days / SM - 13 days
Average Altitude: FM - 426 m / SM - 442 m
Legend
Langley AFB, VA
M54 Point Locations - FM
M54 Flight Track - FM
M54 Point Locations - SM
M54 Flight Track - SM
Airfield
MOA
Range Area
Instrument Training Route
Visual Training Route
Warning Area
Starting Point - Fall Migration
Location: Back River - Langley AFB, VA
Date: 9/12/2007
Ending Point - Spring Migration
Location: Back River - Langley AFB, VA
Date: 3/19/2008
Location: VR-043 Training Rt, NC
Date: 3/19/2008
Time: 1700 hrs
Altitude: 152 m
Speed: 74 kph
Location: Beaufort 1 MOA, SC
Date: 9/15/2007
Time: 1500 hrs
Altitude: 279 m
Speed: 36 kph
Location: VR-1002 Training Rt, GA
Date: 3/18/2008
Time: 1300 hrs
Altitude: 275 m
Speed: 17 kph
Location: Key West Warning Area, FL
Date: 9/18/2007
Time: 1500 hrs
Altitude: 508 m
Speed: 63 kph
Location: IVO Palma, Cuba
Date: 3/11/2008
Time: 1100 hrs
Altitude: 639 m
Speed: 38 kph
Ending Point - Fall Migration
Location: Lake Valencia, Venezuela
Date: 9/27/2007
Starting Point - Spring Migration
Location: Lake Valencia, Venezuela
Date: 3/07/2008
Legacy Project:
06/07/08-292
Scale: 1: 13,000,000
0
395
790
Kilometers
Imagery Source: NaturalVue
2005 MDA Federal, Inc. /NaturalVue License
Produced By: 36IS / ING MIPS Team



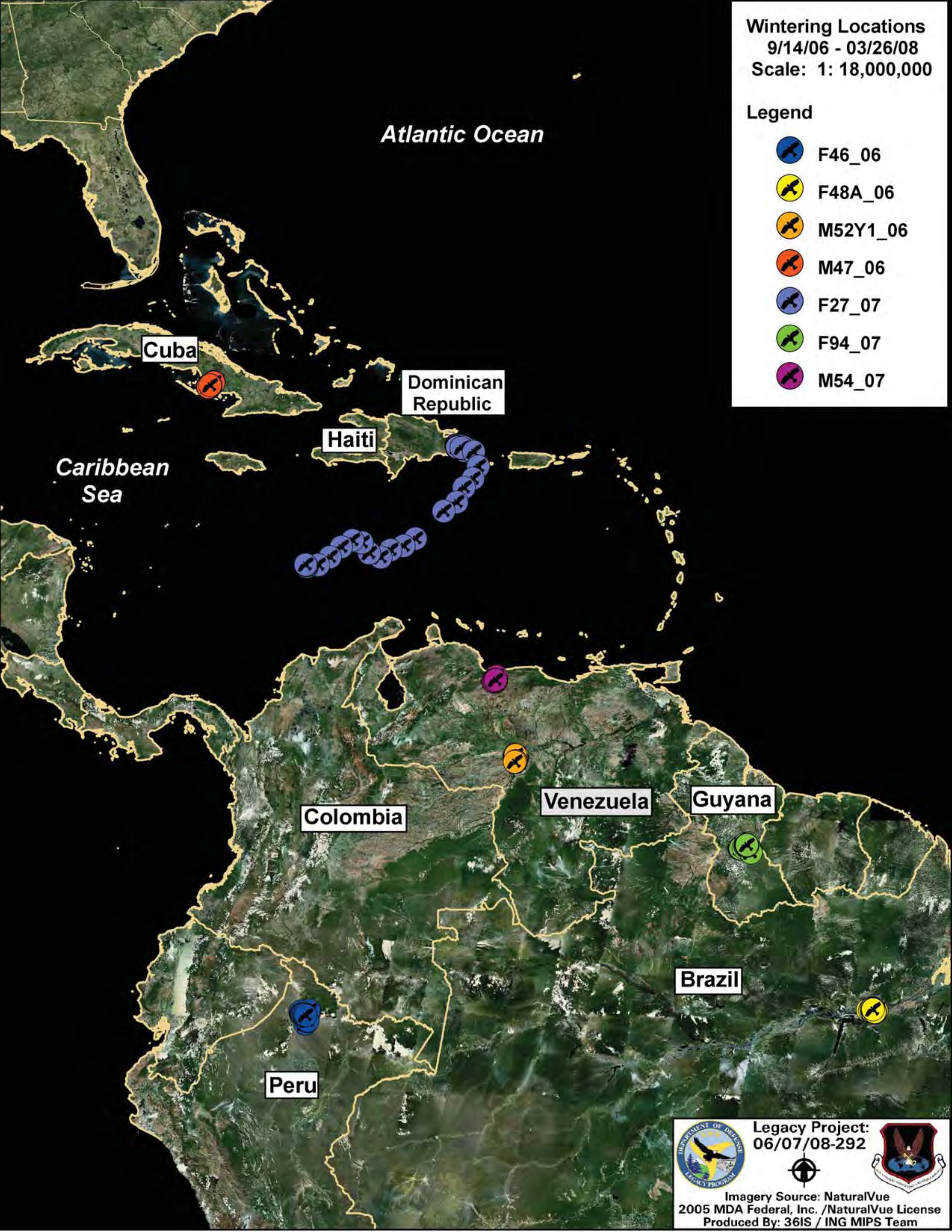
2008 Fall / 2009 Spring Migration
Osprey M54
Total Distance: FM - 4,100 km / SM - 4,275 km
Trip Duration: FM - 16 days / SM 11 - days
Average Altitude: FM - 333 m / SM - 361 m
Legend
Langley AFB, VA
M54 Point Locations - FM
M54 Flight Track - FM
M54 Point Locations - SM
M54 Flight Track - SM
Airfield
MOA
Range Area
Instrument Training Route
Visual Training Route
Warning Area
Starting Point - Fall Migration
Location: Back River - Langley AFB, VA
Date: 9/15/2008
Ending Point - Spring Migration
Location: Back River - Langley AFB, VA
Date: 3/19/2009
Location: IR-062 Training Rt, NC
Date: 9/15/2008
Time: 1700 hrs
Altitude: 106 m
Speed: 0 kph
Location: Beaufort 2/3 MOA, SC
Date: 3/17/2009
Time: 1100 hrs
Altitude: 218 m
Speed: 48 kph
Location: R2903C - Stevens Lake, FL
Date: 9/18/2008
Time: 1300 hrs
Altitude: 899 m
Speed: 51 kph
Location: Lake Placid MOA, FL
Date: 3/15/2009
Time: 1300 hrs
Altitude: 886 m
Speed: 65 kph
Location: IVO Rio Seco, Cuba
Date: 9/25/2008
Time: 1600 hrs
Altitude: 606 m
Speed: 42 kph
Location: IVO Puerto Bolivar, Venezuela
Date: 3/11/2009
Time: 1400 hrs
Altitude: 246 m
Speed: 49 kph
Starting Point - Spring Migration
Location: Lake Valencia, Venezuela
Date: 3/09/2009
Ending Point - Fall Migration
Location: Lake Valencia, Venezuela
Date: 9/30/2008
Legacy Project:
06/07/08-292
Scale: 1: 13,000,000
0
395
790
Kilometers
Imagery Source: NaturalVue
2005 MDA Federal, Inc. /NaturalVue License
Produced By: 36IS / ING MIPS Team


Starting Point - Fall Migration
Location: Back River - Langley AFB, VA
Date: 9/07/2006
Ending Point - Spring Migration
Location: Back River - Langley AFB, VA
Date: 3/11/2007
2006 Fall / 2007 Spring Migration
Osprey M52
Total Distance: FM- 4,490 km / SM- 4,230 km
Trip Duration: FM- 16 days / SM- 15 days
Average Altitude: FM- 303 m / SM- 315 m
Legend
Langley AFB, VA
M52 Point Locations - FM
M52 Flight Track - FM
M52 Point Locations - SM
M52 Flight Track - SM
Airfield
Alert Area
MOA
Range Area
Instrument Training Route
Visual Training Route
Warning Area
Location: VR-084 Training Rt, NC
Date: 9/07/2006
Time: 1500 hrs
Altitude: 534 m
Speed: 57 kph
Location: VR-1059 Training Rt, SC
Date: 3/09/2007
Time: 1300 hrs
Altitude: 48 m
Speed: 48 kph
Location: IR-056 Training Rt, FL
Date: 9/10/2006
Time: 1500 hrs
Altitude: 570 m
Speed: 75 kph
Location: Key West Warning Area, FL
Date: 3/03/2007
Time: 1500 hrs
Altitude: 15 m
Speed: 48 kph
Location: IVO Guantanamo, Cuba
Date: 9/14/2006
Time: 1700 hrs
Altitude: 763 m
Speed: 61 kph
Location: IVO Punto Fijo, Venezuela
Date: 2/27/2007
Time: 2200 hrs
Altitude: 26 m
Speed: 0 kph
Ending Point - Fall Migration
Location: Rio Orinoco, Venezuela
Date: 9/22/2006
Starting Point - Spring Migration
Location: Rio Orinoco, Venezuela
Date: 2/25/2007
Legacy Project:
06/07/08-292
Scale: 1: 13,500,000
0
450
900
Kilometers
Imagery Source: NaturalVue
2005 MDA Federal, Inc. /NaturalVue License
Produced By: 36IS / ING MIPS Team

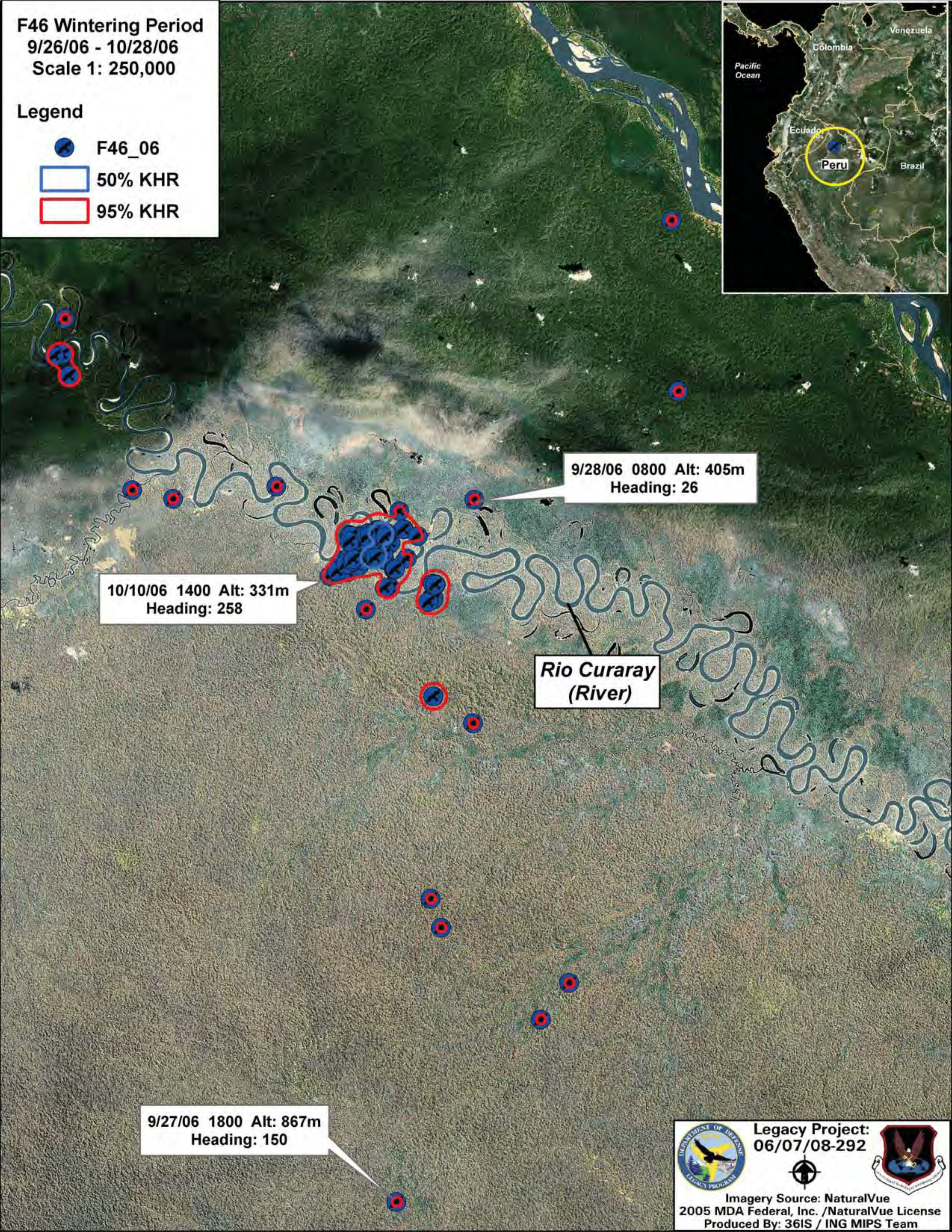
APPENDIX D.

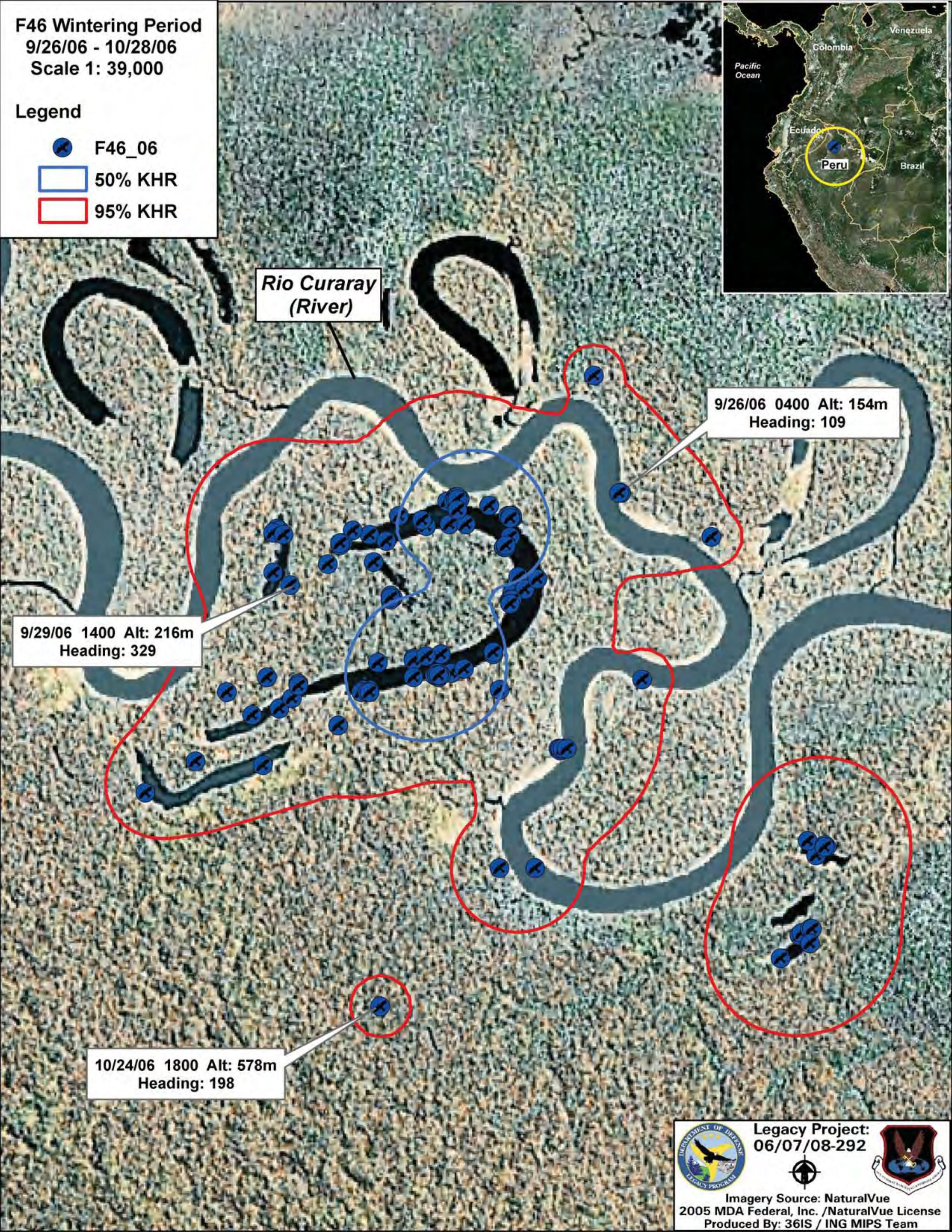
Winter Period Maps

Appendix D features 16 high-quality reference maps illustrating point locations and home-range sizes of satellite-tagged Osprey during the winter period.

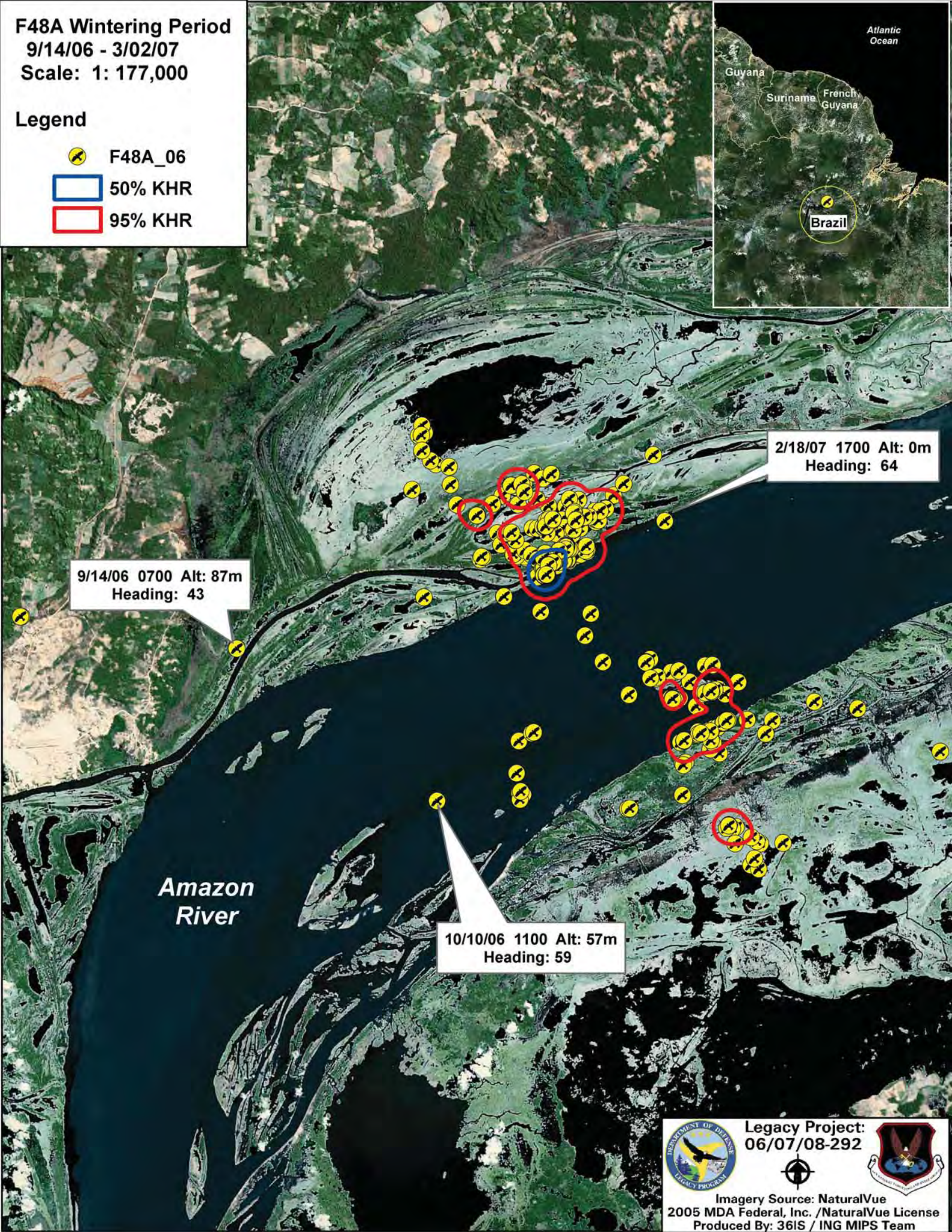


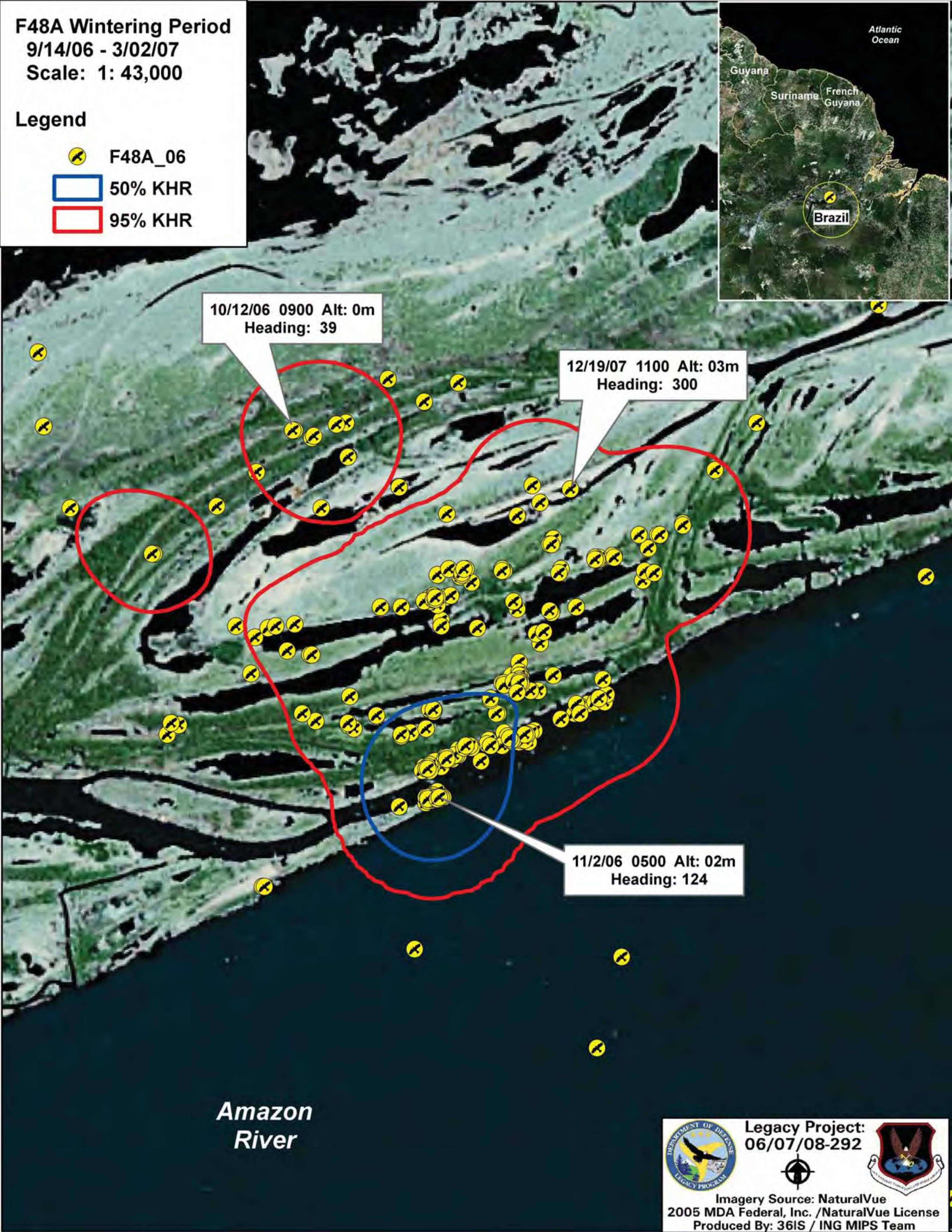
Wintering Locations
9/14/06 - 03/26/08
Scale: 1: 18,000,000
Legend
F46_06
F48A_06
M52Y1_06
M47_06
F27_07
F94_07
M54_07
Atlantic Ocean
Cuba
Dominican Republic
Haiti
Caribbean Sea
Colombia
Venezuela
Guyana
Brazil
Peru
Legacy Project:
06/07/08-292
Imagery Source: NaturalVue
2005 MDA Federal, Inc. /NaturalVue License
Produced By: 36IS / ING MIPS Team

