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1.0 Introduction

The Naval Facilities Engineering Command (NAVFACENGCOM) conducts aircraft noise surveys at various Naval and Marine Corps Air Stations throughout the United States and overseas. The noise exposure contours developed during these studies are incorporated into Air Installation Compatible Use Zones (AICUZ) or other environmental documents for each station. These environmental documents are, in turn, used to promote the compatibility of Navy and Marine Corps activities with neighboring land uses. This report presents the results of a noise study for Naval Air Facility (NAF) Key West, Florida. For the purposes of brevity, NAF Key West will often be referred to as the NAF in this report.

The purpose of this report is to present the aircraft noise exposure for forecast aircraft operations at the NAF for calendar year 2007 (CY07). Section 1.1 summarizes the noise metrics discussed throughout this report, and Section 1.2 describes the computer noise model used to compute the noise exposure. Section 2 provides a description of NAF Key West. Section 3 addresses forecast aircraft operations, noise exposure, and AICUZ-related information for CY07 conditions. Appendix A provides a detailed discussion of noise and its effects on people and the environment. Appendices B through G contain the modeled aircraft flight profiles discussed in Section 3.

1.1 Noise Metrics

Noise represents one of the most prominent environmental issues associated with aircraft operations. Although many other sources of noise are present in today's communities, aircraft noise is readily identifiable. An assessment of aircraft noise requires a general understanding of how sound is measured and how it affects people and the natural environment. See Appendix A for further detail.

The noise environment around a military or civil airfield is normally described in terms of the time-average sound level generated by the aircraft operating at that facility. These operations consist of the flight activities conducted during an average day at the airfield. Operations generally include fixed- and rotary-wing arrivals and departures at the airfield, flight patterns in the general vicinity of the airfield, and aircraft engine "run-ups" associated with engine pre-flight and maintenance checks.

The federal noise measure used for assessing aircraft noise exposures in communities in the vicinity of airfields/airports is the Day-Night Average Sound Level (abbreviated DNL, or sometimes L_{dn}), in units of the decibel (dB). DNL is an average sound level generated by all aviation-related operations during an average 24-hour period with sound levels of nighttime noise events emphasized by adding a 10 dB weighting. Nighttime is defined as the period from 2200 to 0700 the following morning. The 10 dB weighting accounts for the generally lower background sound levels and greater community sensitivity to noise during nighttime hours. As explained in Appendix A, DNL has been found to provide the best measure of long-term community reaction to transportation noises, especially aircraft noise.

Individual, single noise events are described in terms of the Sound Exposure Level (abbreviated SEL), in units of decibels. SEL takes into account the amplitude of a sound and the length of time during which each event occurs. It thus provides a direct comparison of the relative intrusiveness among single noise events of different intensities and time intervals. Appendix A provides a more complete discussion of SEL.

SEL and DNL employ A-weighted sound levels. "A-weighted" denotes the adjustment of the frequency content of a noise event to represent the way in which the average human ear responds to that sound energy.

1.2 Computerized Noise Exposure Model

Analyses of aircraft noise exposures and compatible land uses around Department of the Navy facilities are normally accomplished using a group of computer-based programs for airfield analyses called NOISEMAP.[1,2] The NOISEMAP suite of computer programs was developed by the U.S. Air Force which serves as the lead Department of Defense (DoD) agency for aircraft noise modeling.

There are currently two versions of NOISEMAP available for use, depending on the requirements of the noise analysis. NOISEMAP 6.5 considers the topography in the vicinity of any airfield to be flat and have a uniform surface impendence similar to that of grass-covered ground. NOISEMAP 7.0, on the other hand, accounts for effects of both changes in topography (e.g., mountain, valley) and differences in surface impendence (e.g., water, grass covered ground). This is of particular interest to NAF Key West as it is surrounded by large bodies of water. Noise analysis of operations at NAF Key West using NOISEMAP 7.0 result in an increase in noise level by 2-3 dB over results obtained using NOISEMAP 6.5.

The entire suite encompassed by NOISEMAP 7.0 includes several different programs. The three primary IBM-compatible Personal Computer (PC)-based programs in the suite are BASEOPS 7.0, NMAP 7.0, and NMPLOT 4.2. BASEOPS is used to enter all aircraft operational data including number of flight and static events, flight and static profiles, flight tracks, etc. NMAP is the computational module. This module accepts the data entered in the BASEOPS program and estimates noise levels caused by aircraft events at many points on the ground in the airbase vicinity. NMPLOT is used to draw lines of equal noise level (noise contours) to determine the overall noise exposure and related environmental impacts[14].

The NMPLOT program draws contours of equal DNL for overlay onto land-use maps. For AICUZ studies, as a minimum, DNL contours of 65, 70, 75, and 80 dB are developed. Results of these computer programs and noise impact guidelines provide a relative measure of noise effects around air facilities[14].

NOISEMAP is most accurate for comparing "before-and-after" noise effects, which would result from proposed airfield changes or alternative noise control actions, when the calculations are made in a consistent manner. It allows noise predictions for such proposed actions without the actual implementation and noise monitoring of those actions[14].

2.0 Description of NAF Key West

NAF Key West, the U.S. Navy's premier pilot training facility for transient tactical aviation squadrons, is located on the Boca Chica Key, five (5) miles east of downtown Key West and 153 miles southwest of Miami, Florida. The NAF is served by one major arterial road, Route 1. The regional location of the NAF is depicted in Figure 2-1.

NAF Key West was first established as a naval base in 1823 in order to deter piracy acts in the area. It was established as a naval submarine base in 1917 and played a major role in both World Wars I and II. The NAF became a training facility after WWII and continues to provide training facilities and capabilities for transient aviation squadrons. In addition, the NAF, in conjunction with Coast Guard Group Key West, provides search and rescue services for the Gulf of Mexico and the Atlantic Ocean.[3]

NAF Key West comprises a total area of approximately 5,300 acres with facilities located in 13 different areas of the lower Florida Keys. Boca Chica Field, NAF Key West's primary site and airfield, is located on Boca Chica Key. Boca Chica Field is located approximately five miles east of the City of Key West. Boca Chica Field, as shown in Figure 2-2, consists of approximately 4,680 acres and encompasses nearly the entire Key. The areas surrounding the NAF consist of ocean waters and flat terrain.

The NAF has three runways. Runways 03-21 and 13-31 are 7,000 feet long and 150 feet wide. Runway 07-25 is 10,000 feet long and 200 feet wide. The NAF serves flight units from around the country. Under forecast CY07 conditions, military units are expected to use the NAF to conduct training operations using E-2/C-2, F/A-18, F-15, F-16, A-4 and a variety of other fighter jet and transport aircraft[5].

The airfield is typically in operation from 0700 to 2200 daily, except in observance of federal holidays. However, the airfield remains occasionally open to accommodate some nighttime operations after 2200. In 2001, the NAF reported that approximately 4 percent of the airfield operations took place after 2200 local time (mainly FCLP operations conducted by the E-2/C-2 aircraft per ATC's CY 2001 records). Following the extensive data collection effort conducted to derive forecast CY07 operations, the NAF is expected to accommodate approximately 6 percent of its forecast annual operations after 2200 local time.

The NAF is equipped with a sophisticated Tactical Aircrew Combat Training System (TACTS) and utilizes a TACAN (NQX) as a primary navigational aid. The elevation of the NAF is six (6) feet above mean sea level (MSL). The magnetic declination as of October 1998 is 3.3 degrees West. All maps in this report depict a north arrow pointing to true north.