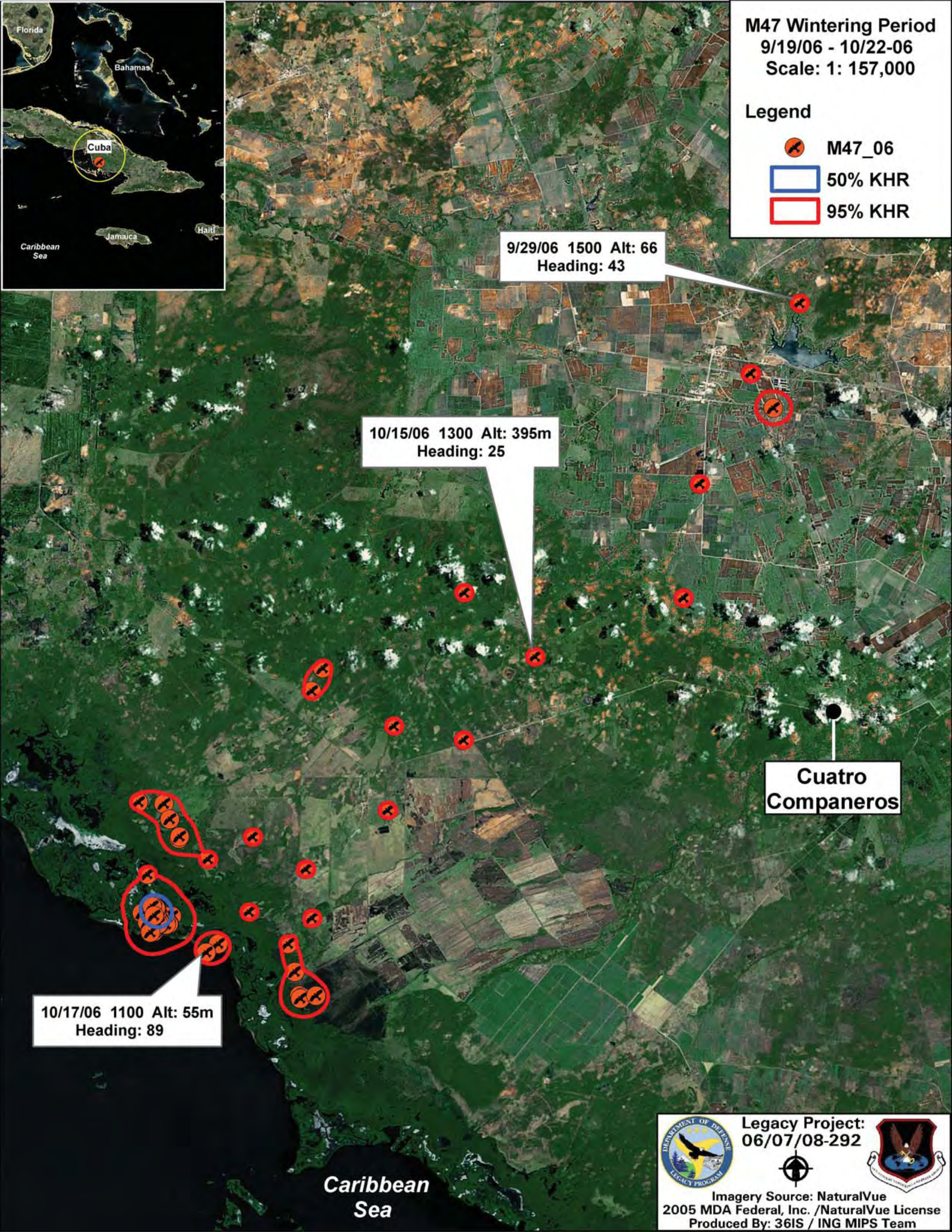

F46 Wintering Period
9/26/06 - 10/28/06
Scale 1: 250,000
Legend
F46_06
50% KHR
95% KHR
Venezuela
Colombia
Pacific Ocean
Ecuador
Peru
Brazil
9/28/06 0800 Alt: 405m
Heading: 26
10/10/06 1400 Alt: 331m
Heading: 258
Rio Curaray
(River)
9/27/06 1800 Alt: 867m
Heading: 150
Legacy Project:
06/07/08-292
Imagery Source: NaturalVue
2005 MDA Federal, Inc. /NaturalVue License
Produced By: 36IS / ING MIPS Team

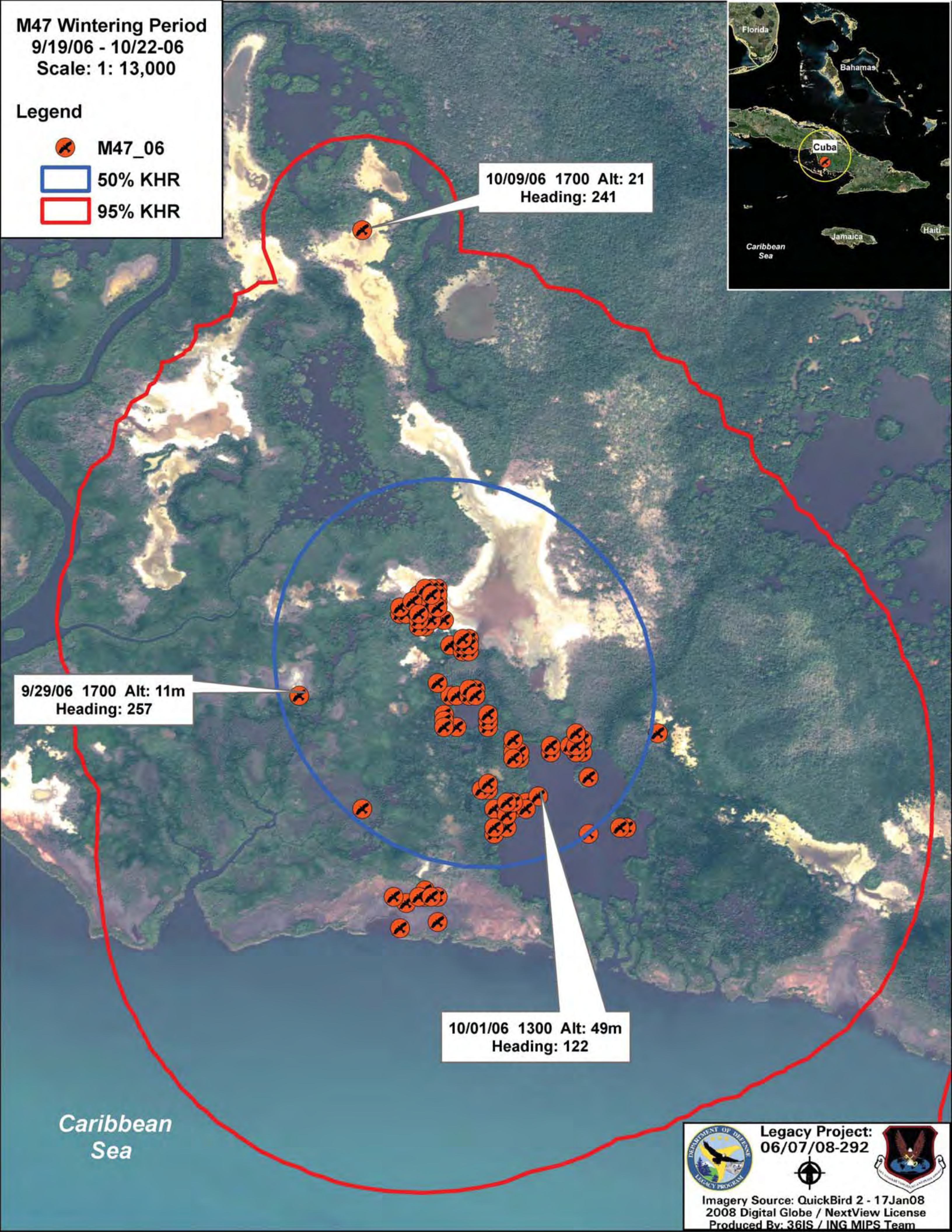


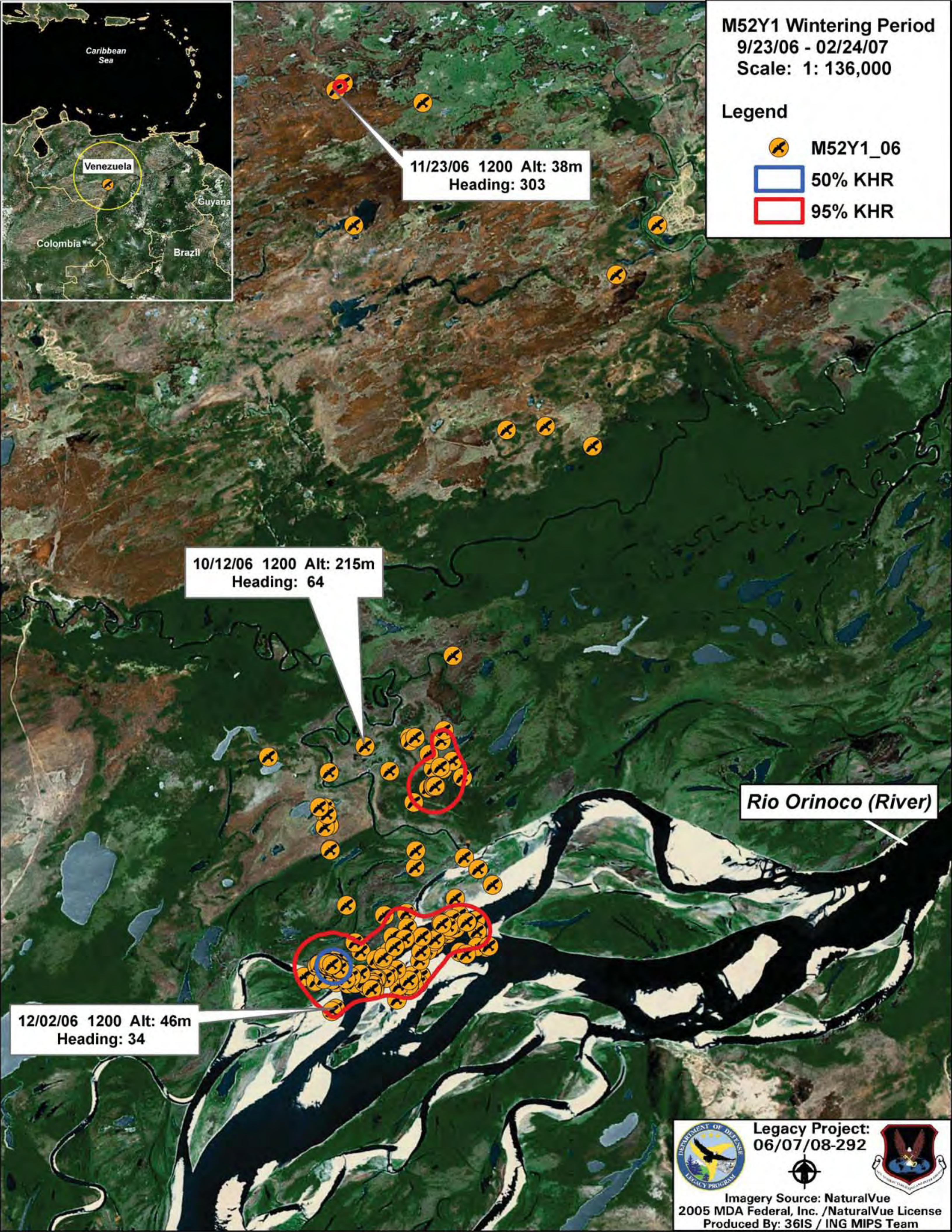
F46 Wintering Period
9/26/06 - 10/28/06
Scale 1: 39,000
Legend
F46_06
50% KHR
95% KHR
Venezuela
Colombia
Pacific Ocean
Ecuador
Peru
Brazil
Rio Curaray (River)
9/26/06 0400 Alt: 154m
Heading: 109
9/29/06 1400 Alt: 216m
Heading: 329
10/24/06 1800 Alt: 578m
Heading: 198
Legacy Project:
06/07/08-292
Imagery Source: NaturalVue
2005 MDA Federal, Inc. /NaturalVue License
Produced By: 36IS / ING MIPS Team

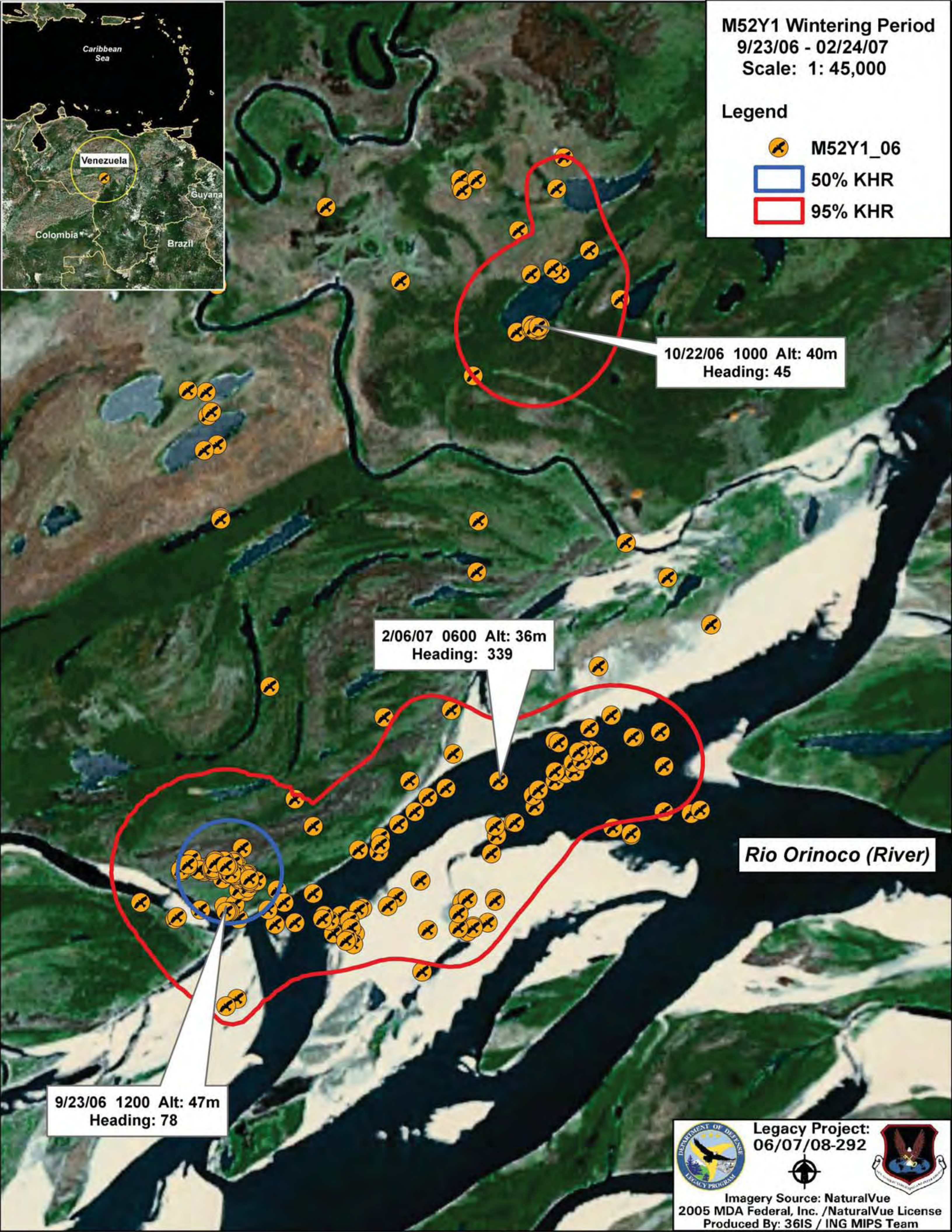

F48A Wintering Period
9/14/06 - 3/02/07
Scale: 1: 177,000
Legend
F48A_06
50% KHR
95% KHR
Atlantic Ocean
Guyana
Suriname
French Guyana
Brazil
2/18/07 1700 Alt: 0m
Heading: 64
9/14/06 0700 Alt: 87m
Heading: 43
Amazon River
10/10/06 1100 Alt: 57m
Heading: 59
Legacy Project:
06/07/08-292
Imagery Source: NaturalVue
2005 MDA Federal, Inc. /NaturalVue License
Produced By: 36IS / ING MIPS Team


F48A Wintering Period
9/14/06 - 3/02/07
Scale: 1: 43,000
Legend
F48A_06
50% KHR
95% KHR
Atlantic Ocean
Guyana
Suriname
French Guyana
Brazil
10/12/06 0900 Alt: 0m
Heading: 39
12/19/07 1100 Alt: 03m
Heading: 300
11/2/06 0500 Alt: 02m
Heading: 124
Amazon River
Legacy Project:
06/07/08-292
Imagery Source: NaturalVue
2005 MDA Federal, Inc. /NaturalVue License
Produced By: 36IS / ING MIPS Team

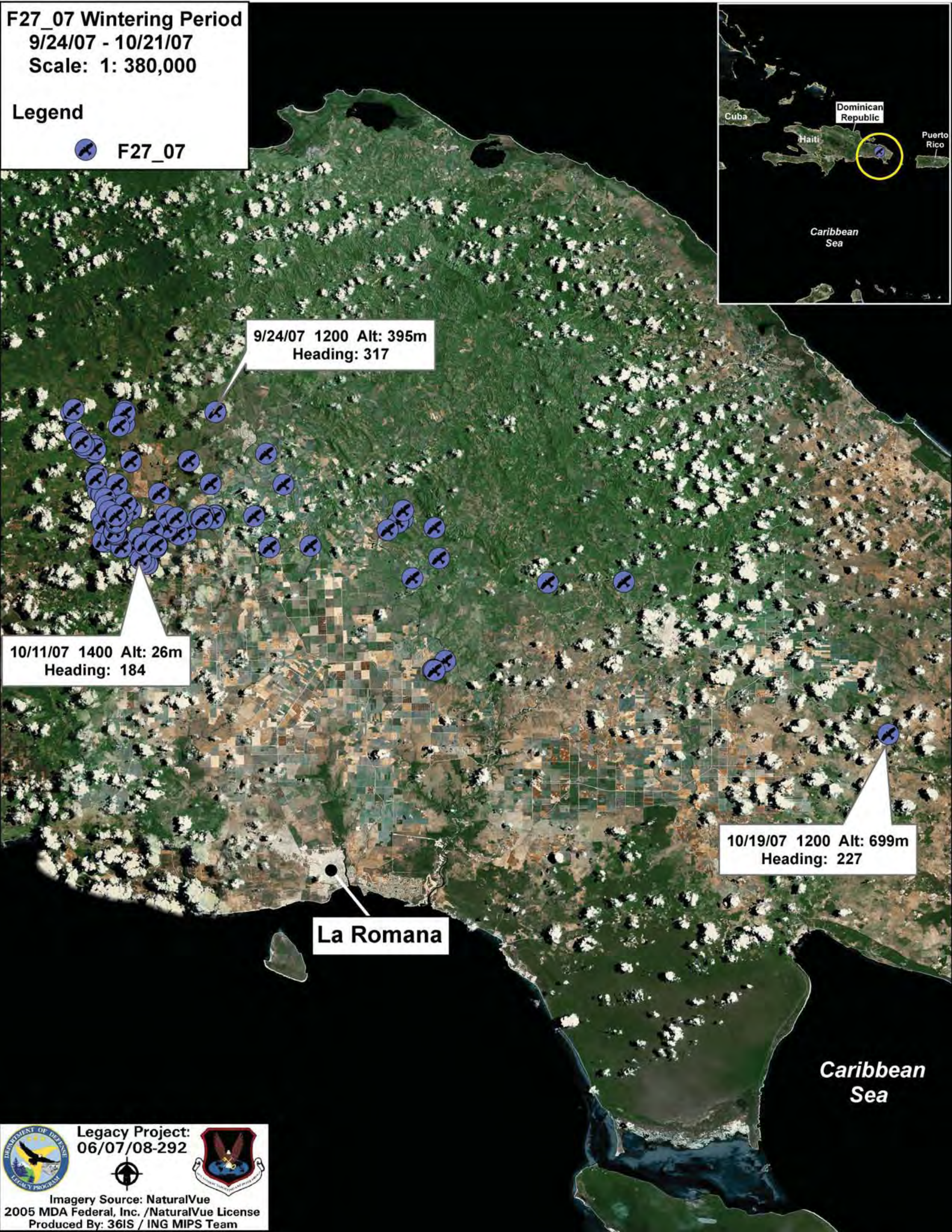

M47 Wintering Period
9/19/06 - 10/22-06
Scale: 1: 157,000
Legend
M47_06
50% KHR
95% KHR
Florida
Bahamas
Cuba
Caribbean Sea
Jamaica
Haiti
9/29/06 1500 Alt: 66
Heading: 43
10/15/06 1300 Alt: 395m
Heading: 25
10/17/06 1100 Alt: 55m
Heading: 89
Cuatro Companeros
Caribbean Sea
Legacy Project:
06/07/08-292
Imagery Source: NaturalVue
2005 MDA Federal, Inc. /NaturalVue License
Produced By: 36IS / ING MIPS Team


M47 Wintering Period
9/19/06 - 10/22-06
Scale: 1: 13,000
Legend
M47_06
50% KHR
95% KHR
Florida
Bahamas
Cuba
Jamaica
Haiti
Caribbean Sea
10/09/06 1700 Alt: 21
Heading: 241
9/29/06 1700 Alt: 11m
Heading: 257
10/01/06 1300 Alt: 49m
Heading: 122
Caribbean Sea
Legacy Project:
06/07/08-292
Imagery Source: QuickBird 2 - 17Jan08
2008 Digital Globe / NextView License
Produced By: 36IS / ING MIPS Team

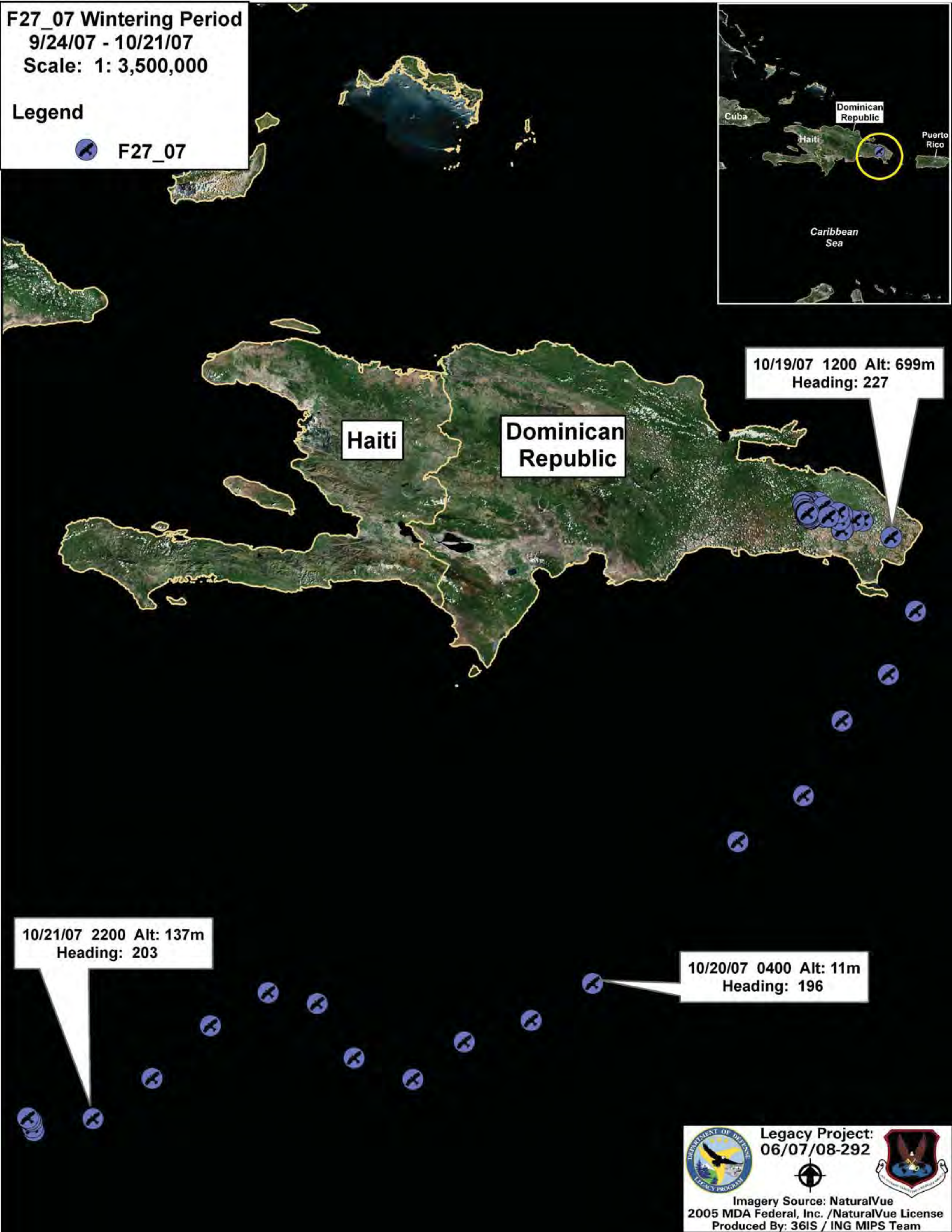

M52Y1 Wintering Period
9/23/06 - 02/24/07
Scale: 1: 136,000
Legend
M52Y1_06
50% KHR
95% KHR
Caribbean Sea
Venezuela
Guyana
Colombia
Brazil
11/23/06 1200 Alt: 38m
Heading: 303
10/12/06 1200 Alt: 215m
Heading: 64
12/02/06 1200 Alt: 46m
Heading: 34
Rio Orinoco (River)
Legacy Project:
06/07/08-292
Imagery Source: NaturalVue
2005 MDA Federal, Inc. /NaturalVue License
Produced By: 36IS / ING MIPS Team

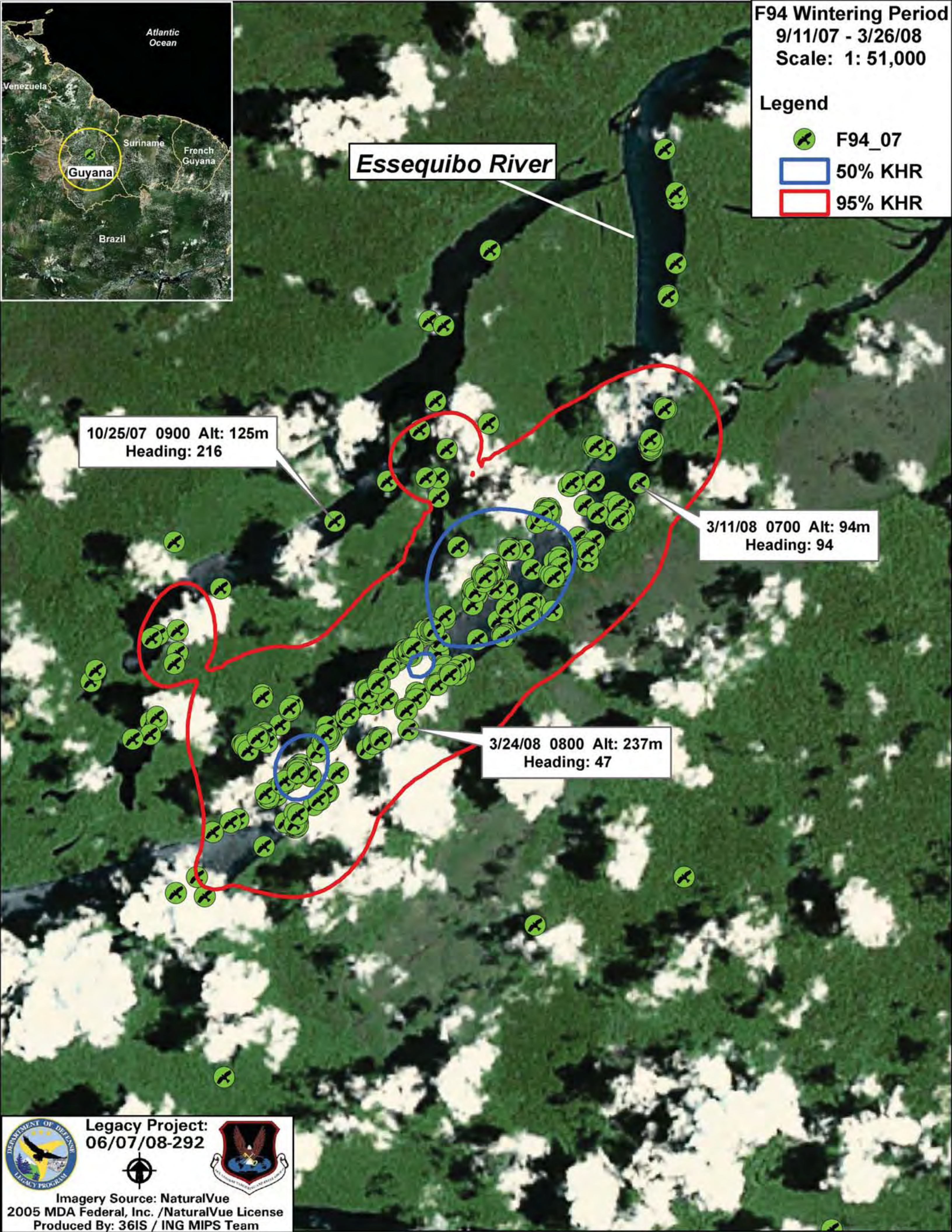


M52Y1 Wintering Period
9/23/06 - 02/24/07
Scale: 1: 45,000
Legend
M52Y1_06
50% KHR
95% KHR
Caribbean Sea
Venezuela
Guyana
Colombia
Brazil
10/22/06 1000 Alt: 40m
Heading: 45
2/06/07 0600 Alt: 36m
Heading: 339
Rio Orinoco (River)
9/23/06 1200 Alt: 47m
Heading: 78
Legacy Project:
06/07/08-292
Imagery Source: NaturalVue
2005 MDA Federal, Inc. /NaturalVue License
Produced By: 36IS / ING MIPS Team

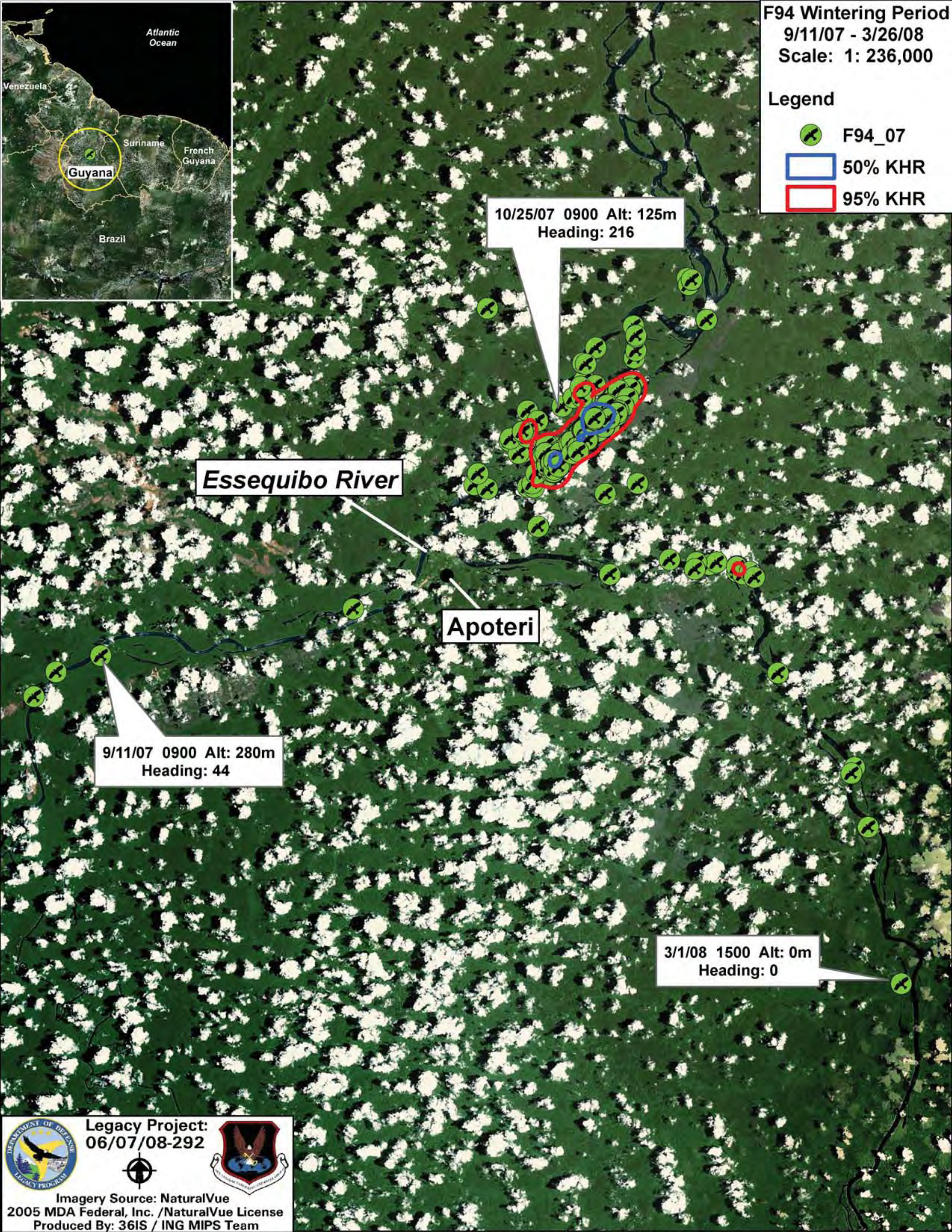


F27_07 Wintering Period
9/24/07 - 10/21/07
Scale: 1: 380,000
Legend
F27_07
Cuba
Dominican Republic
Haiti
Puerto Rico
Caribbean Sea
9/24/07 1200 Alt: 395m
Heading: 317
10/11/07 1400 Alt: 26m
Heading: 184
10/19/07 1200 Alt: 699m
Heading: 227
La Romana
Caribbean Sea
Legacy Project:
06/07/08-292
Imagery Source: NaturalVue
2005 MDA Federal, Inc. /NaturalVue License
Produced By: 36IS / ING MIPS Team

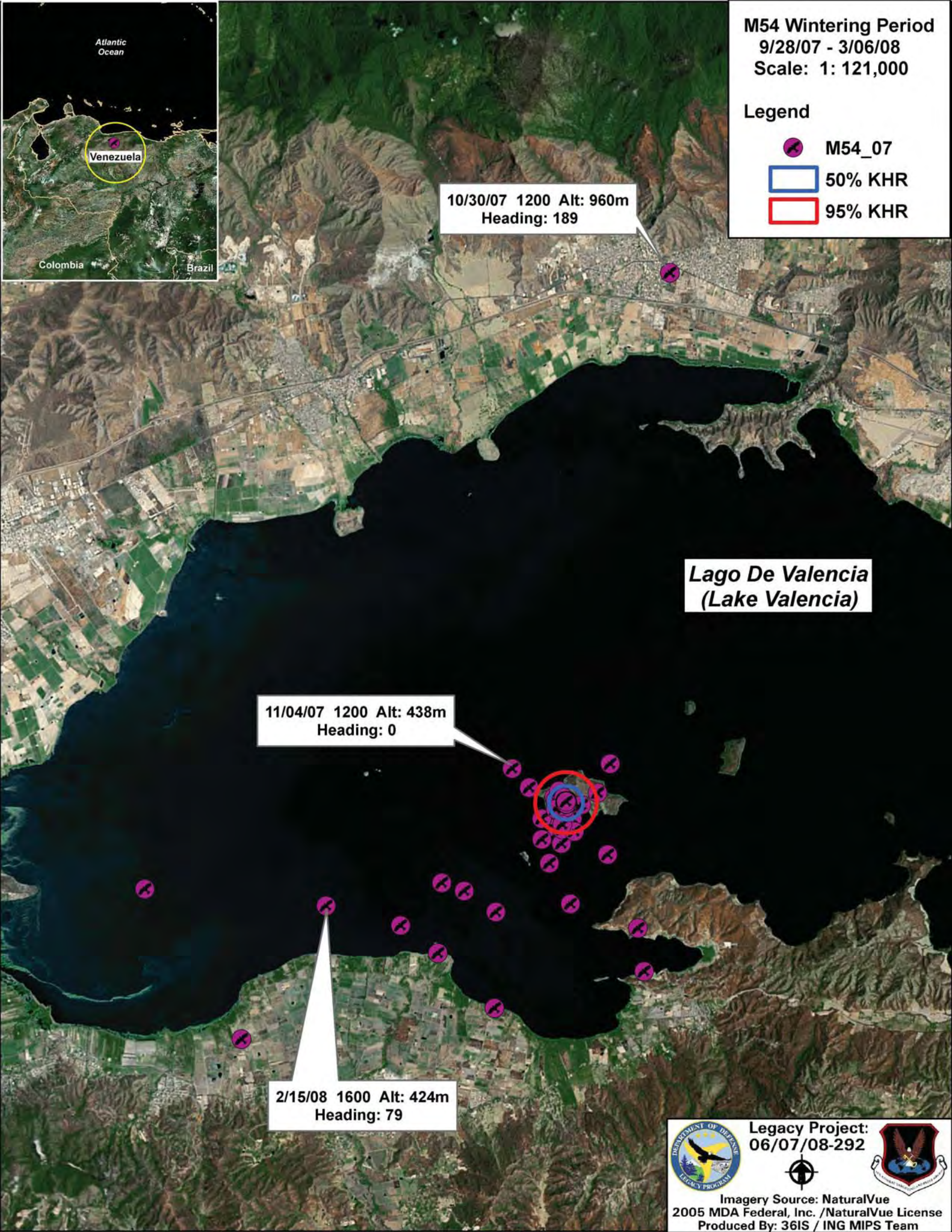

F27_07 Wintering Period
9/24/07 - 10/21/07
Scale: 1: 3,500,000
Legend
F27_07
Cuba
Dominican Republic
Haiti
Puerto Rico
Caribbean Sea
Haiti
Dominican Republic
10/19/07 1200 Alt: 699m
Heading: 227
10/21/07 2200 Alt: 137m
Heading: 203
10/20/07 0400 Alt: 11m
Heading: 196
Legacy Project:
06/07/08-292
Imagery Source: NaturalVue
2005 MDA Federal, Inc. /NaturalVue License
Produced By: 36IS / ING MIPS Team