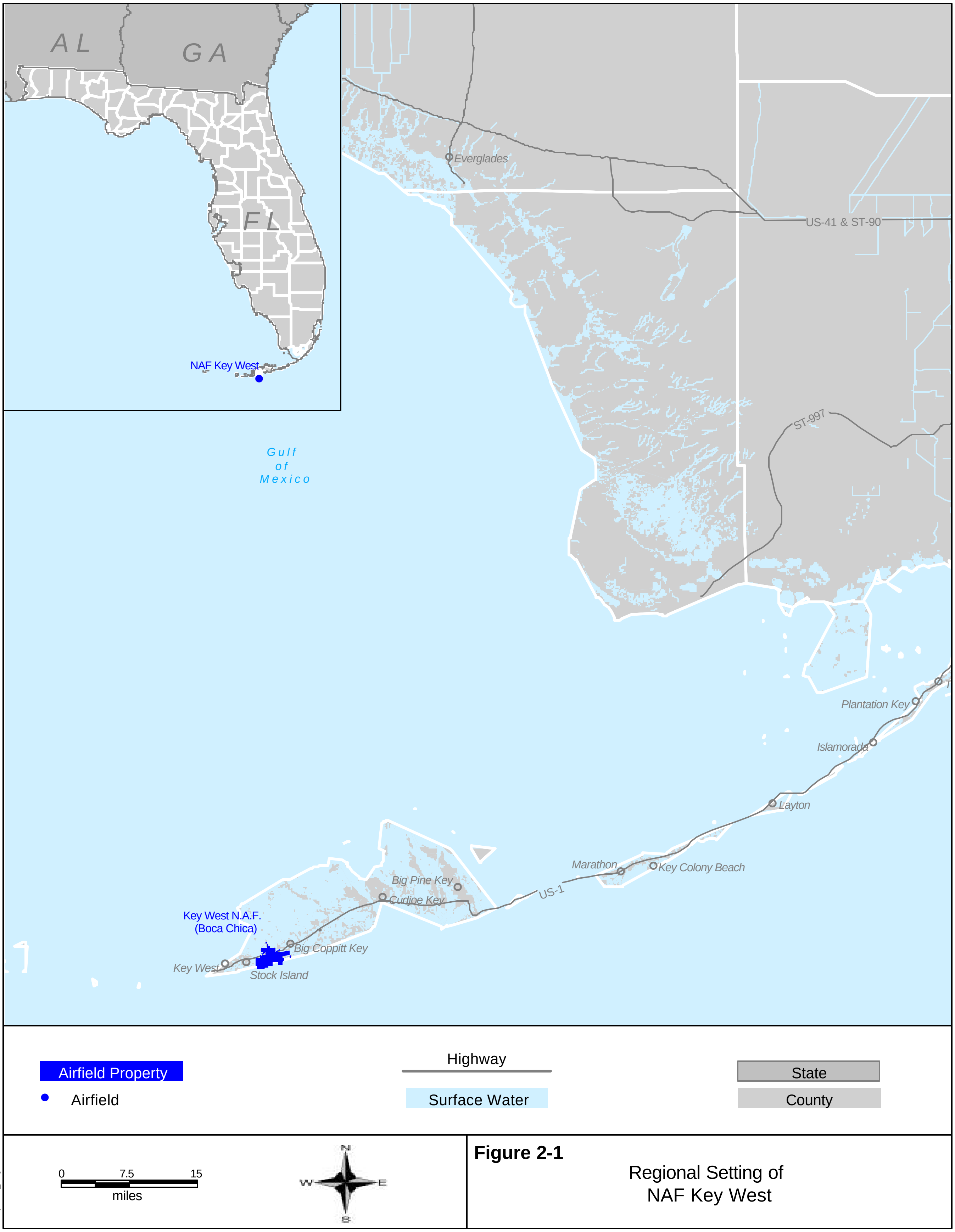

Figure 2-1

Regional Setting of NAF Key West

Source: USGS DRG and Color IR NHAPS Boca Chica - 1994/95, StreetInfo 1993, NMAP6.5

KeyWest_Region.Wor

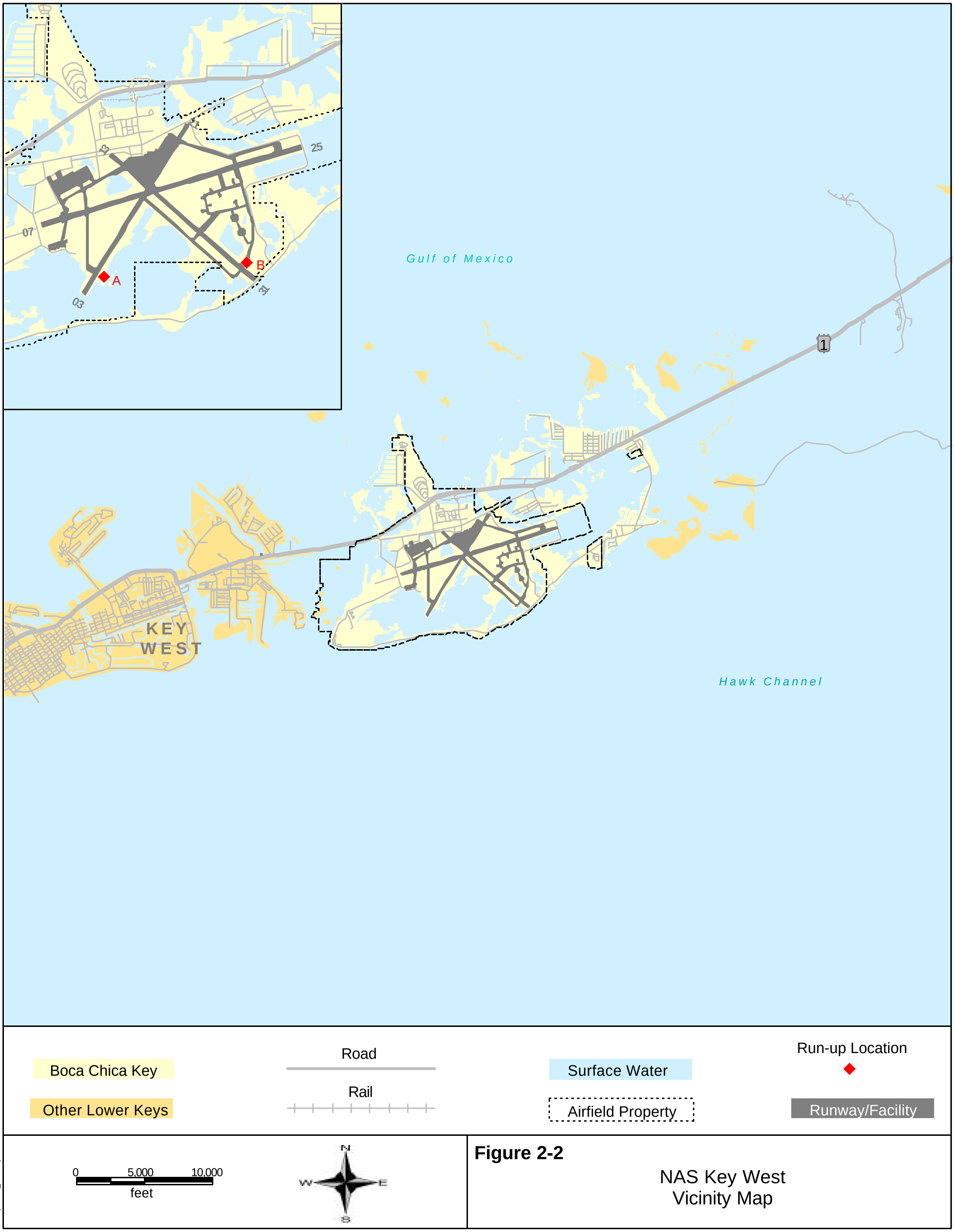

Figure 2-2

NAS Key West
Vicinity Map

KeyWest_Vicinity.Wor

Source: USGS DRG and Color IR NHAPS Boca Chica - 1994/95, StreetInfo 1993, NMAP6.5

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3.0 Forecast (CY07) Aircraft Operations and Noise Exposure

The future condition for NAF Key West is defined as airfield operations forecast to occur in CY07. Section 3.1 discusses reported Average Annual Day (AAD) flight operations and modeled AAD flight operations by aircraft type. Section 3.2 discusses runway and flight track utilization for all operations by aircraft type. Sections 3.3 and 3.4 describe aircraft flight profile and noise data and run-up operations, respectively. Section 3.5 discusses the resulting aircraft noise exposure.

3.1 Flight Operations

The first step in the noise modeling process is to obtain flight operation and airfield data. This began with an extensive data collection/solicitation effort directed by NAVFACENGCOM Southern Division to various military units expected to use the NAF in CY07. The study team examined historical aircraft loading data provided by the NAF. This data collection and validation effort concluded in December of 2002.[5] A site visit to NAF Key West was also conducted to collect/confirm data used in the modeling of forecast CY07 conditions. The recently completed analysis of existing CY01 conditions (see Wyle Research Report WR 02-19)[16] provided a basis for the analysis presented in this report. As a result, the data presented in this report was tailored to the conditions expected to occur at the NAF in CY07 based on the best information currently available to the NAF, its tenants, and its users. NAF Key West ATC and study participants provided these data in a summary format using a generic data package. Table 3-1 lists the reported overall annual operations for calendar years 1990 through 2001, as well as the 61,402 airfield operations forecast to occur in CY 2007.

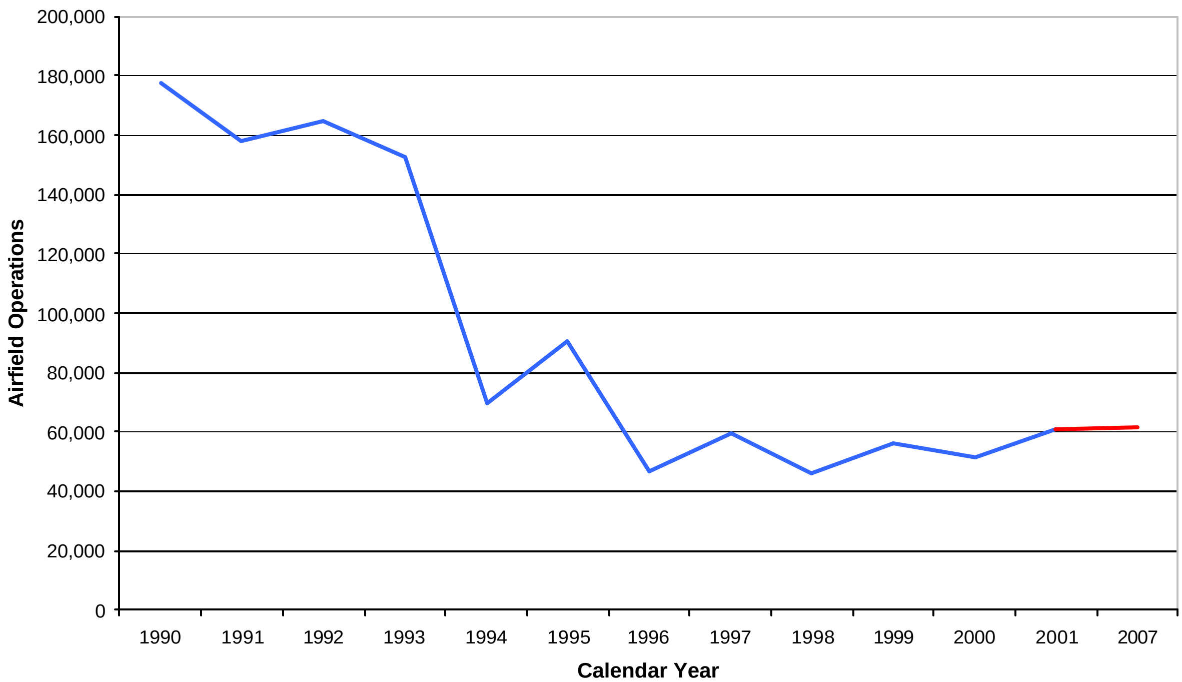
Table 3-1
Historical and Projected Airfield Flight Operations