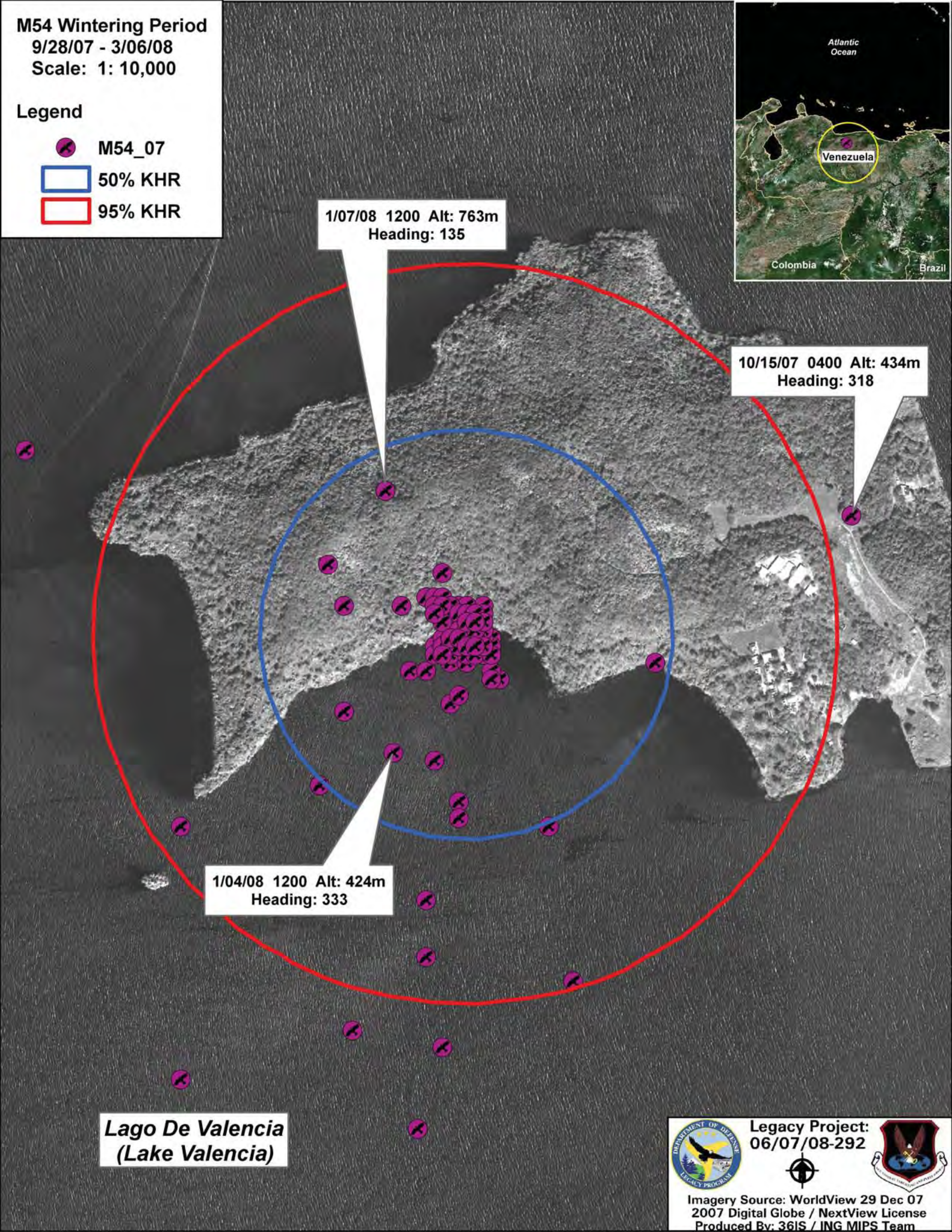
F94 Wintering Period
9/11/07 - 3/26/08
Scale: 1: 51,000
Legend
F94_07
50% KHR
95% KHR
Atlantic Ocean
Venezuela
Suriname
French Guyana
Guyana
Brazil
Essequibo River
10/25/07 0900 Alt: 125m
Heading: 216
3/11/08 0700 Alt: 94m
Heading: 94
3/24/08 0800 Alt: 237m
Heading: 47
Legacy Project:
06/07/08-292
Imagery Source: NaturalVue
2005 MDA Federal, Inc. /NaturalVue License
Produced By: 36IS / ING MIPS Team



F94 Wintering Period
9/11/07 - 3/26/08
Scale: 1: 236,000
Legend
F94_07
50% KHR
95% KHR
Atlantic Ocean
Venezuela
Suriname
French Guyana
Guyana
Brazil
10/25/07 0900 Alt: 125m
Heading: 216
Essequibo River
Apoteri
9/11/07 0900 Alt: 280m
Heading: 44
3/1/08 1500 Alt: 0m
Heading: 0
Legacy Project:
06/07/08-292
Imagery Source: NaturalVue
2005 MDA Federal, Inc. /NaturalVue License
Produced By: 36IS / ING MIPS Team



Atlantic Ocean
Venezuela
Colombia
Brazil
M54 Wintering Period
9/28/07 - 3/06/08
Scale: 1: 121,000
Legend
M54_07
50% KHR
95% KHR
10/30/07 1200 Alt: 960m
Heading: 189
Lago De Valencia
(Lake Valencia)
11/04/07 1200 Alt: 438m
Heading: 0
2/15/08 1600 Alt: 424m
Heading: 79
Legacy Project:
06/07/08-292
Imagery Source: NaturalVue
2005 MDA Federal, Inc. /NaturalVue License
Produced By: 36IS / ING MIPS Team

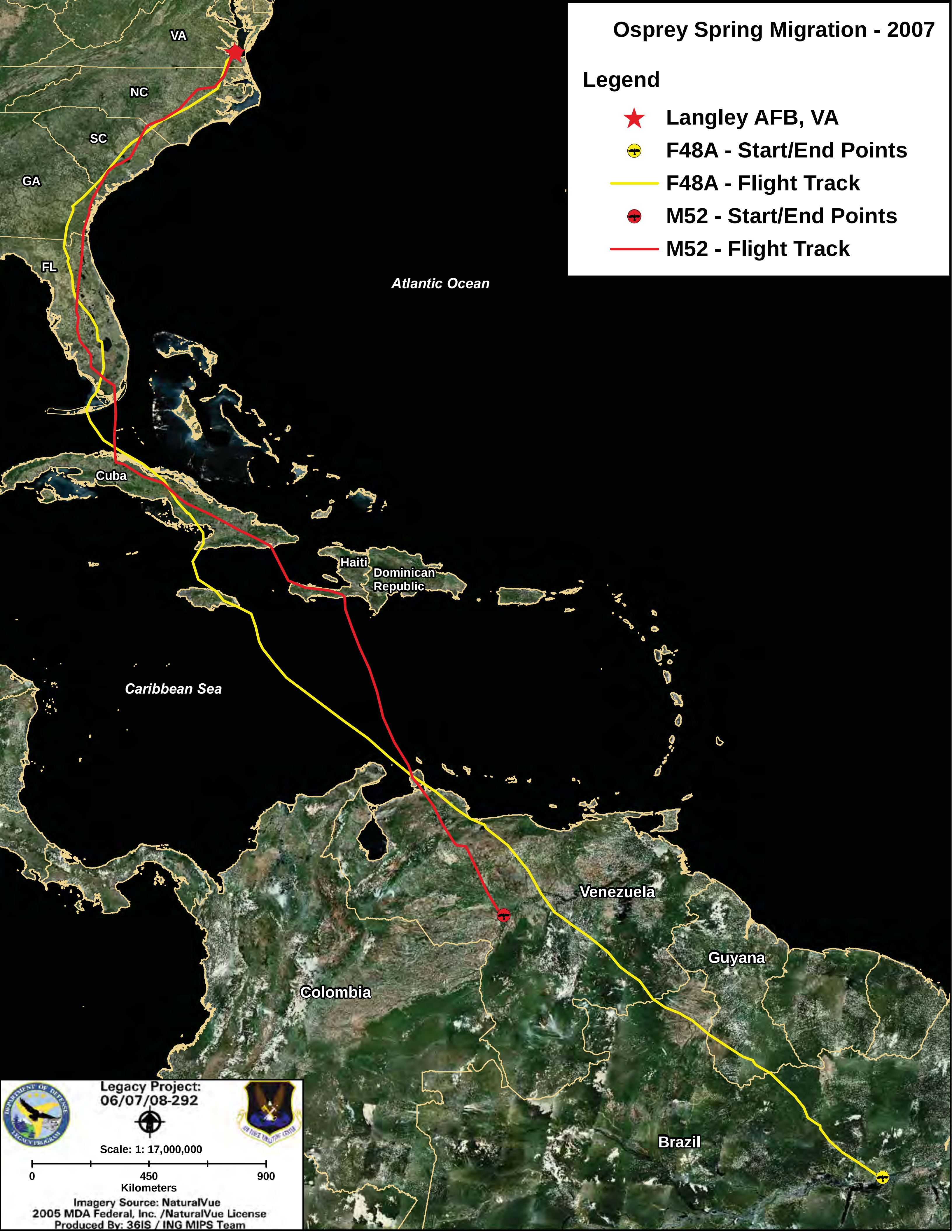


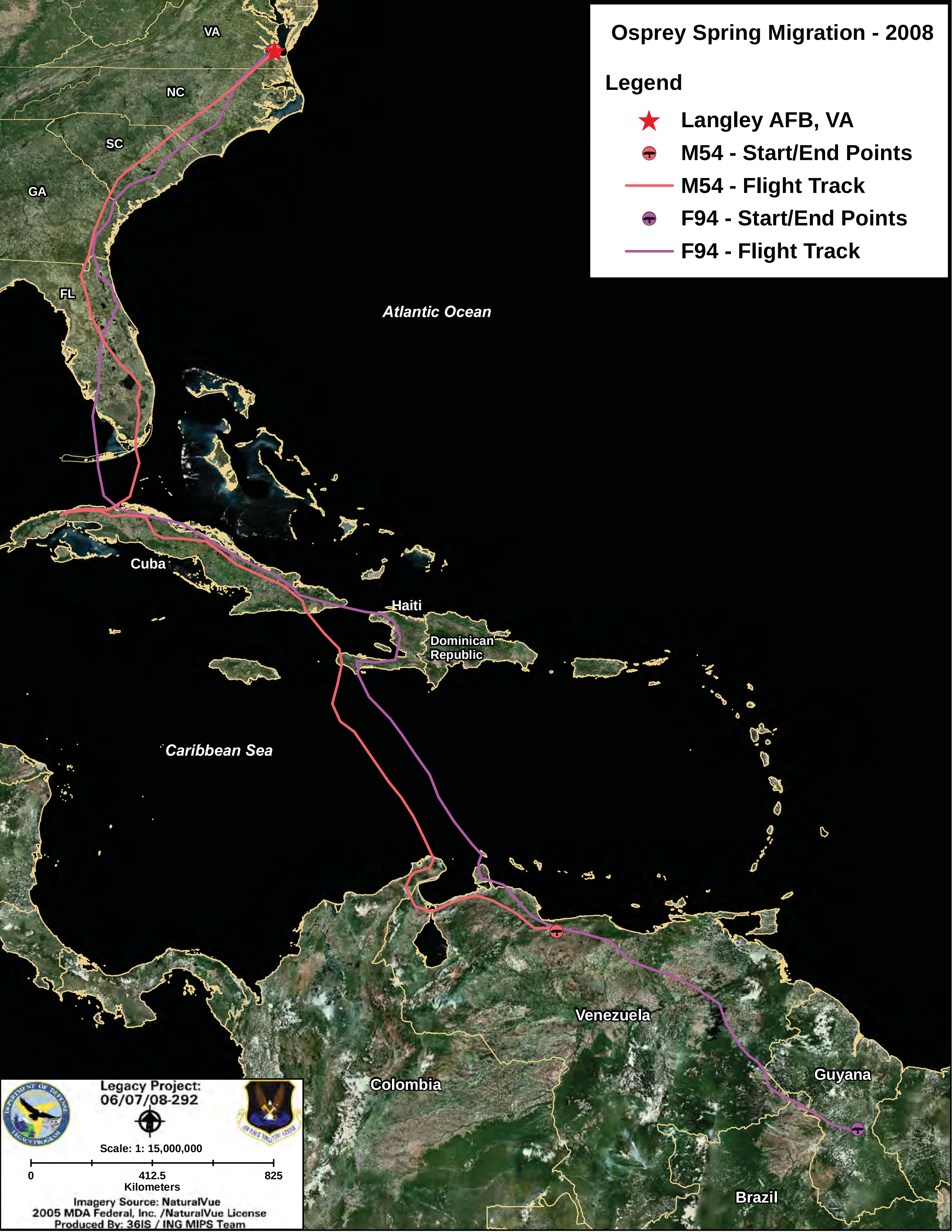
M54 Wintering Period
9/28/07 - 3/06/08
Scale: 1: 10,000
Legend
M54_07
50% KHR
95% KHR
Atlantic Ocean
Venezuela
Colombia
Brazil
1/07/08 1200 Alt: 763m
Heading: 135
10/15/07 0400 Alt: 434m
Heading: 318
1/04/08 1200 Alt: 424m
Heading: 333
Lago De Valencia
(Lake Valencia)
Legacy Project:
06/07/08-292
Imagery Source: WorldView 29 Dec 07
2007 Digital Globe / NextView License
Produced By: 36IS / ING MIPS Team

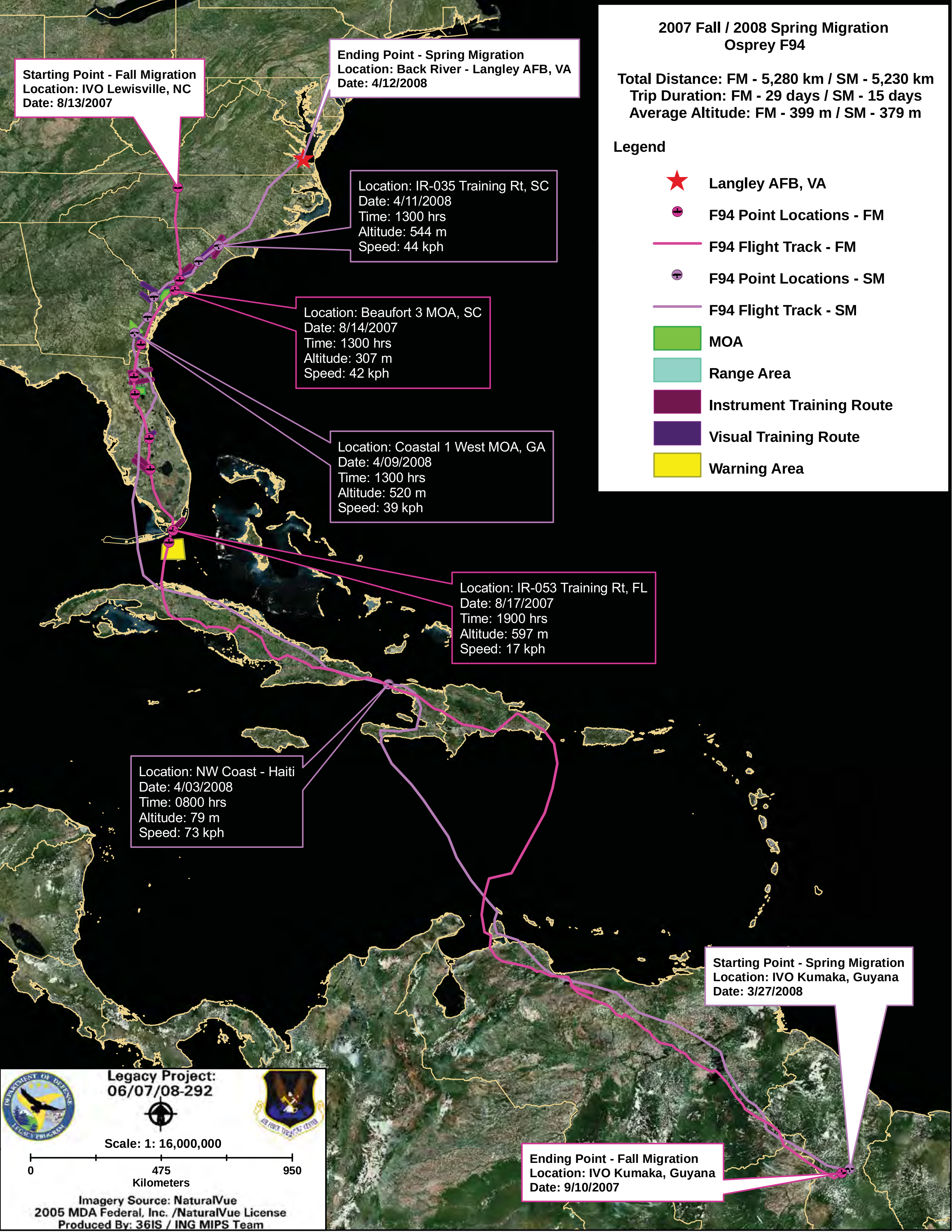
APPENDIX E.

Spring Migration Maps

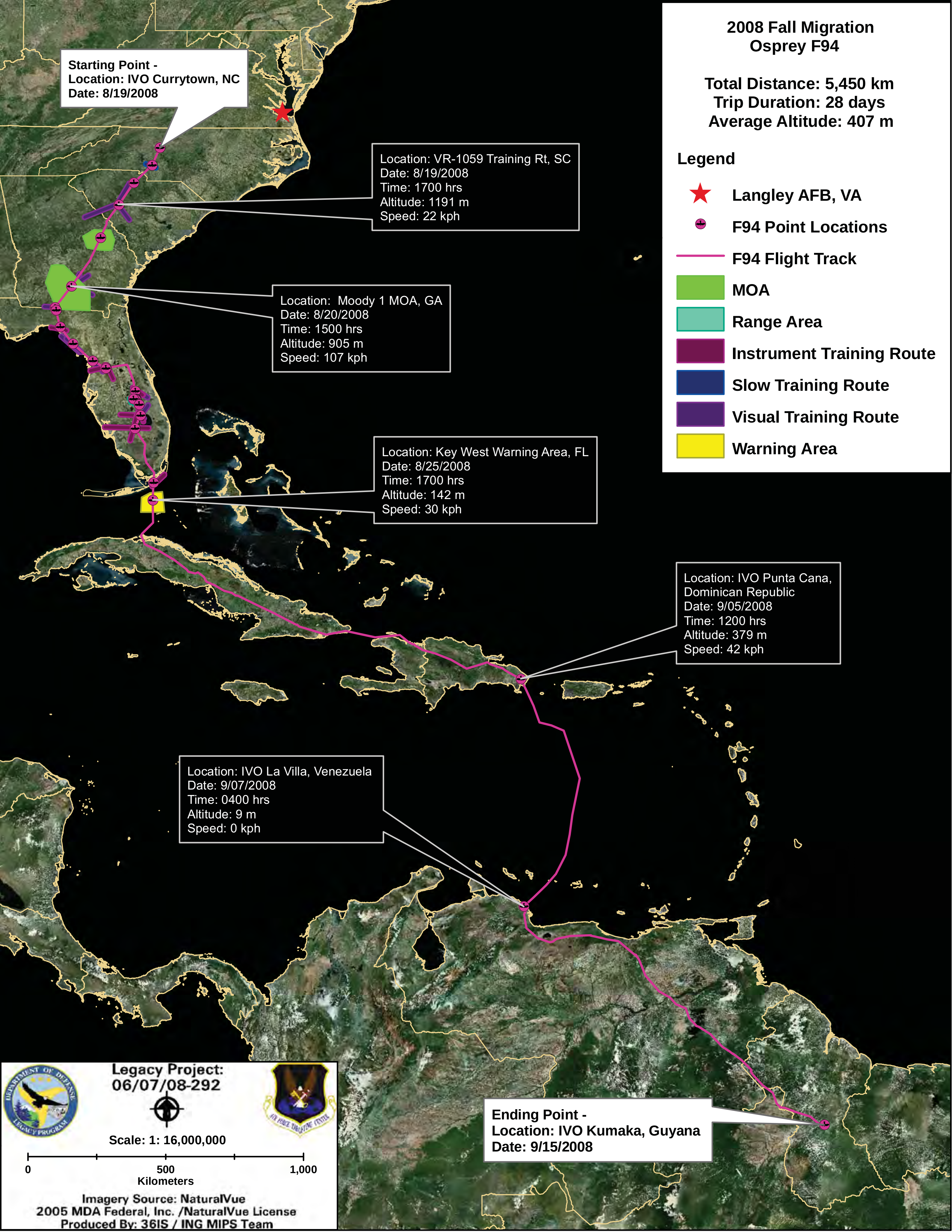
Appendix E features 6 high-quality reference maps illustrating flight tracks, point locations, distance traveled, duration of trip, average altitude, and military training airspace intersects of satellite-tagged Osprey during the spring migration period.