Calendar Year	MILITARY*		CIVIL		TOTAL
	Navy/Marine	Other	Air Carrier	Gen. Aviation	
1990	89,966	24,334	27,400	35,975	177,675
1991	82,927	14,085	27,420	33,440	157,872
1992	78,246	22,093	28,899	35,315	164,553
1993	70,087	17,833	27,715	36,900	152,535
1994	53,855	12,637	508	2,306	69,306
1995	83,054	4,568	840	2,164	90,626
1996	40,484	2,814	1,417	2,282	46,997
1997	53,629	5,294	210	572	59,705
1998	41,198	4,518	36	334	46,086
1999	49,569	6,052	77	188	55,886
2000	47,485	3,873	50	145	51,553
2001	55,123	5,675	39	87	60,924
2007					**61,402**

* Total modeled airfield operations
Source: NAF Key West ATC, 2002

Figure 3-1 shows historical annual flight operations at the NAF for calendar years 1990 through 2001. This figure also presents a trend line extending to CY 2007. The figure illustrates the flow of annual flight operations with the combined total ranging between a low of 46,086 operations in 1998 and a high of 177,675 operations in 1990. The figure shows that the forecasting trend is that of stable increases in operational tempo in comparison to the 5-year average (from 1996 on) of 53,525, but still approximately 23 percent lower than the 10-year average (from 1992 on) of 79,817.

Figure 3-1. Historical Annual Flight Operations at NAF Key West and Forecasting Trend



ATC also provided the distribution of aircraft flight operations by aircraft type, operation type and daytime and nighttime periods[5]. Table 3-2 shows the distribution of the forecast 61,402 CY07 military aircraft operations at the NAF. Eighteen (18) aircraft types, in addition to other representative military transport and rotary-wing aircraft, are listed in Table 3-2 as provided through the CY07 data collection effort. The operation types are departure, straight-in full stop arrival, overhead break arrival, carrier-break arrival, Touch and Go, Field Carrier Landing Practice (FCLP), and Ground Controlled Approach (GCA) Box operations. A total of 3,925 operations, or approximately 6 percent of the total forecast airfield operations, are expected to be conducted during the nighttime period (2200 – 0700 local time) with nearly 31 percent of those nighttime operations forecast to be conducted by the F/A-18 E/F aircraft and about 57 percent by the E-2/C-2 turboprop aircraft. Table 3-2 shows the F/A-18 E/F, the E-2/C-2, and the F/A-18 C/D aircraft being the top three operations contributors for CY01, in that order, with a combined total of 45,518 operations or approximately 74 percent of the total forecast annual airfield operations. Of all forecast airfield operations, pattern operations are estimated to total 17,316 in CY07 with 63 percent of those operations being attributed to the E-2/C-2 aircraft as FCLP operations.[5]

As agreed to by NAVFACENGCOM Southern Division, a screening procedure was used to determine the aircraft types that would not significantly contribute to the overall aircraft noise environment in terms of equivalent daily operations (EDO)* and generalized departure noise levels. The procedure included grouping aircraft types that are similar in noise output and/or configuration while modeling the total reported number of annual operations. This screening procedure uses overflight NOISEMAP data to assess the specific noise contribution of each reported aircraft type based on forecast CY07 airfield operations. Using this overflight noise data, DNL noise levels are calculated for each reported aircraft type at a point where the aircraft is operating at 1,000 feet from the receiver. These DNL values are then compared and a ranking of the noise contributors is derived.

For NAF Key West, the F/A-18 (C/D and E/F) aircraft is the most dominant aircraft in terms of forecast DNL impact at the NAF (99.7 percent of the DNL contributions). In addition, the modeling of the top five noise contributors at the NAF would represent 99.9 percent of the total DNL impact forecast for the NAF under CY07 conditions.

Figure 3-2 shows the noise contributions of each of the reported CY07 aircraft. Per this figure, the top five noise contributors for CY01 operations, in descending order, are: F/A-18E/F, F/A-18C/D, A-4, F-15, and F-5 aircraft. In Figure 3-2, the red line represents a level that is 10 dB lower than the highest aircraft noise contribution expressed in terms of DNL. Therefore, out of all the aircraft types listed in Table 3-2, seventeen (17) aircraft contribute DNL noise levels that are 10 dB lower than the highest contributor (F/A-18E/F). This, once again, demonstrates the dominant contribution of the F/A-18 C/D/E/F aircraft to the DNL noise exposure at the NAF.

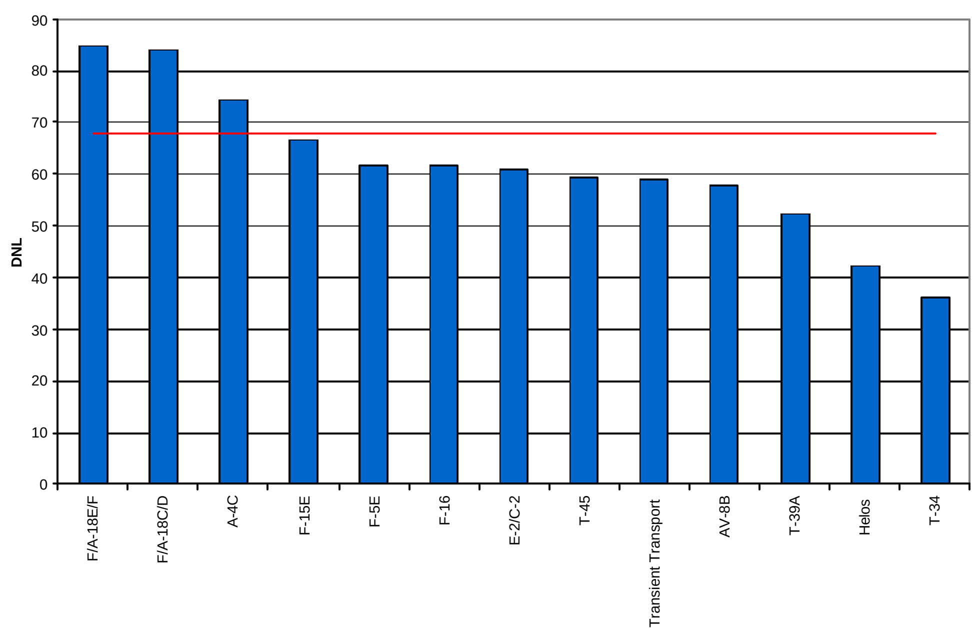


Figure 3-2. Results of Noise Sensitivity Analysis: DNL Noise Contributions of Individual Aircraft Types Forecast for CY07 Conditions at NAF Key West

* Equivalent daily operations represent the daytime operations plus ten times the nighttime operations.

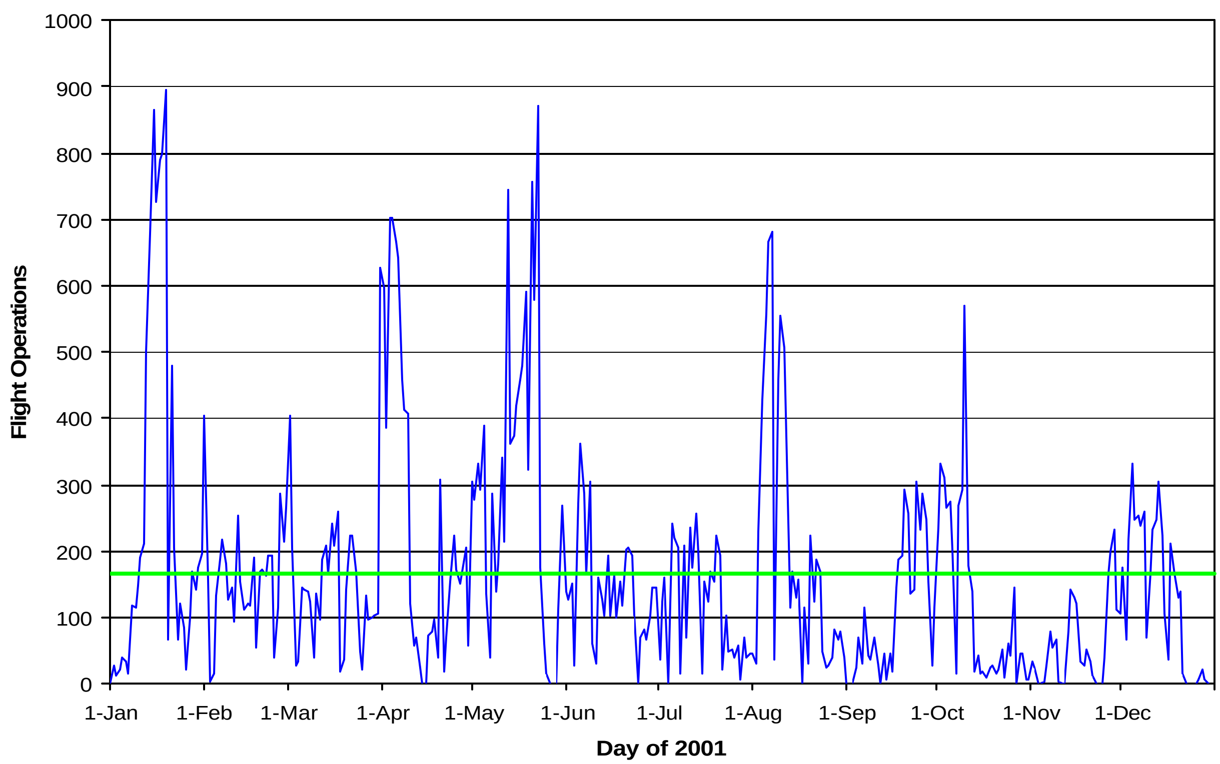
Based on the noise sensitivity analysis discussed above and illustrated in Figure 3-2, as well as consultations with NAVFACENGCOM Southern Division and the NAF, this study uses the aircraft substitutions described below to capture all the forecast aircraft operations while modeling the most significant noise contributors. As a result, many fighter jet aircraft and jet trainers were grouped and modeled as A-4C, many transient transport aircraft were grouped and modeled as C-9A, and helicopters were grouped and modeled as SH-60.

CY07 Aircraft Substitutions			
F/A-18C/D	Each Aircraft Type Modeled Individually	Helicopters	Grouped and Modeled as SH-60
F/A-18E/F		SH-60	
F-15E		SH-65	
F-5E		CH-3	
F-16		A-4C	Grouped and Modeled as A-4
E-2/C-2	Grouped and Modeled as E-2	T-2C	
P-3A		EA-6B	
C-12		T-45	
T-34		T-39A	
C-9A	Grouped with Other Transient Transport Aircraft and Modeled as C-9	T-1	
C-5A		AV-8B	
KC-10A		LearJet	
KC-135		G-1	
Boeing 707		A-10	

Table 3-3 shows the operations of the modeled representative aircraft types. As stated previously, all forecast CY07 aircraft operations (61,402) were modeled. Thus, reported operations for those aircraft that were not modeled were grouped with modeled aircraft based on equivalent noise contributions as shown above

In accordance with aircraft noise surveys conducted by NAVFACENGCOM, noise exposure is presented for Average Annual Day (AAD) flight operations over a period of one year. This study uses AAD as the basis for the modeling of forecast CY07 airfield operations. Figure 3-3 shows the daily tempo of flight operations for CY01 (see WR 02-19).[16] CY01 AAD operational tempo is expected to be comparable to that expected for forecast CY07. The green line in Figure 3-3 shows the AAD level of flight operations for CY01 (167). The forecast AAD level for CY07 is approximately 168 operations a day.

Figure 3-3. CY01 AAD Tempo of Flight Operations at NAF Key West



In order to determine the modeled daily events for forecast CY07, the following calculation was used: the total operations per aircraft per flight track were divided by 365 days to yield the AAD number of events.

3.2 Runway and Flight Track Utilization

The next step in the noise modeling process is to assign the flight operations to runways and to flight tracks. This is accomplished through the use of runway utilization percentages for each operation type. Flight track utilization percentages are also used for those operation types on runways where multiple flight tracks occur. The modeled runway utilization percentages, as provided by the NAF ATC personnel, are contained in Table 3-4.[5] Note that the percentages are dependent upon aircraft type, operation type and time of day. In addition, the runway utilization percentages are the same for all modeled aircraft except for the E-2/C-2 aircraft and the rotary-wing aircraft, which use the airfield in a slightly different manner. Per Table 3-4, Runway 07 is the dominant runway except when conducting FCLP pattern and GCA Box operations.

Table 3-4
Daytime and Nighttime Runway Utilization Percentages for Forecast CY07

Operation Type	Runway	E-2/C-2		Helos		Fixed-Wing	
		0700-2200	2200-0700	0700-2200	2200-0700	0700-2200	2200-0700
Departure	03	11%	50%			11%	11%
	07	49%		25%	25%	49%	49%
	13	32%	50%	25%	25%	32%	32%
	21	1%				1%	1%
	25	5%		50%	50%	5%	5%
	31	2%				2%	2%
"Straight-in" Full-Stop Arrivals	03	11%	11%	25%	25%	11%	15%
	07	69%	69%			69%	71%
	13	6%	6%	25%	25%	6%	8%
	21	3%	3%	25%	25%	3%	
	25	8%	8%			8%	3%
	31	3%	3%	25%	25%	3%	3%
Overhead Breaks (1500')	03	11%	65%			11%	65%
	07	49%				49%	
	13	32%	35%			32%	35%
	21	1%				1%	
	25	5%				5%	
	31	2%				2%	
Carrier Breaks (800')	03	40%	65%				65%
	07	20%				100%	
	13	40%	35%				35%
	21						
	25						
	31						
Touch and Go	03	11%				11%	
	07	49%				49%	
	13	32%				32%	
	21	1%				1%	
	25	5%				5%	
	31	2%				2%	
FCLP	03	45%	45%			45%	45%
	07	10%	10%			10%	10%
	13	45%	45%			45%	45%
	21						
	25						
	31						
GCA Box	03	75%	91%			75%	91%
	07						
	13	7%	9%			7%	9%
	21	3%				3%	
	25	10%				10%	
	31	5%				5%	

Flight track utilization percentages, listed in Table 3-5, were provided by ATC for use in the modeling forecast CY07 conditions and validated in December of 2002. Most operation types have multiple flight tracks. Approximately half of the aircraft departing from the NAF depart to the north-northwest to conduct military training exercises in the training areas northeast of the airfield. Most aircraft performing an overhead break or a straight-in to a full-stop arrival, arrive on Runway 07 using a track which approaches from the southwest and joins a straight-in final at about 2.2 DME (see Figure 3-5).

Touch and go patterns are standard for all aircraft. Input for the Touch & Go patterns modeled for other aircraft types, including the F/A-18, was obtained during the November 2001 data collection effort conducted for NAS Oceana and NALF Fentress and augmented by input obtained from NAF Key West ATC during the on-site data collection meeting of December 2002. Traffic at NAF Key West perform left turns when conducting Touch & Go and GCA Box operations on all runways, except Runway 03, at pattern altitudes of 1,000 feet and 1,500 feet, respectively (F/A-18 and F-14 aircraft conduct Touch & Go operations the same way they conduct FCLPs at a 600-foot pattern altitude).

Furthermore, Wyle personnel observed pattern operations from the ATC Tower and verified the input modeled for this study. It is expected, as reported by the military units surveyed under this effort, that FCLP operations at the NAF during CY07 will be conducted by the E-2/C-2, F/A-18C/D, and F/A-18E/F aircraft at a traffic pattern altitude of 600 feet on Runways 03, 07, and 13. There are three FCLP flight tracks per runway, and all FCLPs use a left-hand pattern. For overhead break arrivals, there is only one flight track per runway. All runways are used for overhead arrivals, with a notable 49 percent being conducted to Runway 07. Two types of overhead procedures are conducted at the NAF: one with a break altitude of 1,500 feet (75 percent of total overheads) and the other with a break altitude of 800 feet (25 percent of total overheads). The latter procedure is also known as a carrier-break arrival. The overhead-break and carrier-break arrival tracks were updated based on input received from the NAF and augmented by the data obtained in November 2001 from NAS Oceana and NALF Fentress as directed by NAVFACENGCOM. This data was, in turn, validated in December 2002 at NAF Key West.

The tracks listed in Table 3-5 are shown in Figures 3-4 through 3-9. These tracks represent typical average daily conditions at the NAF. Figure 3-4 shows the departure flight tracks. Figure 3-5 depicts the “straight-in” arrival flight tracks. Note that track 07A1 intersects runway heading approximately 1.1 nautical miles (nm) from the approach end of Runway 07. Figure 3-6 shows the overhead-break and carrier-break arrival flight tracks. The abeam distances for all overhead flight tracks is 8,000 feet (1.3 nm). Figure 3-7 shows touch and go flight tracks. The length of the downwind leg on the touch and go patterns is 12,000 feet. The FCLP flight tracks of Figure 3-8 are illustrated in sets of three tracks per runway with varying upwind and crosswind leg lengths. The abeam distance on same-runway FCLP tracks is 8,000 feet or 1.3 nm. Lastly, Figure 3-9 contains the GCA Box pattern flight tracks. The GCA tracks are 4-5 nm wide and extend over a downwind distance of 8-10 nm.