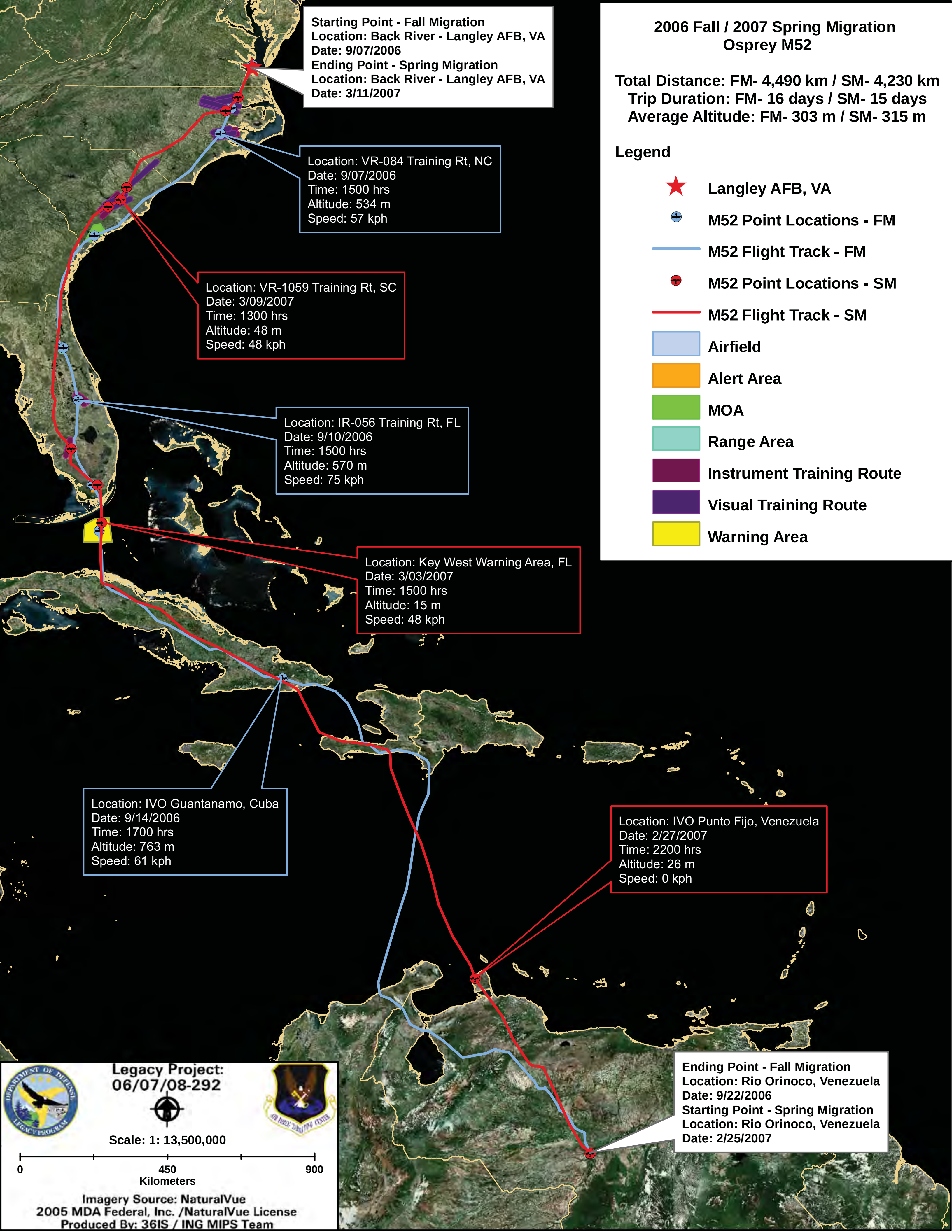

Osprey Spring Migration - 2007
Legend
Langley AFB, VA
F48A - Start/End Points
F48A - Flight Track
M52 - Start/End Points
M52 - Flight Track
VA
NC
SC
GA
FL
Atlantic Ocean
Cuba
Haiti
Dominican Republic
Caribbean Sea
Venezuela
Guyana
Colombia
Brazil
Legacy Project:
06/07/08-292
Scale: 1: 17,000,000
0
450
900
Kilometers
Imagery Source: NaturalVue
2005 MDA Federal, Inc. /NaturalVue License
Produced By: 36IS / ING MIPS Team

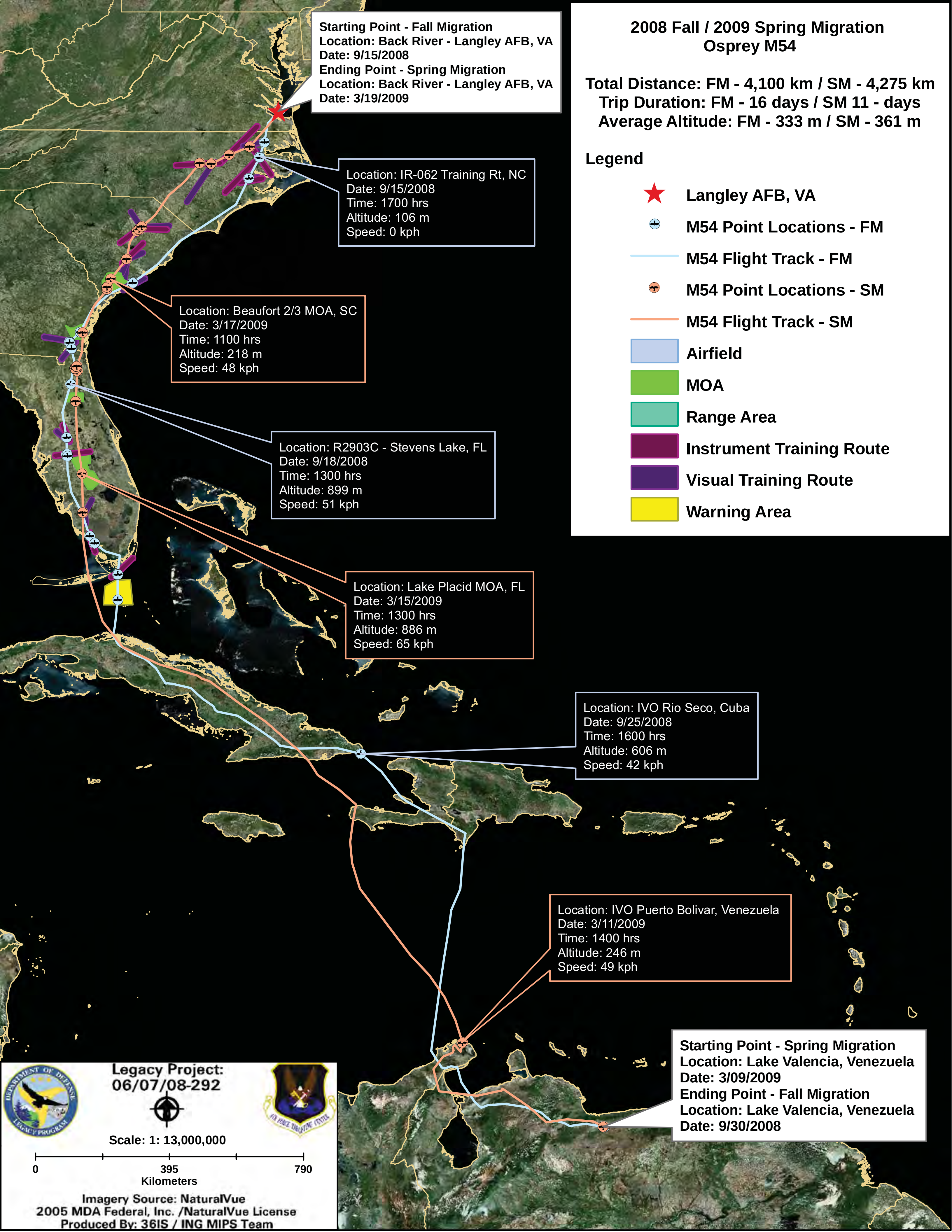

Osprey Spring Migration - 2008
Legend
Langley AFB, VA
M54 - Start/End Points
M54 - Flight Track
F94 - Start/End Points
F94 - Flight Track
VA
NC
SC
GA
FL
Atlantic Ocean
Cuba
Haiti
Dominican Republic
Caribbean Sea
Venezuela
Colombia
Guyana
Brazil
Legacy Project:
06/07/08-292
Scale: 1: 15,000,000
0
412.5
825
Kilometers
Imagery Source: NaturalVue
2005 MDA Federal, Inc. /NaturalVue License
Produced By: 36IS / ING MIPS Team



2007 Fall / 2008 Spring Migration
Osprey F94
Total Distance: FM - 5,280 km / SM - 5,230 km
Trip Duration: FM - 29 days / SM - 15 days
Average Altitude: FM - 399 m / SM - 379 m
Legend
Langley AFB, VA
F94 Point Locations - FM
F94 Flight Track - FM
F94 Point Locations - SM
F94 Flight Track - SM
MOA
Range Area
Instrument Training Route
Visual Training Route
Warning Area
Starting Point - Fall Migration
Location: IVO Lewisville, NC
Date: 8/13/2007
Ending Point - Spring Migration
Location: Back River - Langley AFB, VA
Date: 4/12/2008
Location: IR-035 Training Rt, SC
Date: 4/11/2008
Time: 1300 hrs
Altitude: 544 m
Speed: 44 kph
Location: Beaufort 3 MOA, SC
Date: 8/14/2007
Time: 1300 hrs
Altitude: 307 m
Speed: 42 kph
Location: Coastal 1 West MOA, GA
Date: 4/09/2008
Time: 1300 hrs
Altitude: 520 m
Speed: 39 kph
Location: IR-053 Training Rt, FL
Date: 8/17/2007
Time: 1900 hrs
Altitude: 597 m
Speed: 17 kph
Location: NW Coast - Haiti
Date: 4/03/2008
Time: 0800 hrs
Altitude: 79 m
Speed: 73 kph
Starting Point - Spring Migration
Location: IVO Kumaka, Guyana
Date: 3/27/2008
Ending Point - Fall Migration
Location: IVO Kumaka, Guyana
Date: 9/10/2007
Legacy Project:
06/07/08-292
Scale: 1: 16,000,000
0
475
950
Kilometers
Imagery Source: NaturalVue
2005 MDA Federal, Inc. /NaturalVue License
Produced By: 36IS / ING MIPS Team


2008 Fall Migration
Osprey F94
Total Distance: 5,450 km
Trip Duration: 28 days
Average Altitude: 407 m
Legend
Langley AFB, VA
F94 Point Locations
F94 Flight Track
MOA
Range Area
Instrument Training Route
Slow Training Route
Visual Training Route
Warning Area
Starting Point -
Location: IVO Currytown, NC
Date: 8/19/2008
Location: VR-1059 Training Rt, SC
Date: 8/19/2008
Time: 1700 hrs
Altitude: 1191 m
Speed: 22 kph
Location: Moody 1 MOA, GA
Date: 8/20/2008
Time: 1500 hrs
Altitude: 905 m
Speed: 107 kph
Location: Key West Warning Area, FL
Date: 8/25/2008
Time: 1700 hrs
Altitude: 142 m
Speed: 30 kph
Location: IVO Punta Cana, Dominican Republic
Date: 9/05/2008
Time: 1200 hrs
Altitude: 379 m
Speed: 42 kph
Location: IVO La Villa, Venezuela
Date: 9/07/2008
Time: 0400 hrs
Altitude: 9 m
Speed: 0 kph
Ending Point -
Location: IVO Kumaka, Guyana
Date: 9/15/2008
Legacy Project:
06/07/08-292
Scale: 1: 16,000,000
0
500
1,000
Kilometers
Imagery Source: NaturalVue
2005 MDA Federal, Inc. /NaturalVue License
Produced By: 36IS / ING MIPS Team


2006 Fall / 2007 Spring Migration
Osprey M52
Total Distance: FM- 4,490 km / SM- 4,230 km
Trip Duration: FM- 16 days / SM- 15 days
Average Altitude: FM- 303 m / SM- 315 m
Legend
Langley AFB, VA
M52 Point Locations - FM
M52 Flight Track - FM
M52 Point Locations - SM
M52 Flight Track - SM
Airfield
Alert Area
MOA
Range Area
Instrument Training Route
Visual Training Route
Warning Area
Starting Point - Fall Migration
Location: Back River - Langley AFB, VA
Date: 9/07/2006
Ending Point - Spring Migration
Location: Back River - Langley AFB, VA
Date: 3/11/2007
Location: VR-084 Training Rt, NC
Date: 9/07/2006
Time: 1500 hrs
Altitude: 534 m
Speed: 57 kph
Location: VR-1059 Training Rt, SC
Date: 3/09/2007
Time: 1300 hrs
Altitude: 48 m
Speed: 48 kph
Location: IR-056 Training Rt, FL
Date: 9/10/2006
Time: 1500 hrs
Altitude: 570 m
Speed: 75 kph
Location: Key West Warning Area, FL
Date: 3/03/2007
Time: 1500 hrs
Altitude: 15 m
Speed: 48 kph
Location: IVO Guantanamo, Cuba
Date: 9/14/2006
Time: 1700 hrs
Altitude: 763 m
Speed: 61 kph
Location: IVO Punto Fijo, Venezuela
Date: 2/27/2007
Time: 2200 hrs
Altitude: 26 m
Speed: 0 kph
Ending Point - Fall Migration
Location: Rio Orinoco, Venezuela
Date: 9/22/2006
Starting Point - Spring Migration
Location: Rio Orinoco, Venezuela
Date: 2/25/2007
Legacy Project:
06/07/08-292
Scale: 1: 13,500,000
0
450
900
Kilometers
Imagery Source: NaturalVue
2005 MDA Federal, Inc. /NaturalVue License
Produced By: 36IS / ING MIPS Team

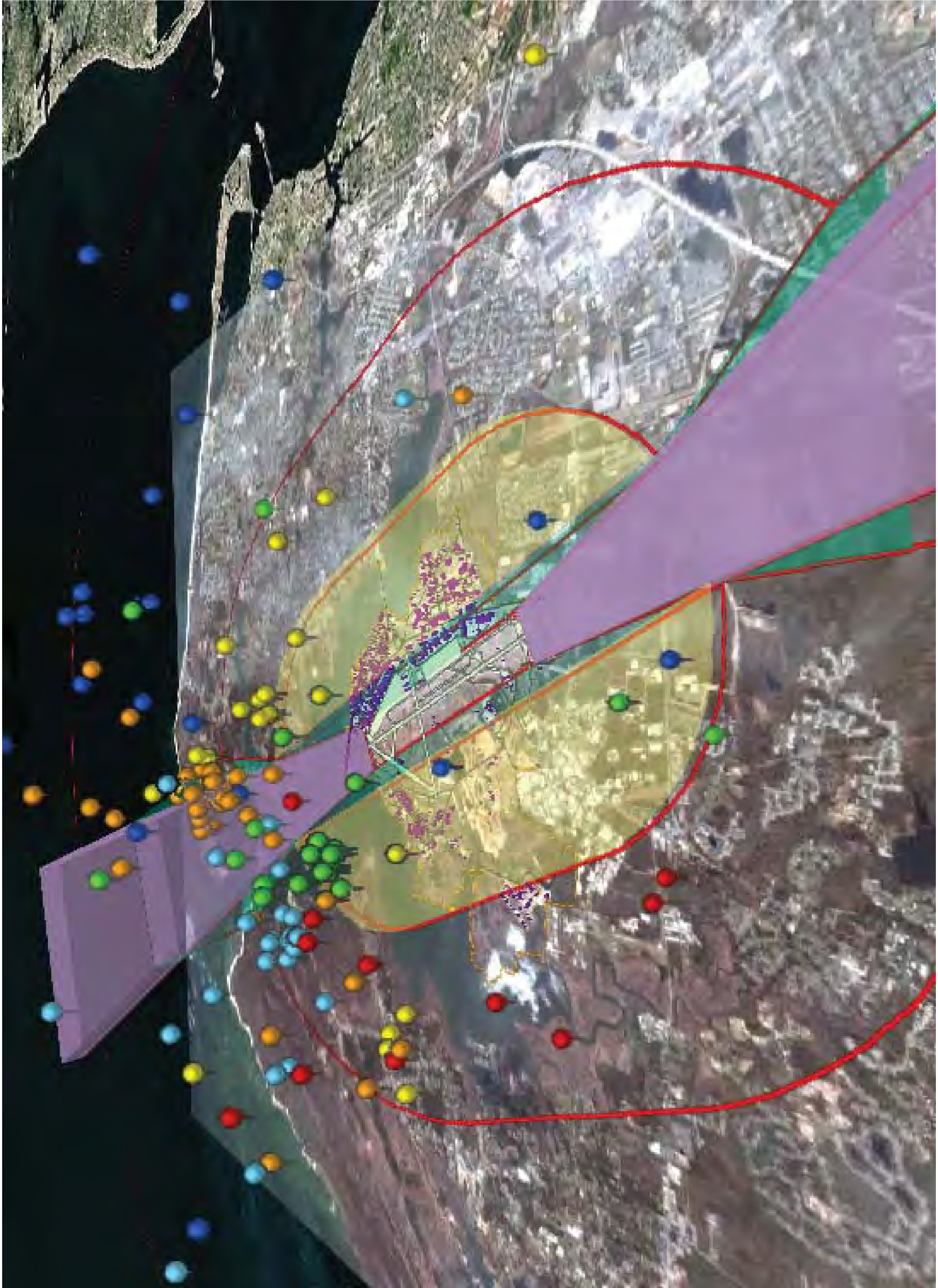


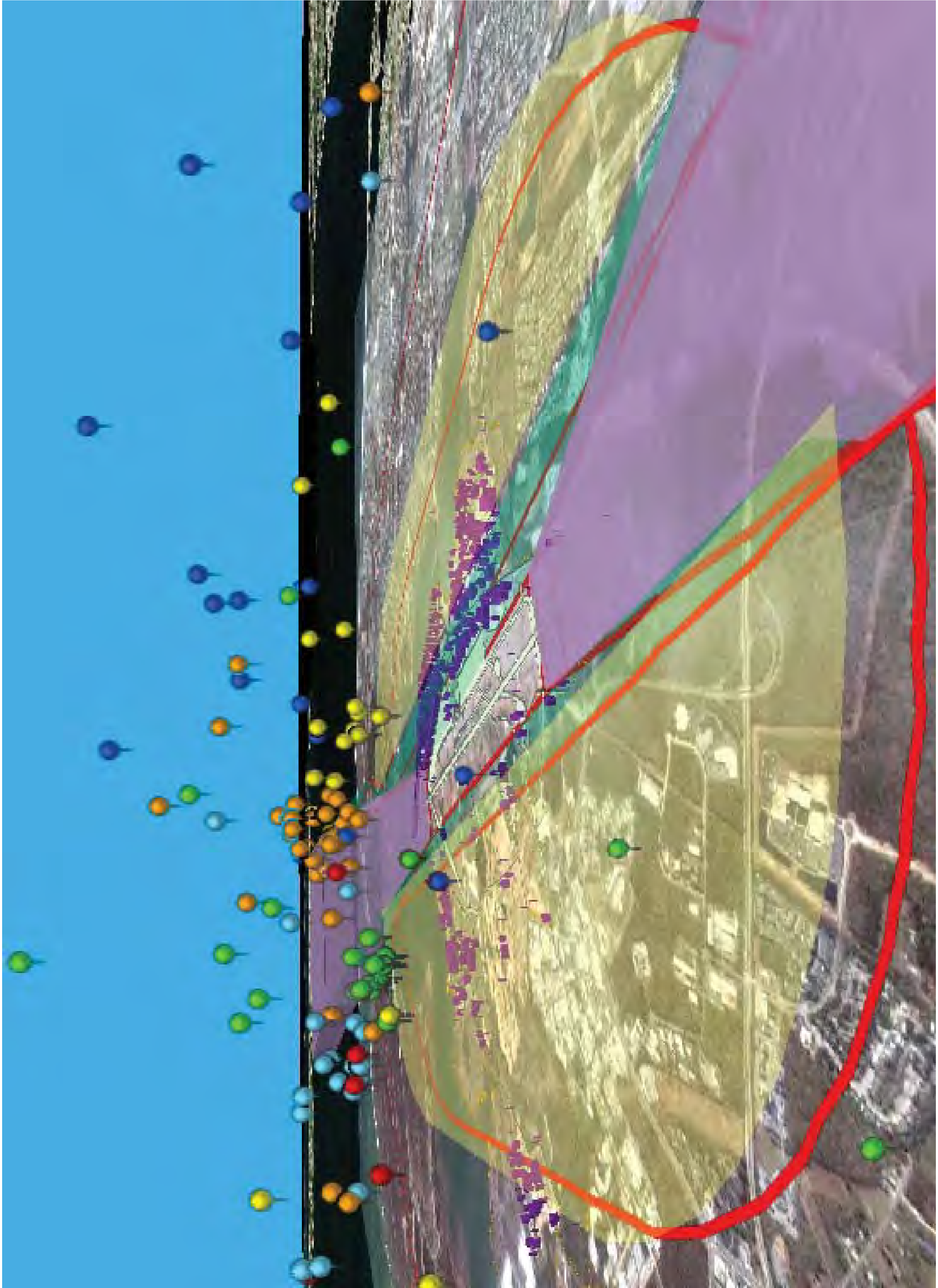
2008 Fall / 2009 Spring Migration
Osprey M54
Total Distance: FM - 4,100 km / SM - 4,275 km
Trip Duration: FM - 16 days / SM 11 - days
Average Altitude: FM - 333 m / SM - 361 m
Legend
Langley AFB, VA
M54 Point Locations - FM
M54 Flight Track - FM
M54 Point Locations - SM
M54 Flight Track - SM
Airfield
MOA
Range Area
Instrument Training Route
Visual Training Route
Warning Area
Starting Point - Fall Migration
Location: Back River - Langley AFB, VA
Date: 9/15/2008
Ending Point - Spring Migration
Location: Back River - Langley AFB, VA
Date: 3/19/2009
Location: IR-062 Training Rt, NC
Date: 9/15/2008
Time: 1700 hrs
Altitude: 106 m
Speed: 0 kph
Location: Beaufort 2/3 MOA, SC
Date: 3/17/2009
Time: 1100 hrs
Altitude: 218 m
Speed: 48 kph
Location: R2903C - Stevens Lake, FL
Date: 9/18/2008
Time: 1300 hrs
Altitude: 899 m
Speed: 51 kph
Location: Lake Placid MOA, FL
Date: 3/15/2009
Time: 1300 hrs
Altitude: 886 m
Speed: 65 kph
Location: IVO Rio Seco, Cuba
Date: 9/25/2008
Time: 1600 hrs
Altitude: 606 m
Speed: 42 kph
Location: IVO Puerto Bolivar, Venezuela
Date: 3/11/2009
Time: 1400 hrs
Altitude: 246 m
Speed: 49 kph
Starting Point - Spring Migration
Location: Lake Valencia, Venezuela
Date: 3/09/2009
Ending Point - Fall Migration
Location: Lake Valencia, Venezuela
Date: 9/30/2008
Legacy Project:
06/07/08-292
Scale: 1: 13,000,000
0
395
790
Kilometers
Imagery Source: NaturalVue
2005 MDA Federal, Inc. /NaturalVue License
Produced By: 36IS / ING MIPS Team

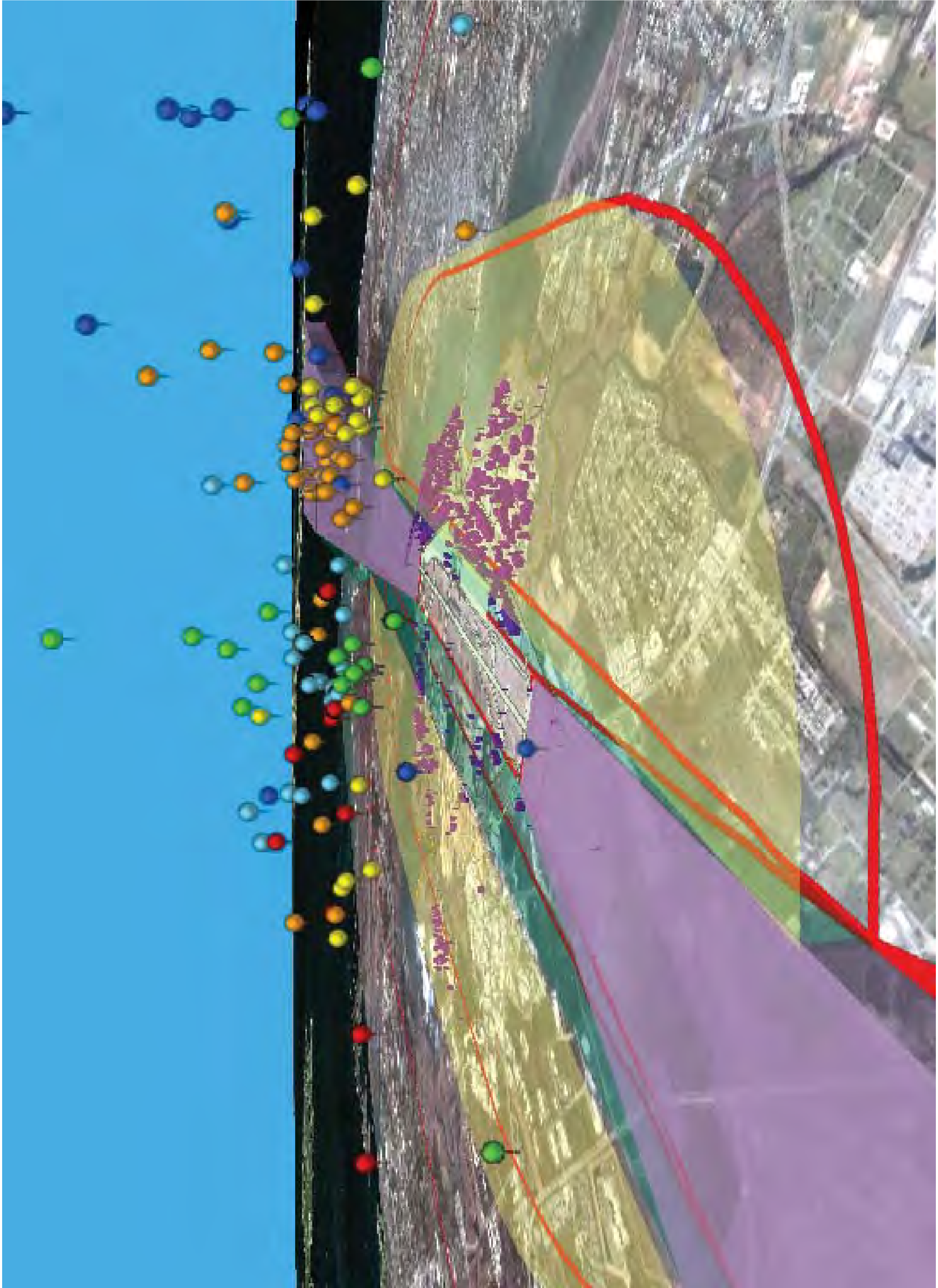
APPENDIX F.

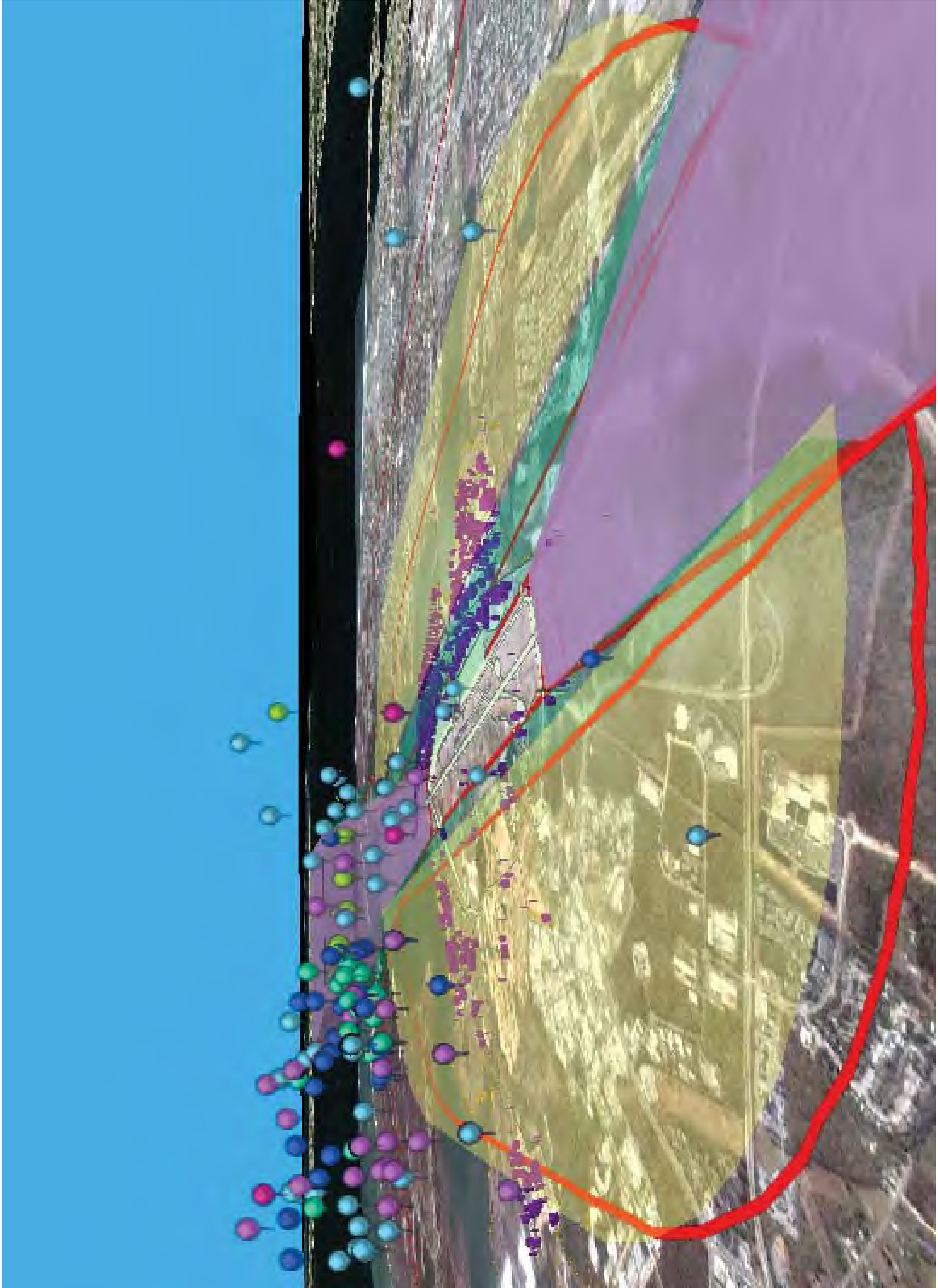
Breeding (Summer) Period BASH Assessment Illustrations

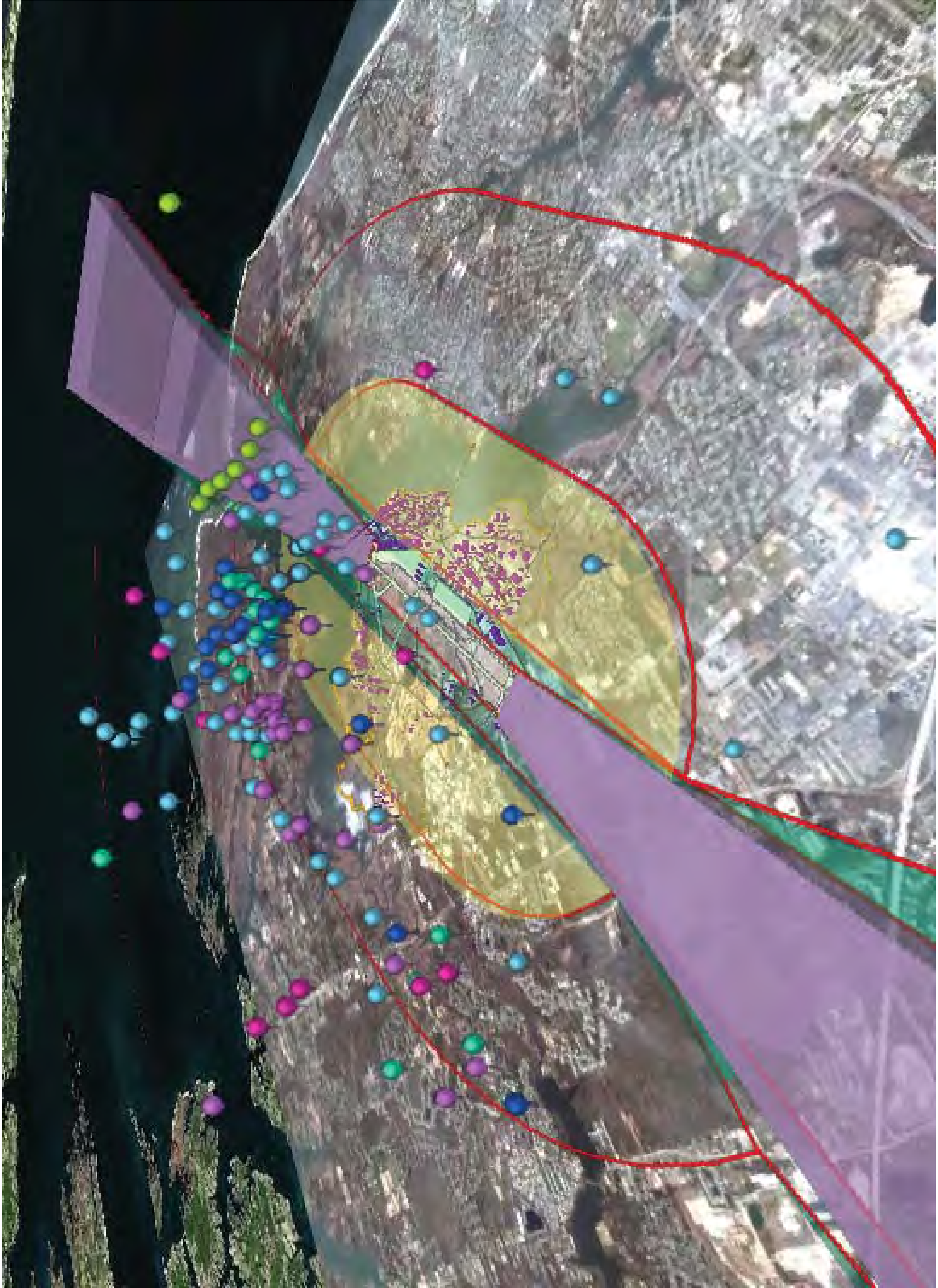
Appendix F features 12 high-quality three dimensional reference illustrations of at-risk locations within the Langley AFB imaginary surfaces. Each colored at-risk balloon location represents individual Osprey that were located via satellite within Langley AFB imaginary surfaces at varying times during the 2006, 2007, and 2008 breeding (summer) periods.