Table 3-5
Modeled Flight Track Utilization Percentages for Forecast CY07 Conditions

Operation Type	Runway	Flight Track	C-9A		F-16		F-15E	
			0700-2200	2200-0700	0700-2200	2200-0700	0700-2200	2200-0700
Departure	03	03D1	5%	5%	5%	5%	5%	5%
		03D2	80%	80%	80%	80%	80%	80%
		03D3	15%	15%	15%	15%	15%	15%
	07	07D1	5%	5%	5%	5%	5%	5%
		07D2	80%	80%	80%	80%	80%	80%
		07D3	15%	15%	15%	15%	15%	15%
	13	13D1	100%	100%	100%	100%	100%	100%
	21	21D1	100%	100%	100%	100%	100%	100%
	25	25D1	50%	50%	50%	50%	50%	50%
		25D2	50%	50%	50%	50%	50%	50%
	31	31D1	100%	100%	100%	100%	100%	100%
Straight-In Arrivals	03	03A1	100%	100%	100%	100%	100%	100%
	07	07A1	100%	100%	100%	100%	100%	100%
	13	13A1	100%	100%	100%	100%	100%	100%
	21	21A1	100%	100%	100%	100%	100%	100%
	25	25A1	100%	100%	100%	100%	100%	100%
	31	31A1	100%	100%	100%	100%	100%	100%
Overhead Break (1500')	03	03O1	100%		100%		100%	
	07	07O1	100%		100%		100%	
	13	13O1	100%		100%		100%	
	21	21O1	100%		100%		100%	
	25	25O1	100%		100%		100%	
	31	31O1	100%		100%		100%	
Carrier Break (800')	03	03O1			100%			
	07	07O1			100%			
	13	13O1			100%			
	21	21O1			100%			
	25	25O1			100%			
	31	31O1			100%			
Touch & Go	03	03T2	100%		100%		100%	
	07	07T2	100%		100%		100%	
	13	13T2	100%		100%		100%	
	21	21T2	100%		100%		100%	
	25	25T2	100%		100%		100%	
	31	31T2	100%		100%		100%	
FCLP	03	03F1						
		03F2						
		03F3						
	07	07F1						
		07F2						
		07F3						
	13	13F1						
		13F2						
		13F3						
GCA Box Pattern	03	03G1	100%		100%		100%	
	07	07G1						
	13	13G1	100%		100%		100%	
	21	21G1	100%		100%		100%	
	25	25G1	100%		100%		100%	
	31	31G1	100%		100%		100%	

Source: NAF Key West ATC, 2002

Table 3-5
Modeled Flight Track Utilization Percentages for Forecast CY07 Conditions (cont'd)

Operation Type	Runway	Flight Track	A-4C		F/A-18CD		F/A-18EF	
			0700-2200	2200-0700	0700-2200	2200-0700	0700-2200	2200-0700
Departure	03	03D1	5%	5%	5%	5%	5%	5%
		03D2	80%	80%	80%	80%	80%	80%
		03D3	15%	15%	15%	15%	15%	15%
	07	07D1	5%	5%	5%	5%	5%	5%
		07D2	80%	80%	80%	80%	80%	80%
		07D3	15%	15%	15%	15%	15%	15%
	13	13D1	100%	100%	100%	100%	100%	100%
	21	21D1	100%	100%	100%	100%	100%	100%
	25	25D1	50%	50%	50%	50%	50%	50%
		25D2	50%	50%	50%	50%	50%	50%
	31	31D1	100%	100%	100%	100%	100%	100%
Straight-In Arrivals	03	03A1	100%	100%	100%	100%	100%	100%
	07	07A1	100%	100%	100%	100%	100%	100%
	13	13A1	100%	100%	100%	100%	100%	100%
	21	21A1	100%	100%	100%	100%	100%	100%
	25	25A1	100%	100%	100%	100%	100%	100%
	31	31A1	100%	100%	100%	100%	100%	100%
Overhead Break (1500')	03	03O1	100%	100%	100%	100%	100%	100%
	07	07O1	100%	100%	100%	100%	100%	100%
	13	13O1	100%	100%	100%	100%	100%	100%
	21	21O1	100%	100%	100%	100%	100%	100%
	25	25O1	100%	100%	100%	100%	100%	100%
	31	31O1	100%	100%	100%	100%	100%	100%
Carrier Break (800')	03	03O1	100%	100%	100%	100%	100%	100%
	07	07O1	100%	100%	100%	100%	100%	100%
	13	13O1	100%	100%	100%	100%	100%	100%
	21	21O1	100%	100%	100%	100%	100%	100%
	25	25O1	100%	100%	100%	100%	100%	100%
	31	31O1	100%	100%	100%	100%	100%	100%
Touch & Go	03	03T2	100%	100%	100%		100%	
	07	07T2	100%	100%	100%		100%	
	13	13T2	100%	100%	100%		100%	
	21	21T2	100%	100%	100%		100%	
	25	25T2	100%	100%	100%		100%	
	31	31T2	100%	100%	100%		100%	
FCLP	03	03F1	34%	34%	34%	34%	34%	34%
		03F2	33%	33%	33%	33%	33%	33%
		03F3	33%	33%	33%	33%	33%	33%
	07	07F1	34%	34%	34%	34%	34%	34%
		07F2	33%	33%	33%	33%	33%	33%
		07F3	33%	33%	33%	33%	33%	33%
	13	13F1	34%	34%	34%	34%	34%	34%
		13F2	33%	33%	33%	33%	33%	33%
		13F3	33%	33%	33%	33%	33%	33%
GCA Box Pattern	03	03G1	100%	100%	100%	100%	100%	100%
	07	07G1						
	13	13G1	100%	100%	100%	100%	100%	100%
	21	21G1	100%		100%		100%	
	25	25G1	100%		100%		100%	
	31	31G1	100%		100%		100%	

Source: NAF Key West, 2002

Table 3-5
Modeled Flight Track Utilization Percentages for Forecast CY07 Conditions (concluded)

Operation Type	Runway	Flight Track	E-2/C-2		F-5E		Helos	
			0700-2200	2200-0700	0700-2200	2200-0700	0700-2200	2200-0700
Departure	03	03D1	5%		5%	5%		
		03D2	80%	100%	80%	80%		
		03D3	15%		15%	15%		
	07	07D1	5%		5%	5%		
		07D2	80%		80%	80%	100%	100%
		07D3	15%		15%	15%		
	13	13D1	100%	100%	100%	100%	100%	100%
	21	21D1	100%		100%	100%		
	25	25D1	50%		50%	50%	50%	50%
		25D2	50%		50%	50%	50%	50%
	31	31D1	100%		100%	100%		
Straight-In Arrivals	03	03A1	100%	100%	100%	100%	100%	100%
	07	07A1	100%	100%	100%	100%		
	13	13A1	100%	100%	100%	100%	100%	100%
	21	21A1	100%	100%	100%	100%	100%	100%
	25	25A1	100%	100%	100%	100%		
	31	31A1	100%	100%	100%	100%	100%	100%
Overhead Break (1500')	03	03O1	100%	100%	100%			
	07	07O1	100%	100%	100%			
	13	13O1	100%	100%	100%			
	21	21O1	100%	100%	100%			
	25	25O1	100%	100%	100%			
	31	31O1	100%	100%	100%			
Carrier Break (800')	03	03O1	100%	100%	100%			
	07	07O1	100%	100%	100%			
	13	13O1	100%	100%	100%			
	21	21O1	100%	100%	100%			
	25	25O1	100%	100%	100%			
	31	31O1	100%	100%	100%			
Touch & Go	03	03T2	100%	100%	100%			
	07	07T2	100%	100%	100%			
	13	13T2	100%	100%	100%			
	21	21T2	100%	100%	100%			
	25	25T2	100%	100%	100%			
	31	31T2	100%	100%	100%			
FCLP	03	03F1	34%	34%				
		03F2	33%	33%				
		03F3	33%	33%				
	07	07F1	34%	34%				
		07F2	33%	33%				
		07F3	33%	33%				
	13	13F1	34%	34%				
		13F2	33%	33%				
		13F3	33%	33%				
GCA Box Pattern	03	03G1	100%	100%	100%			
	07	07G1						
	13	13G1	100%	100%	100%			
	21	21G1	100%		100%			
	25	25G1	100%		100%			
	31	31G1	100%		100%			

Source: NAF Key West, 2002

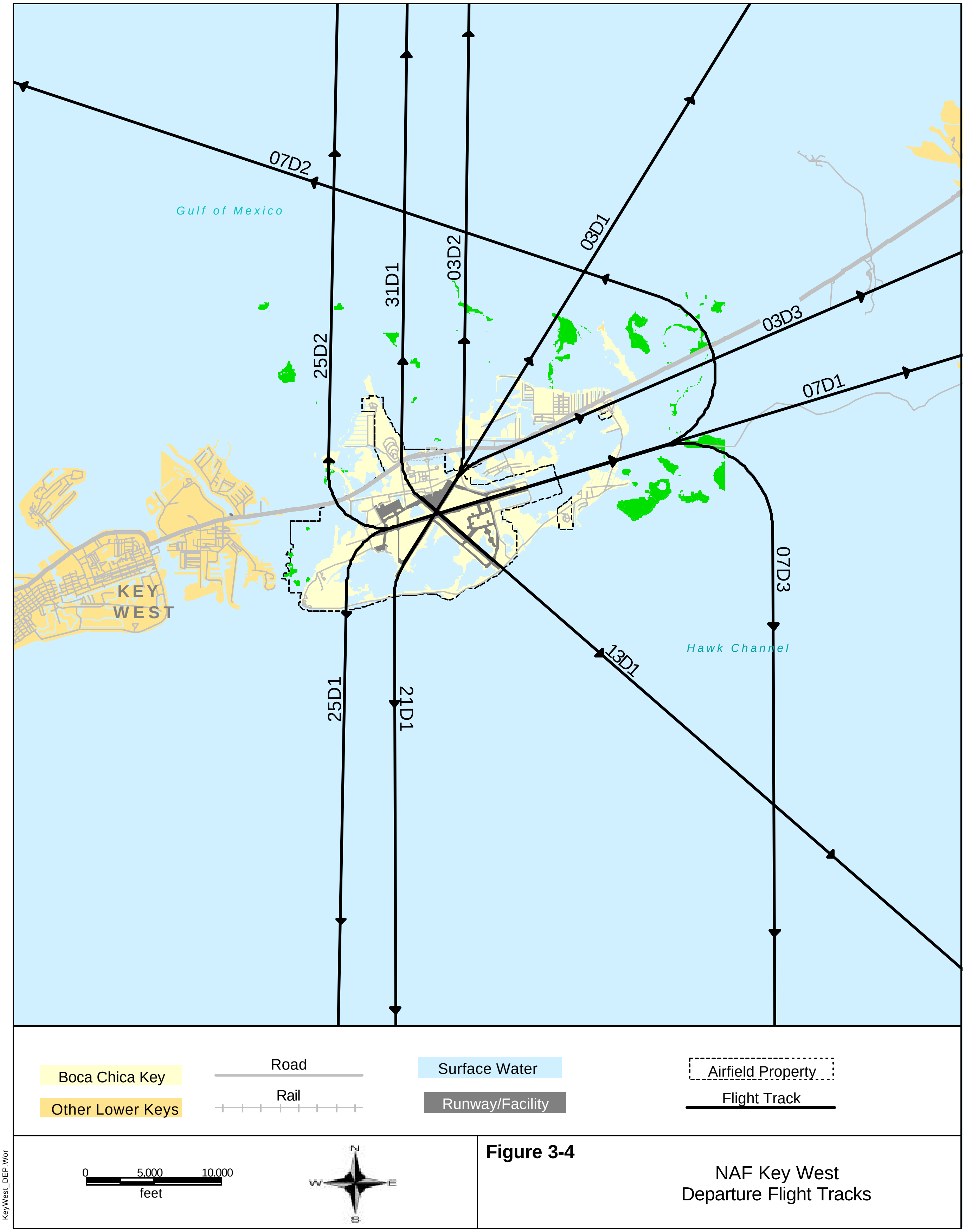


Figure 3-4

NAF Key West
Departure Flight Tracks

Source: USGS DRG and Color IR NHAPS Boca Chica - 1994/95, StreetInfo 1993

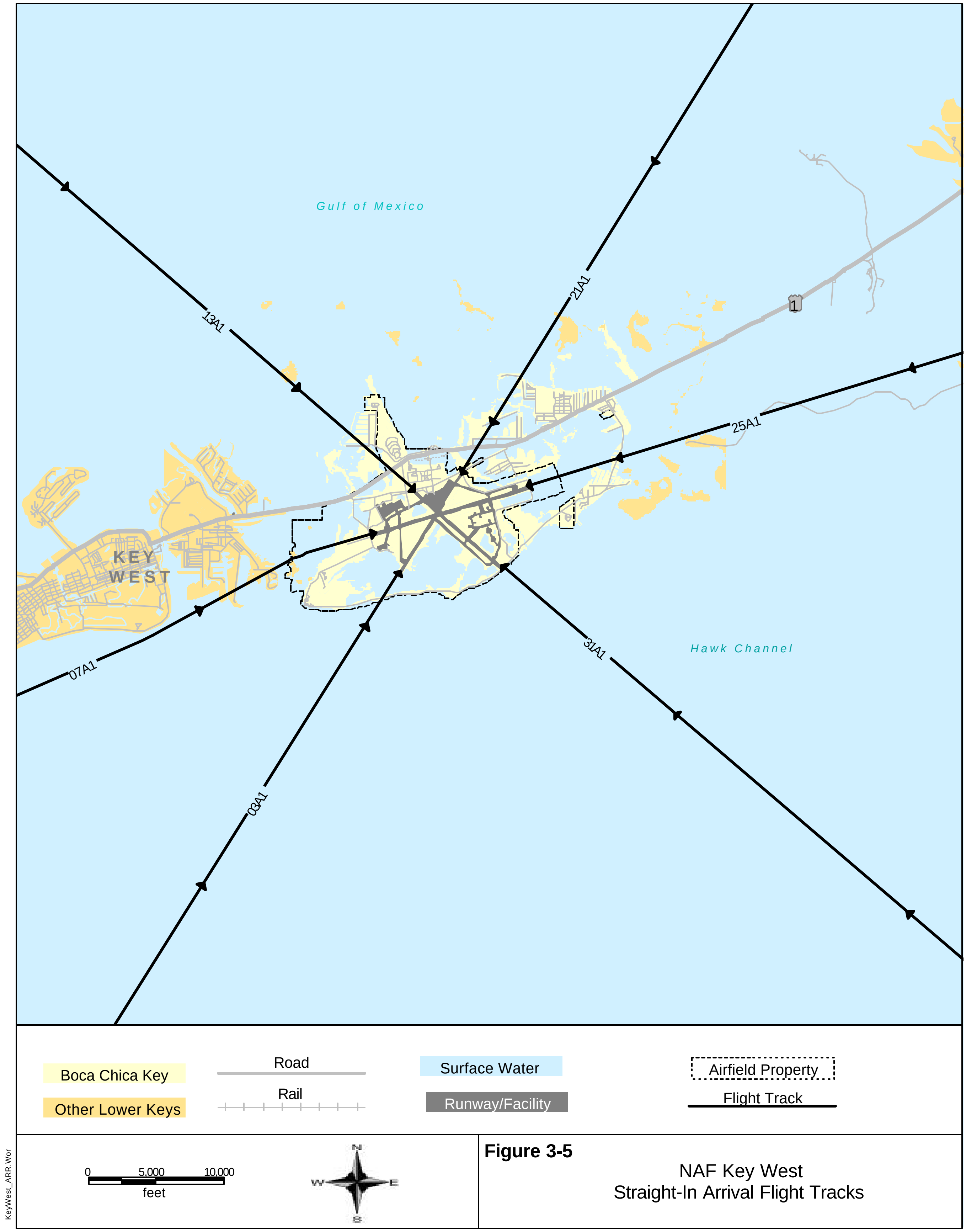


Figure 3-5

NAF Key West
Straight-In Arrival Flight Tracks

Source: USGS DRG and Color IR NHAPS Boca Chica - 1994/95, StreetInfo 1993

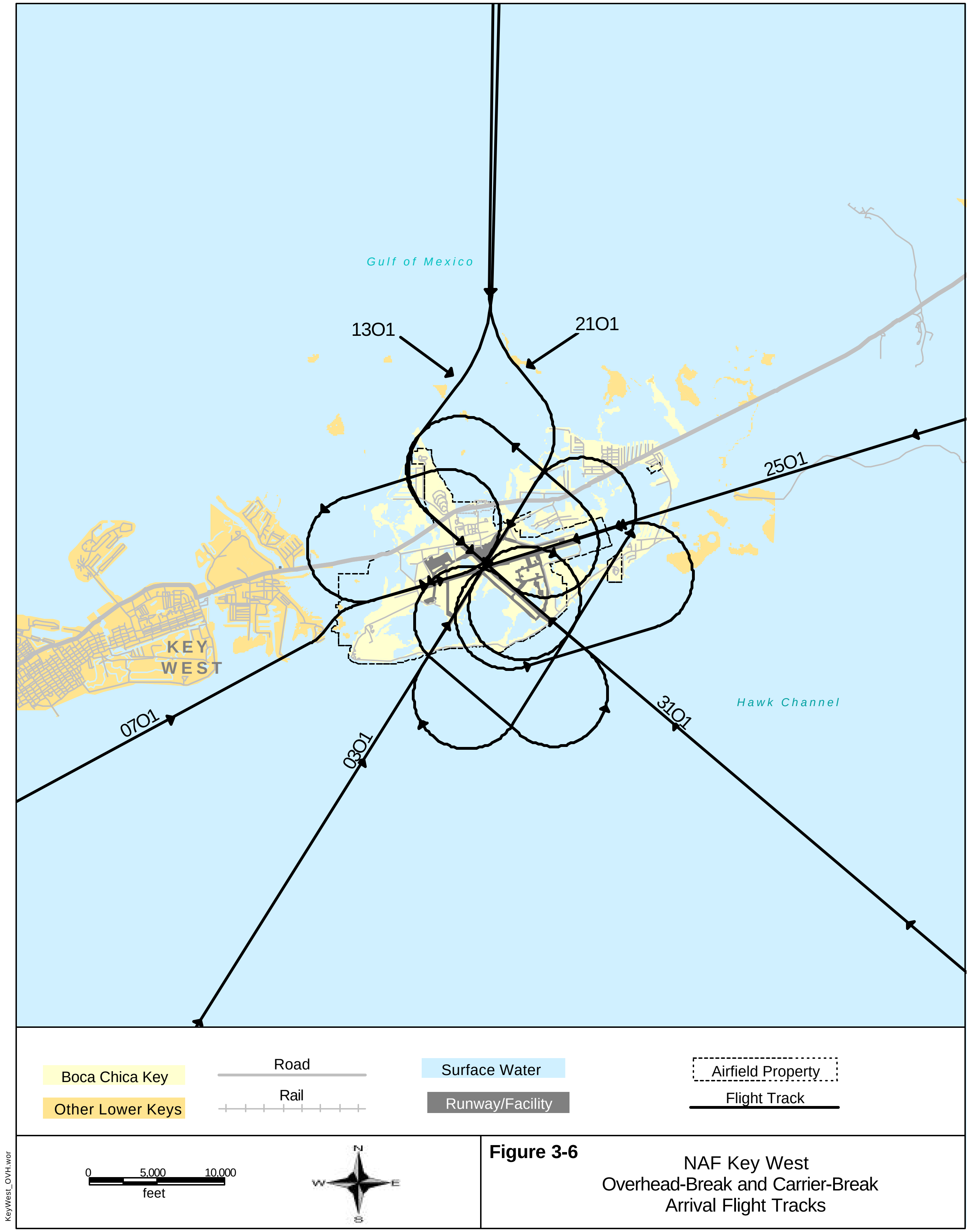