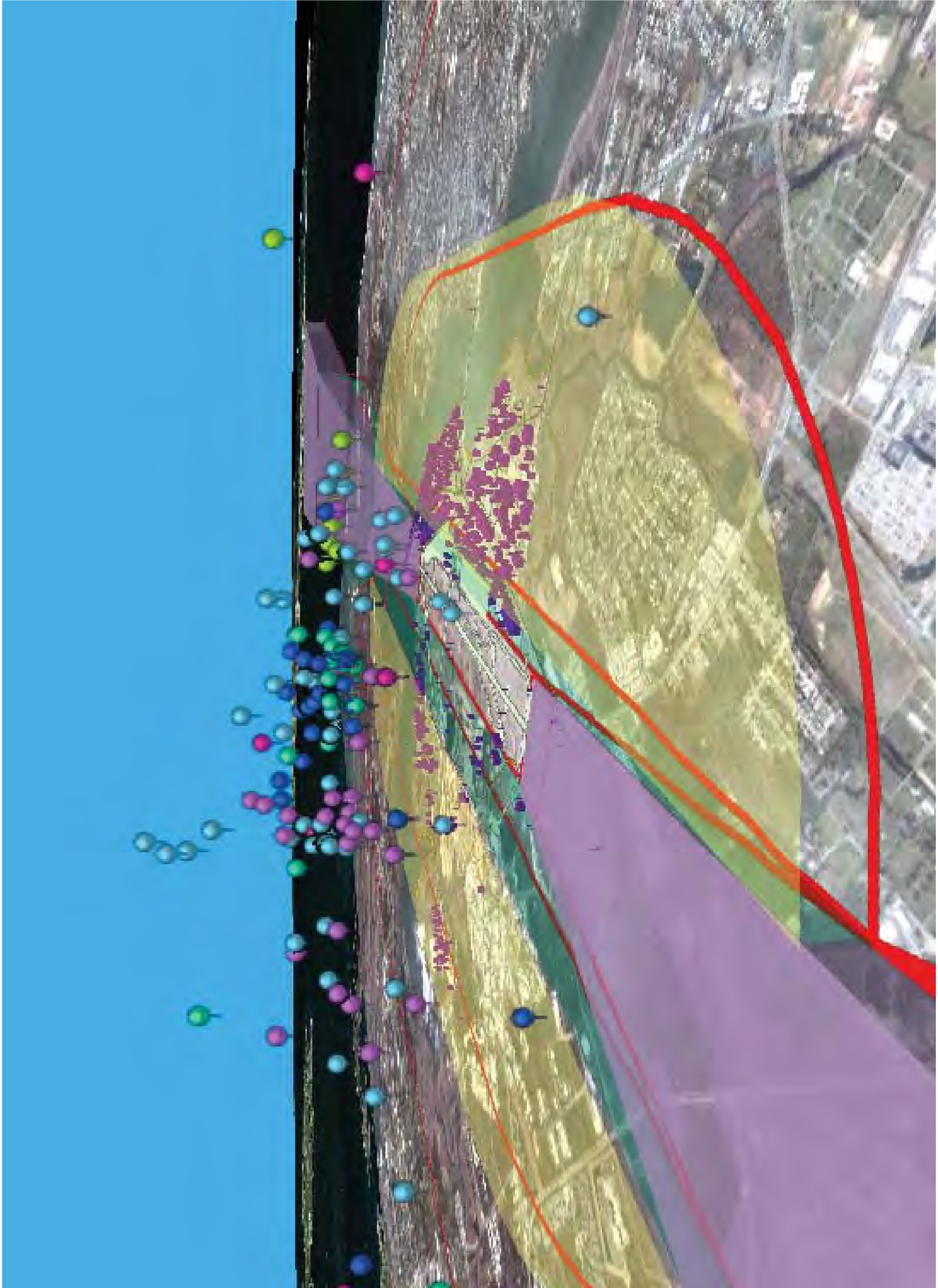


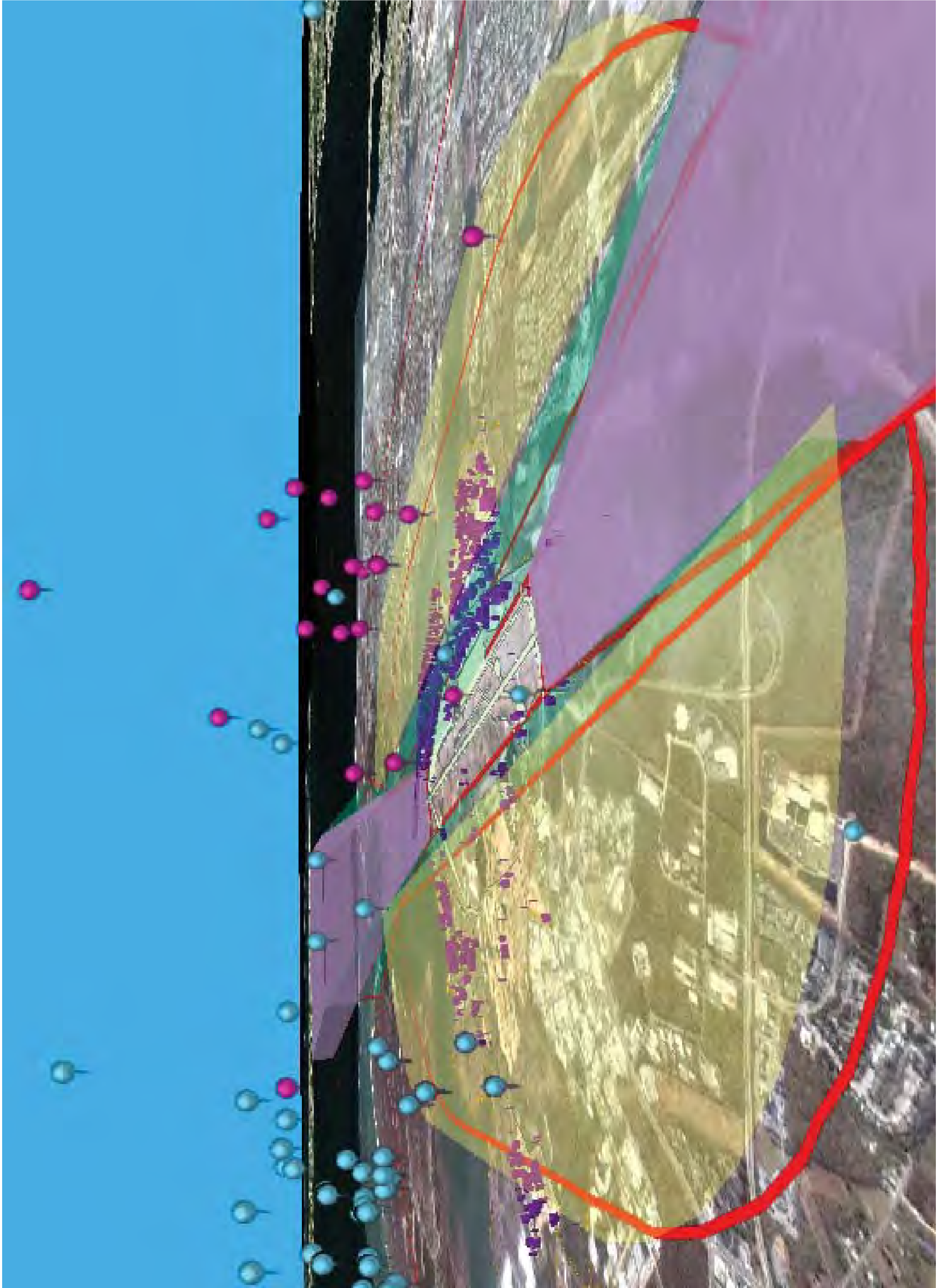


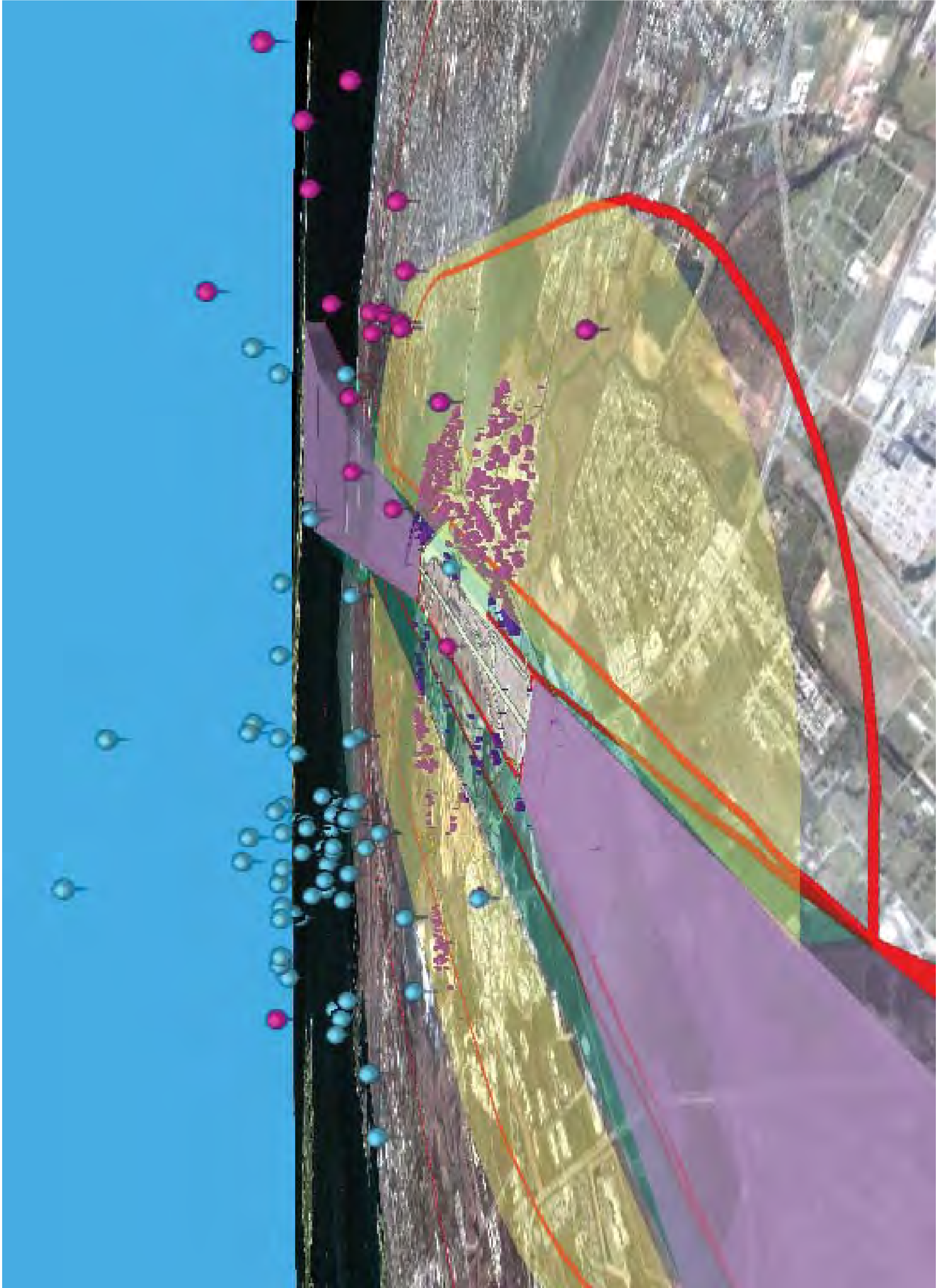


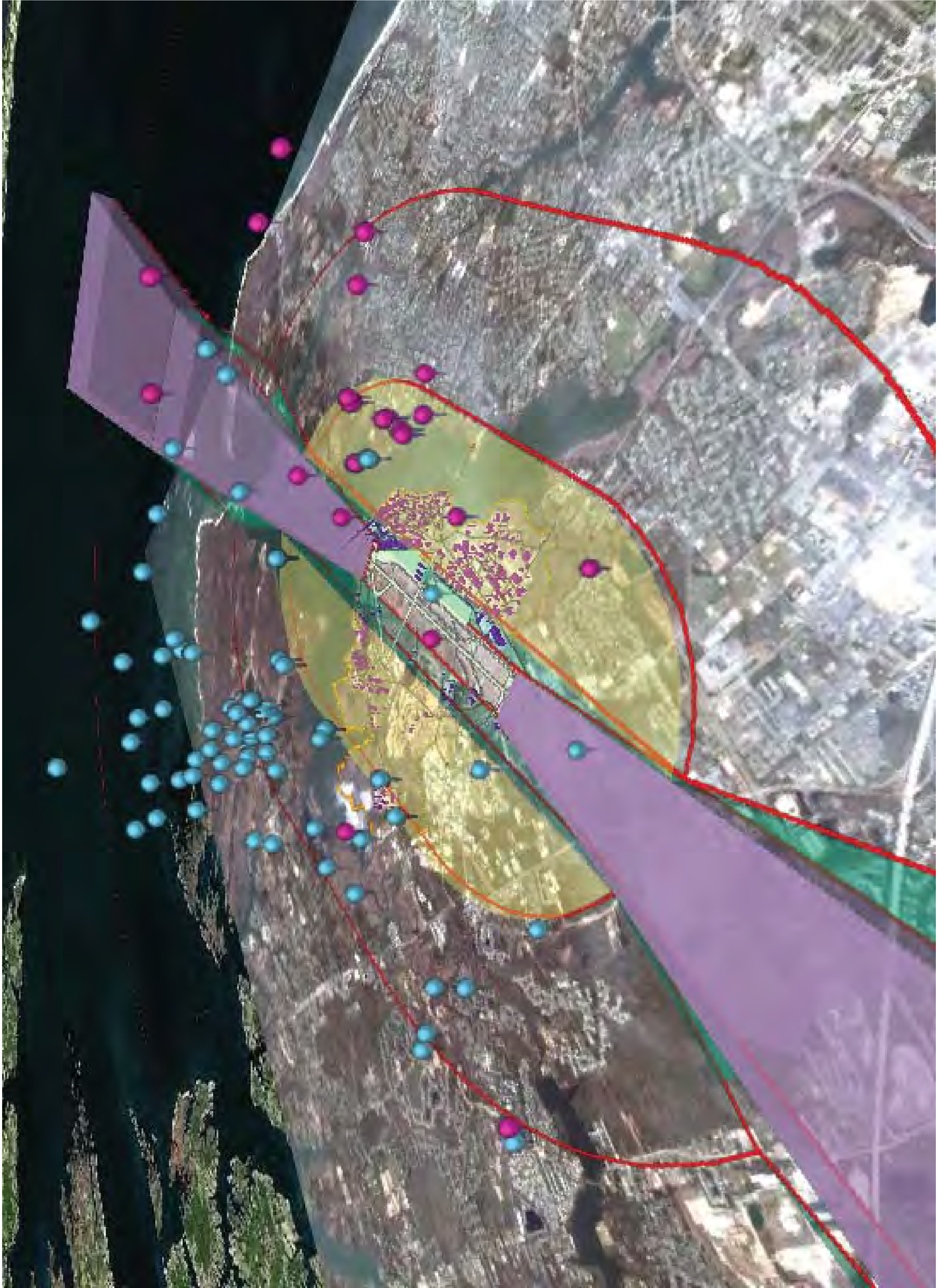


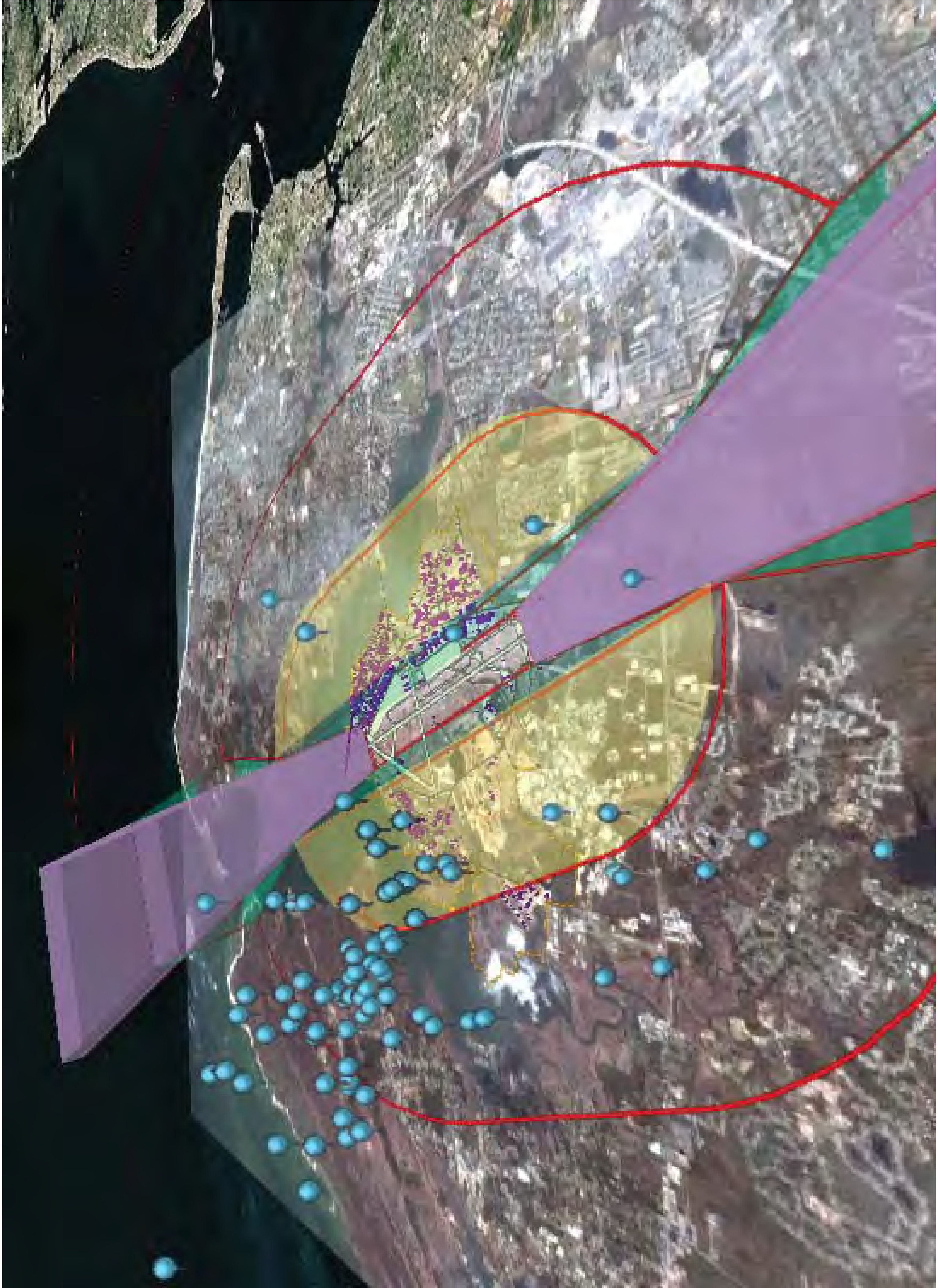


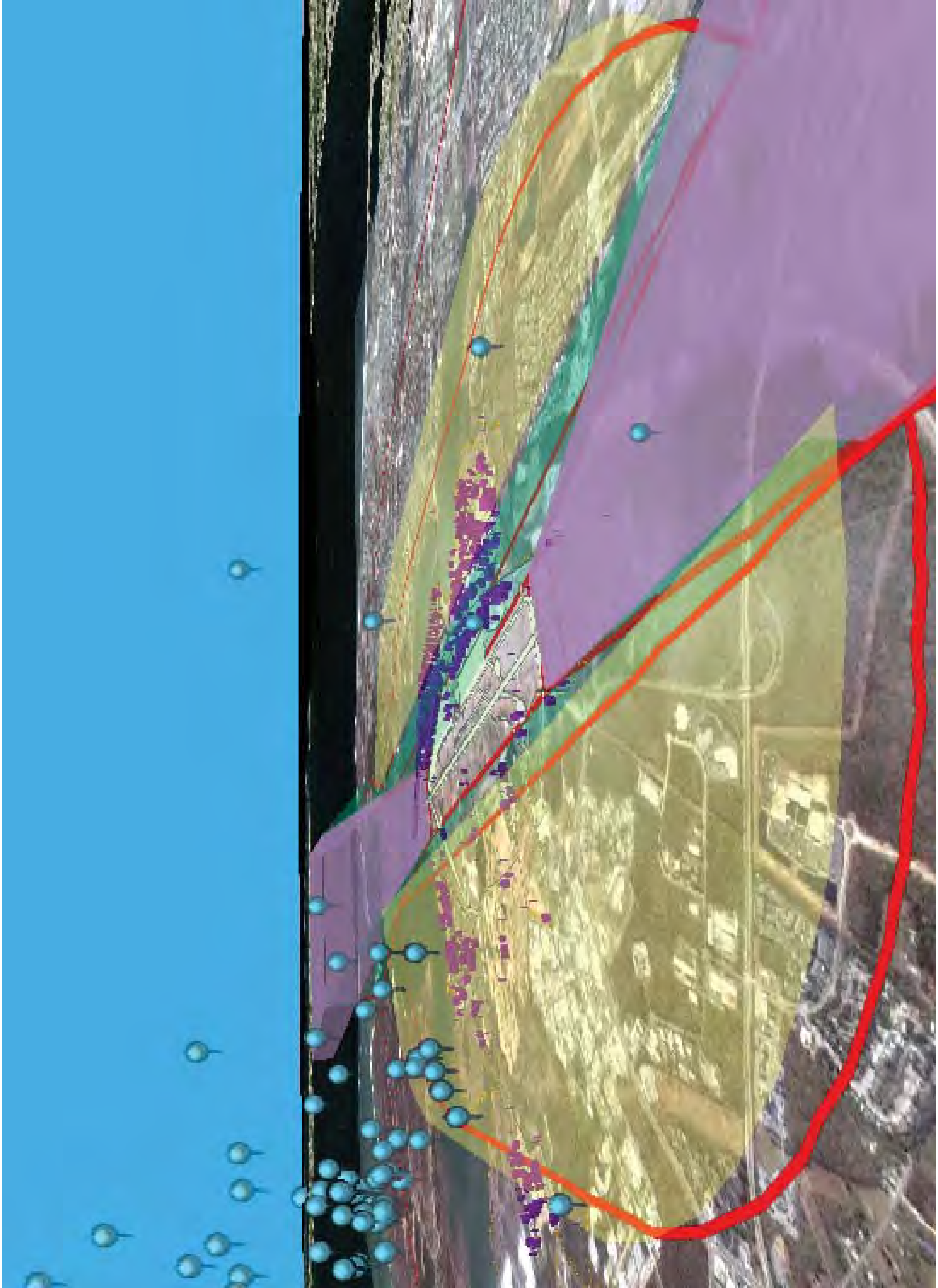








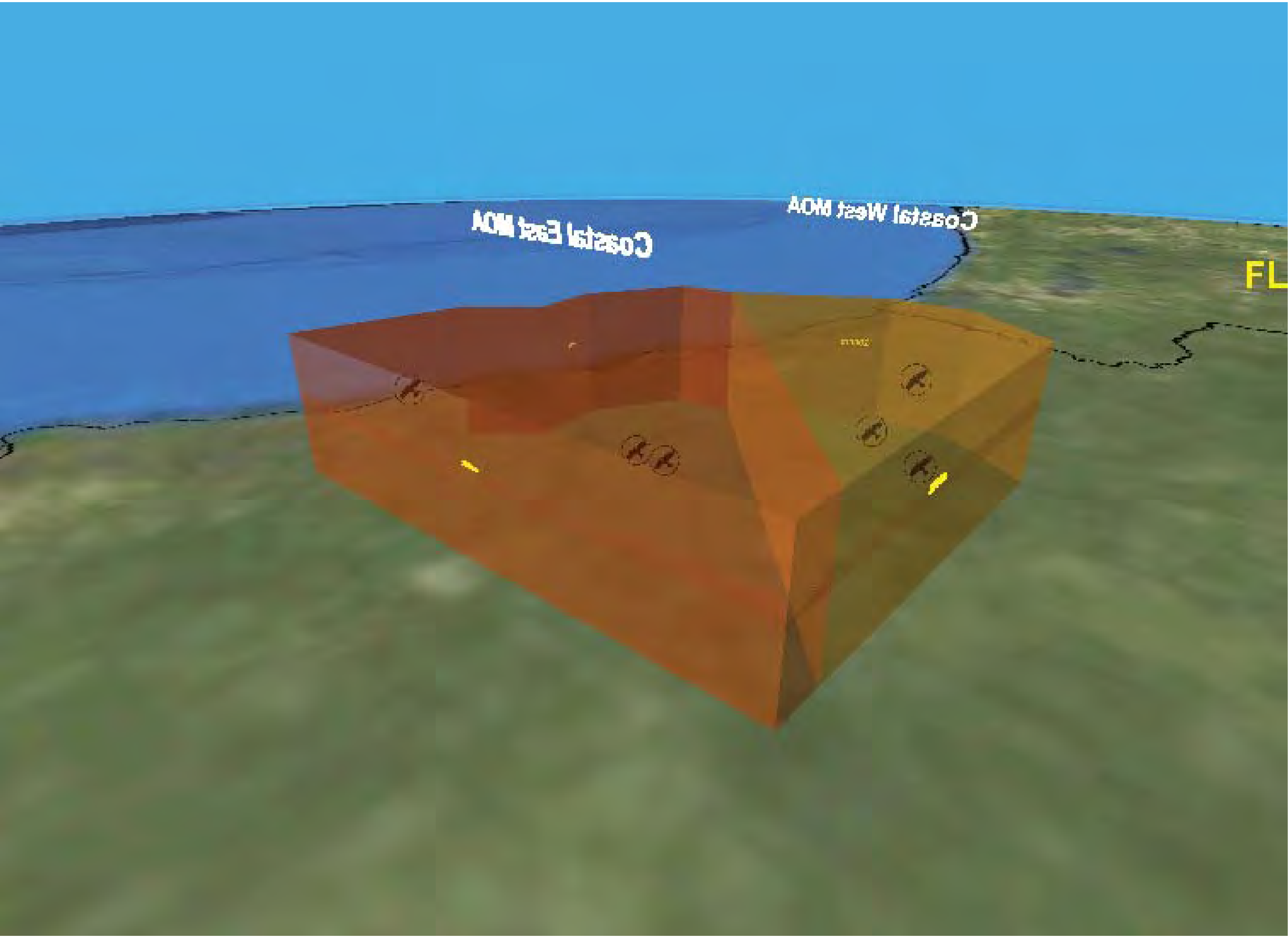


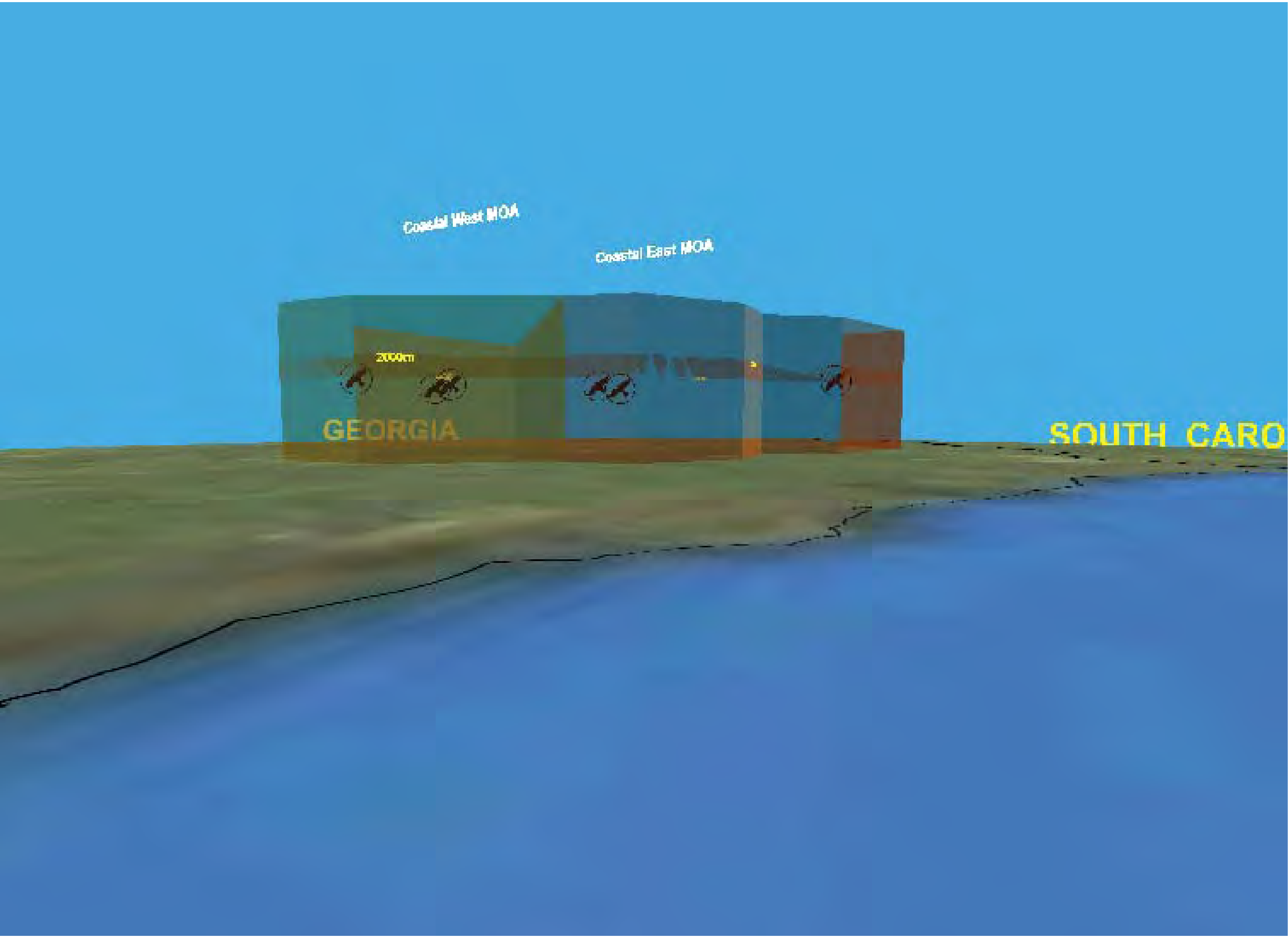


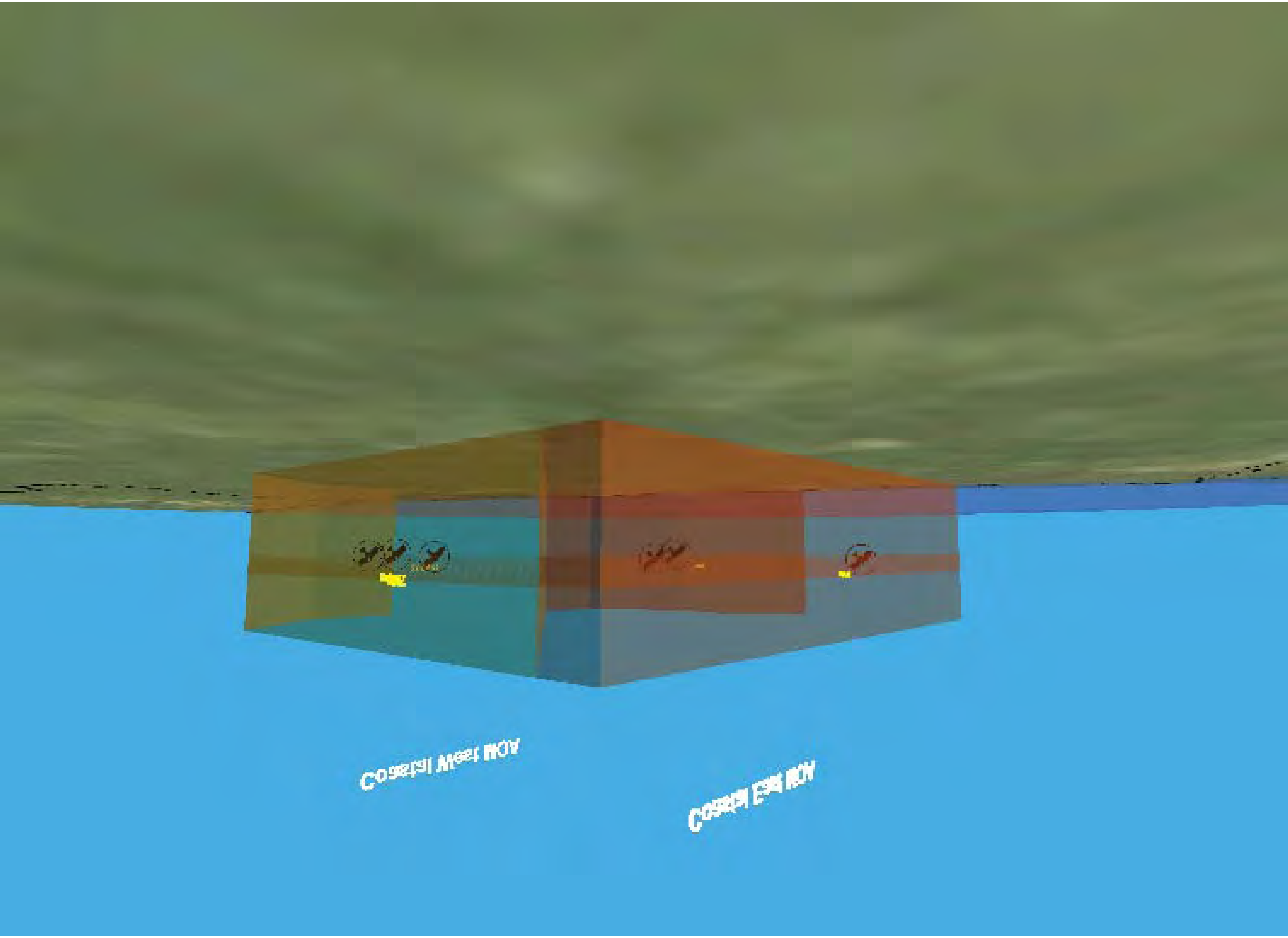
APPENDIX G.