Figure 3-6
NAF Key West
Overhead-Break and Carrier-Break
Arrival Flight Tracks

Source: USGS DRG and Color IR NHAPS Boca Chica - 1994/95, StreetInfo 1993

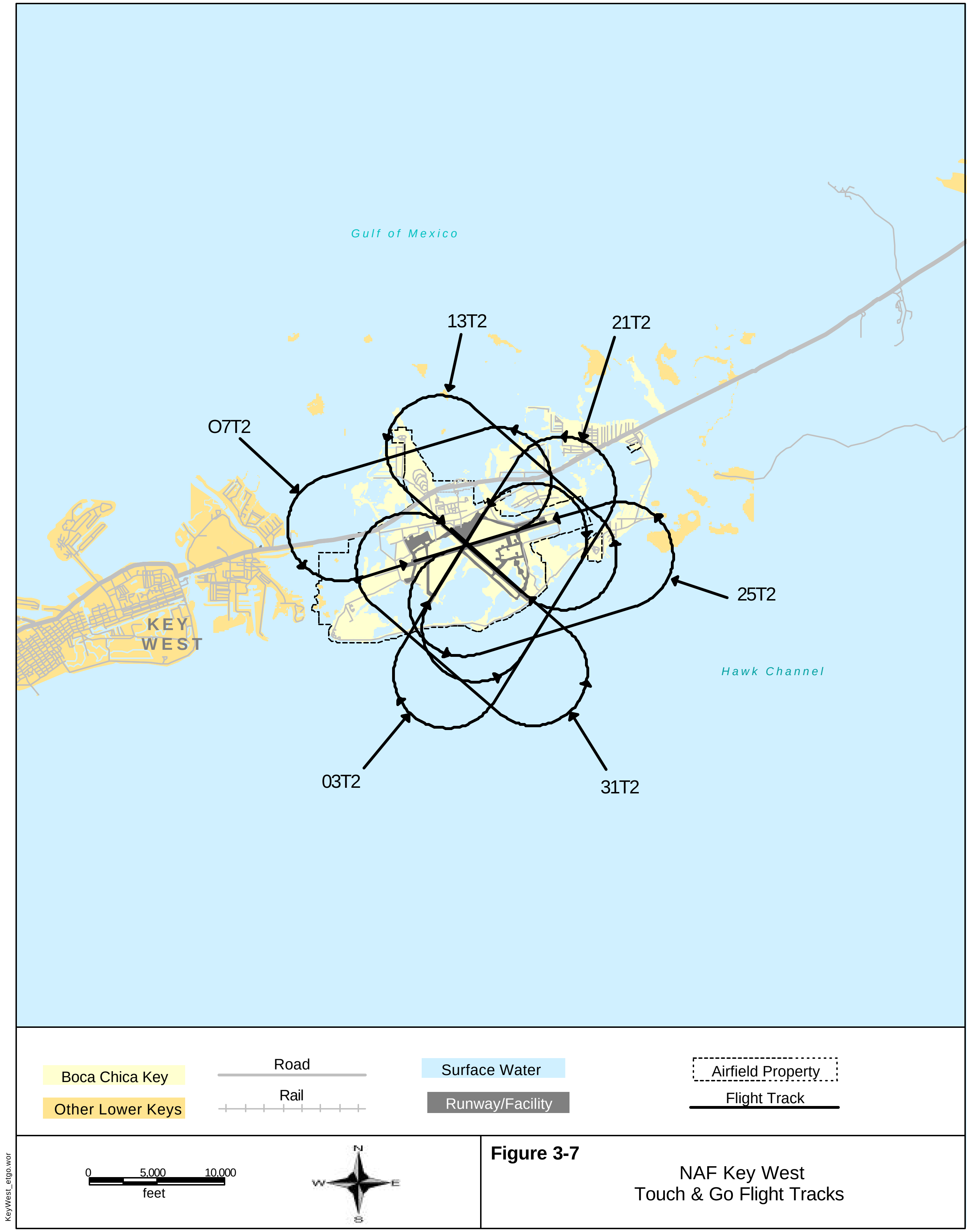


Figure 3-7 NAF Key West Touch & Go Flight Tracks

Source: USGS DRG and Color IR NHAPS Boca Chica - 1994/95, StreetInfo 1993

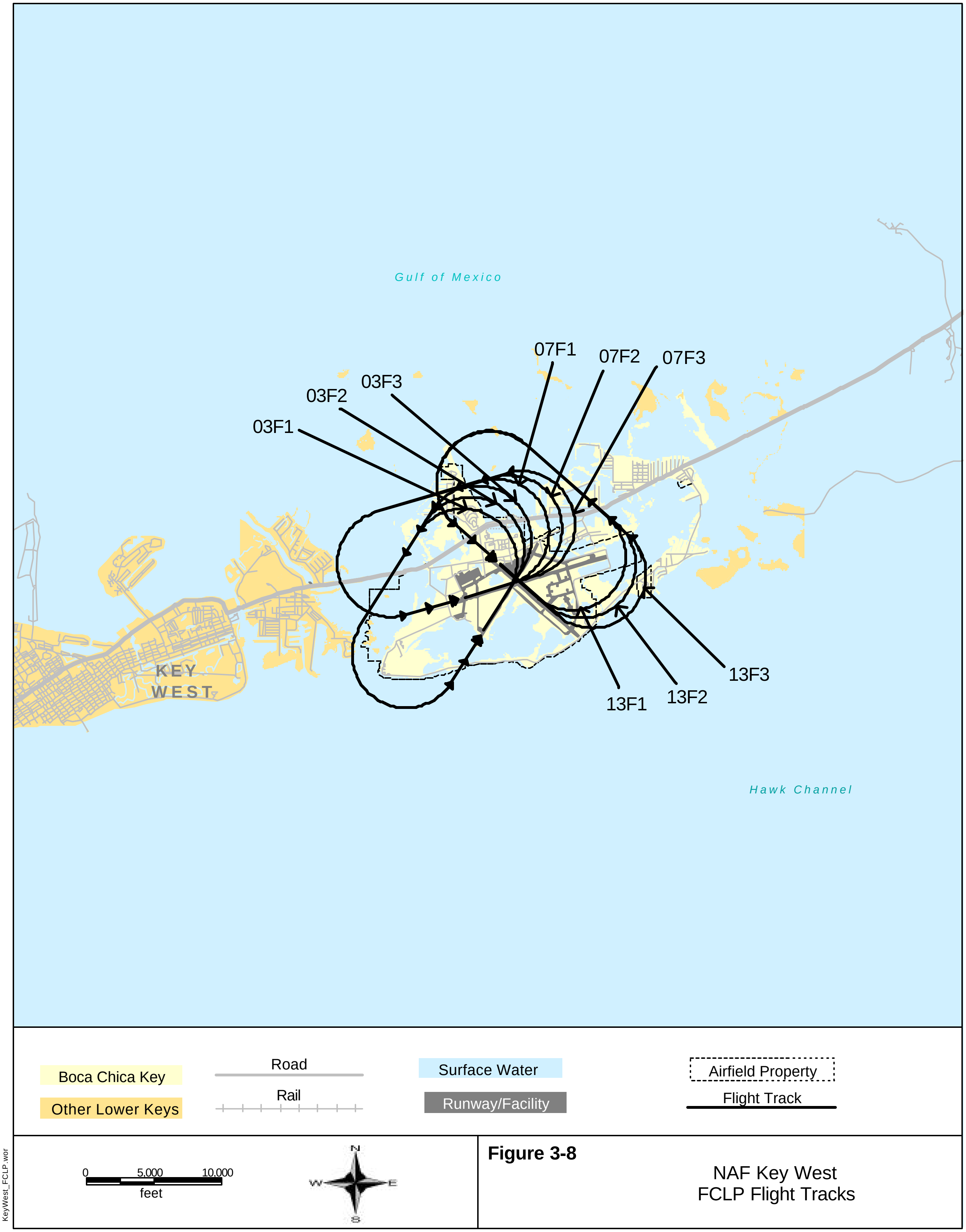
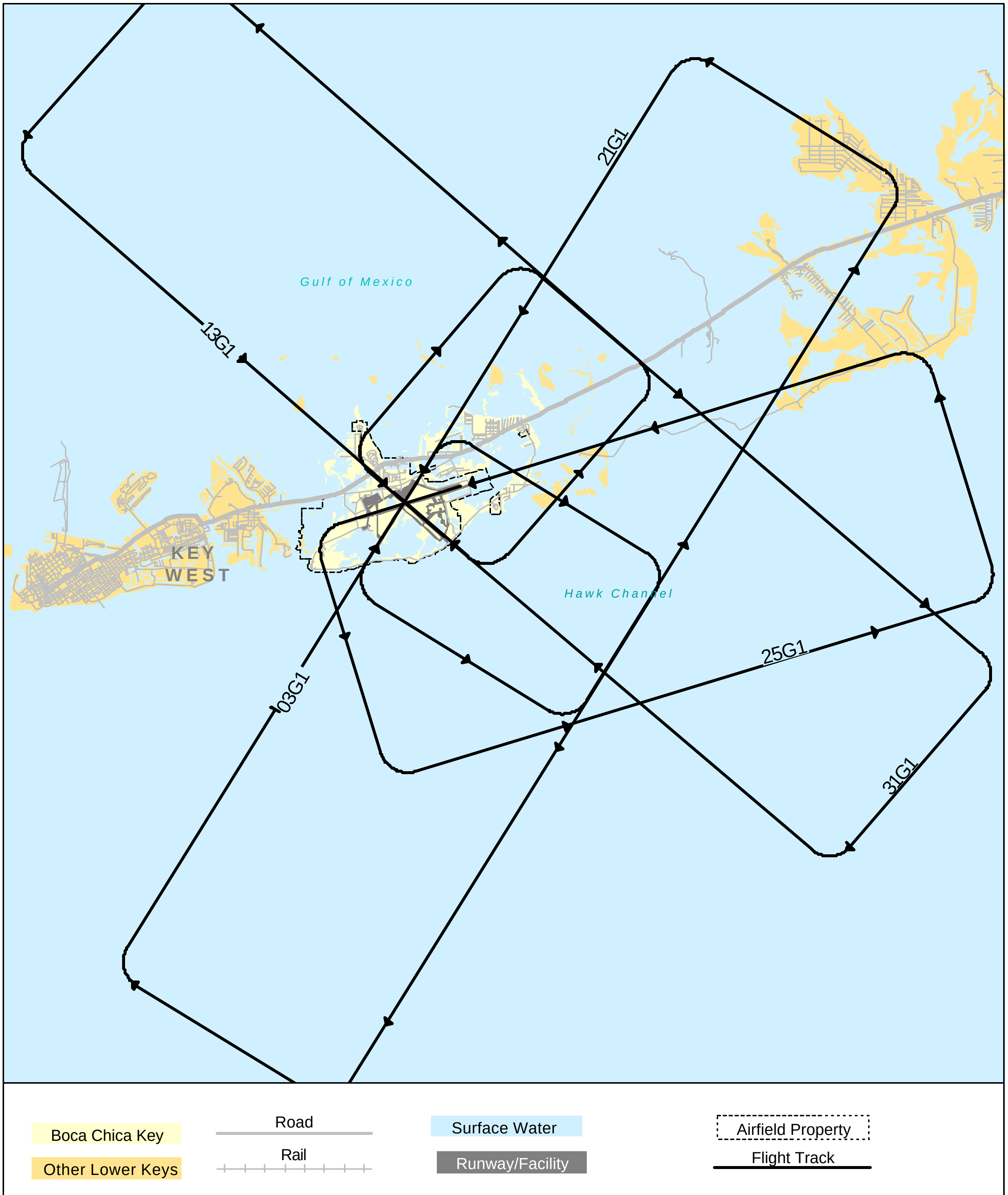