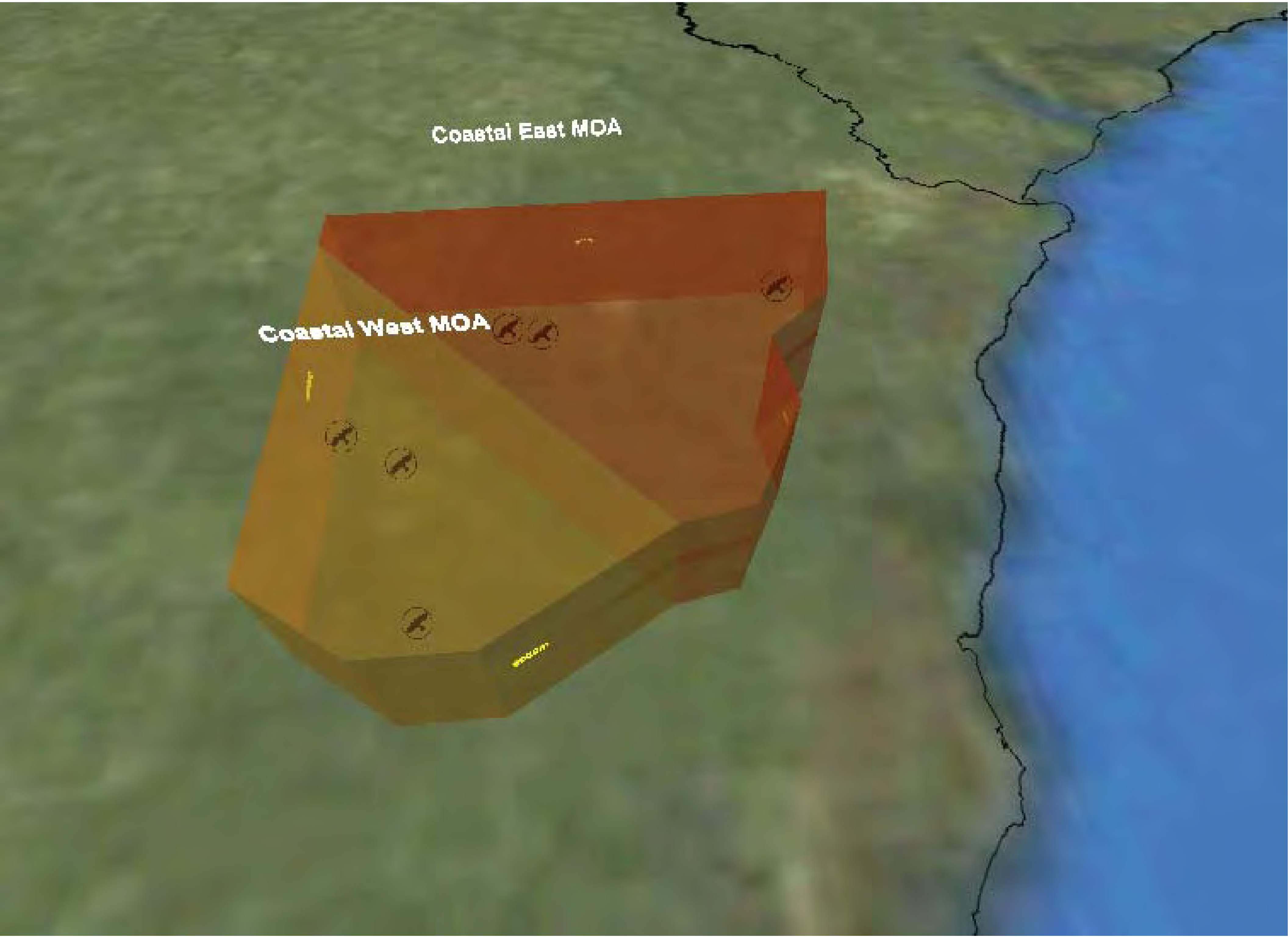
Migration BASH Assessment Illustrations

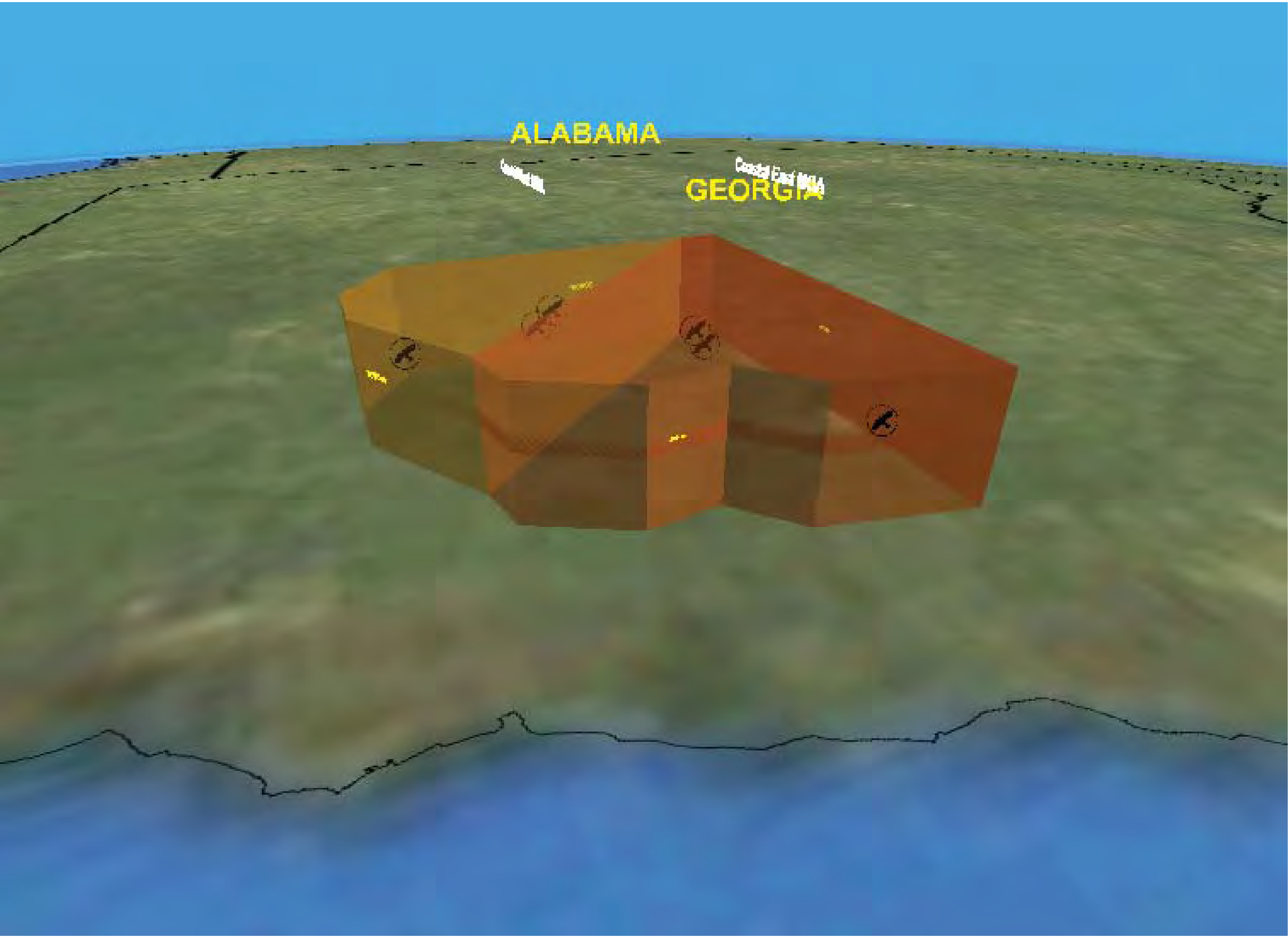
Appendix G features 8 high-quality three dimensional reference illustrations of at-risk locations of satellite-tagged Osprey within the coastal east and west military operations airspace. Each point location represents individual Osprey that were located via satellite within coastal east and west military operations airspace at varying times during the 2006, 2007, and 2008 migration periods.

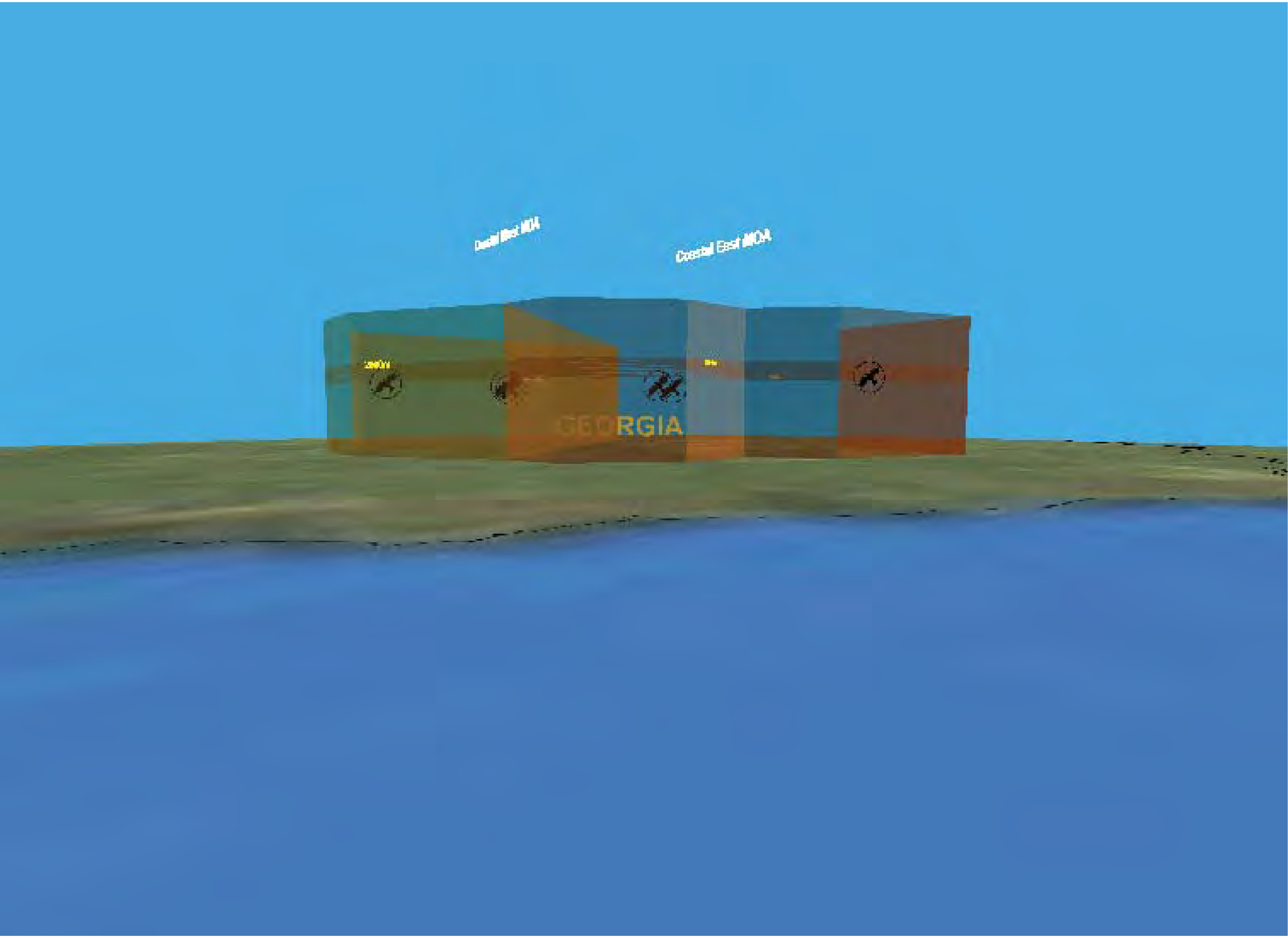

Coastal East MOA
Coastal West MOA
FL

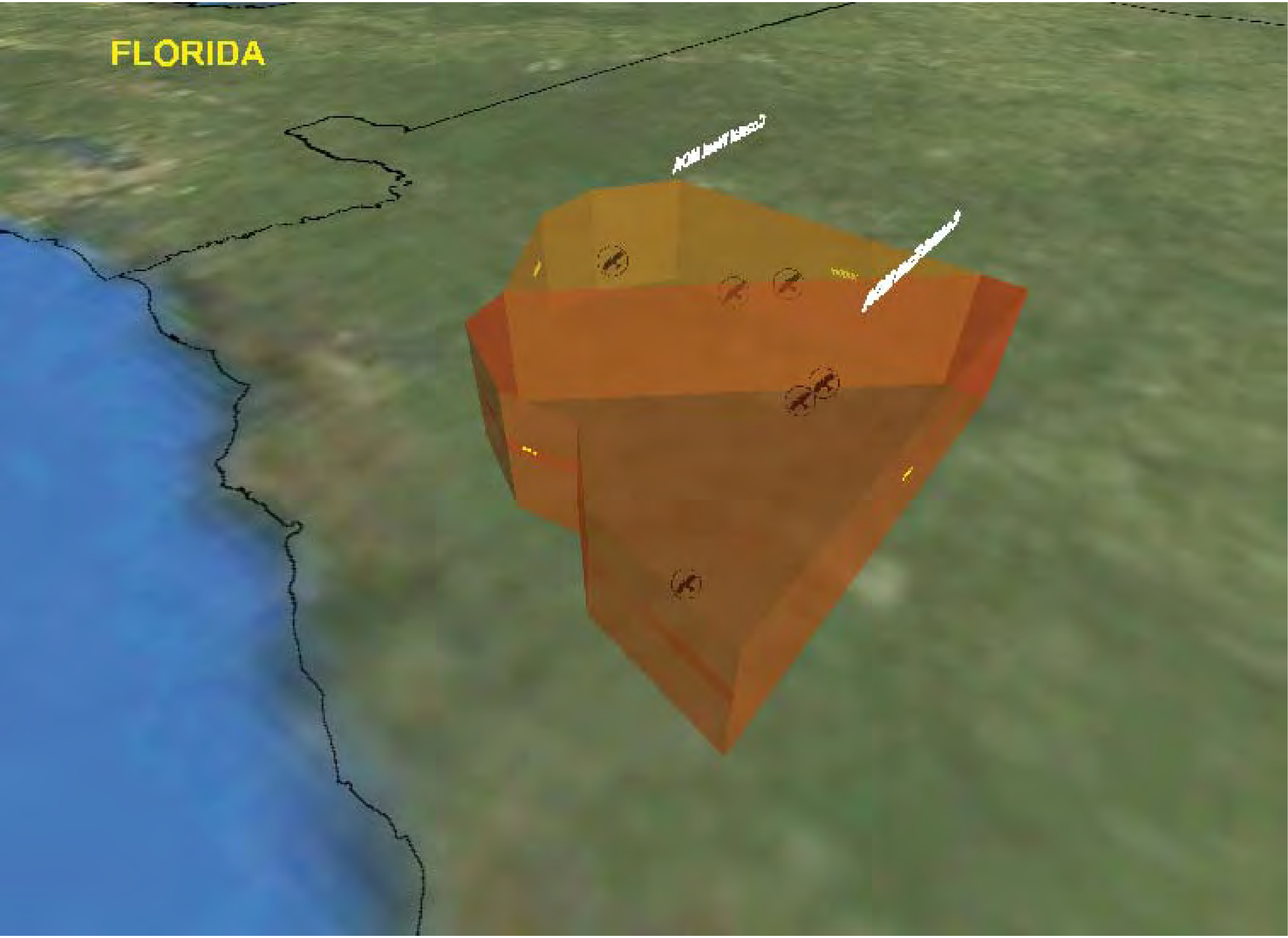

Coastal West MOA
Coastal East MOA
2000m
GEORGIA
SOUTH CARO

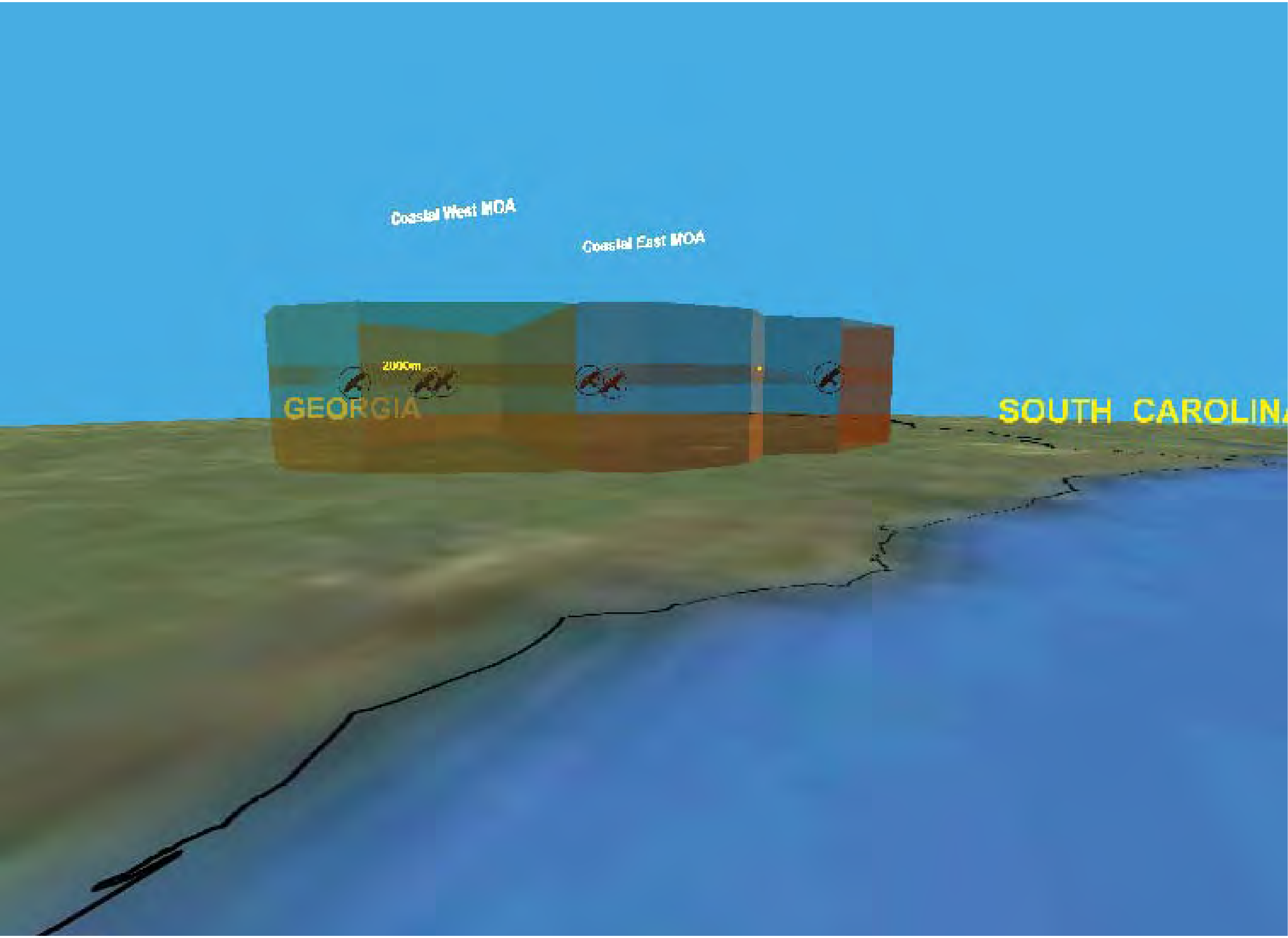

Coastal West MOA
Coastal East MOA


Coastal East MOA
Coastal West MOA


ALABAMA
GEORGIA


Coastal East MOA
GEORGIA


FLORIDA


Coastal West MOA
Coastal East MOA
2000m
GEORGIA
SOUTH CAROLINA

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