Figure 3-8

NAF Key West
FCLP Flight Tracks

Source: USGS DRG and Color IR NHAPS Boca Chica - 1994/95, StreetInfo 1993



KeyWest_gca.wor

0 7,500 15,000
feet

N W E S

Figure 3-9

NAF Key West
GCA Box Flight Tracks

Source: USGS DRG and Color IR NHAPS Boca Chica - 1994/95, StreetInfo 1993

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Multiplying the annual operations in Table 3-3 by the runway and track utilization percentages in Tables 3-5 and 3-6 and dividing by 365 days allows for the computation of the modeled AAD daytime and nighttime events by flight track for each aircraft category as shown in Table 3-6, rounded to the nearest 0.01 event. Table 3-6 yields a total of 168 modeled AAD events at the NAF for forecast CY07 conditions. A large portion of the modeled nighttime flight operations are expected to be conducted by the E-2/C-2 (~57%) and the F/A-18E/F (~30%) aircraft.

Table 3-6. Modeled CY07 AAD Aircraft Operations at NAF Key West

Operation Type	Runway	Flight Track	C-9A		F-16		F-15E	
			0700-2200	2200-0700	0700-2200	2200-0700	0700-2200	2200-0700
Departure	03	03D1	0.03	0.00	0.01		0.01	
		03D2	0.45	0.00	0.11		0.10	
		03D3	0.08	0.00	0.02		0.02	
	07	07D1	0.12	0.00	0.03		0.03	
		07D2	1.99	0.01	0.50		0.45	
		07D3	0.37	0.00	0.09		0.08	
	13	13D1	1.63	0.01	0.41		0.37	
	21	21D1	0.05	0.00	0.01		0.01	
	25	25D1	0.13	0.00	0.03		0.03	
		25D2	0.13	0.00	0.03		0.03	
	31	31D1	0.10	0.00	0.03		0.02	
	TOTAL		5.08	0.02	1.29		1.15	
Straight-In Arrivals	03	03A1	0.60	0.02	0.05		0.04	
	07	07A1	3.75	0.08	0.32		0.23	
	13	13A1	0.33	0.01	0.03		0.02	
	21	21A1	0.16		0.01		0.01	
	25	25A1	0.43	0.00	0.04		0.03	
	31	31A1	0.16	0.00	0.01		0.01	
	TOTAL		5.43	0.12	0.47		0.33	
Overhead Break (1500')	03	03O1	0.01					
	07	07O1	0.03		0.82		0.82	
	13	13O1	0.02					
	21	21O1	0.00					
	25	25O1	0.00					
	31	31O1	0.00					
	TOTAL		0.05		0.82		0.82	
Carrier Break (800')	03	03O1						
	07	07O1						
	13	13O1						
	21	21O1						
	25	25O1						
	31	31O1						
	TOTAL							
Touch & Go	03	03T2	0.14					
	07	07T2	0.63					
	13	13F2	0.41					
	21	21T2	0.01					
	25	25T2	0.06					
	31	31T2	0.03					
	TOTAL		1.28					
FCLP	03	03F1						
		03F2						
		03F3						
	07	07F1						
		07F2						
		07F3						
	13	13F1						
		13F2						
		13F3						
	TOTAL							
GCA Pattern	03	03G1	0.60		0.12		0.12	
	07	07G1						
	13	13G1	0.06		0.01		0.01	
	21	21G1	0.02		0.00		0.00	
	25	25G1	0.08		0.02		0.02	
	31	31G1	0.04		0.01		0.01	
	TOTAL		0.80		0.16		0.16	
Grand Total - Patterns Counted as 1			12.64	0.14	2.74		2.47	
GrandTotal - Patterns Counted as 2			14.73	0.14	2.90		2.63	

Table 3-6. Modeled CY07 AAD Aircraft Operations at NAF Key West (cont'd)

Operation Type	Runway	Flight Track	A-4C		F/A-18CD		F/A-18EF	
			0700-2200	2200-0700	0700-2200	2200-0700	0700-2200	2200-0700
Departure	03	03D1	0.04		0.10	0.00	0.10	0.01
		03D2	0.70		1.58	0.04	1.54	0.08
		03D3	0.13		0.30	0.01	0.29	0.02
	07	07D1	0.20		0.44	0.01	0.43	0.02
		07D2	3.12	0.01	7.03	0.16	6.87	0.37
		07D3	0.59		1.32	0.03	1.29	0.07
	13	13D1	2.55		5.74	0.13	5.61	0.30
	21	21D1	0.08		0.18	0.00	0.18	0.01
	25	25D1	0.20		0.45	0.01	0.44	0.02
		25D2	0.20		0.45	0.01	0.44	0.02
	31	31D1	0.16		0.36	0.01	0.35	0.02
	TOTAL		7.97	0.01	17.92	0.40	17.52	0.94
Straight-In Arrivals	03	03A1	0.04		0.20	0.03	0.15	0.05
	07	07A1	0.25	0.02	1.24	0.15	0.94	0.25
	13	13A1	0.02		0.11	0.02	0.08	0.03
	21	21A1	0.01		0.05		0.04	
	25	25A1	0.03		0.14	0.01	0.11	0.01
	31	31A1	0.01		0.05	0.01	0.04	0.01
	TOTAL		0.36	0.02	1.79	0.20	1.36	0.35
Overhead Break (1500')	03	03O1	0.54		0.75	0.13	1.05	0.36
	07	07O1	2.40		3.36		4.66	
	13	13O1	1.57		2.19	0.07	3.04	0.19
	21	21O1	0.05		0.07		0.10	
	25	25O1	0.24		0.34		0.48	
	31	31O1	0.10		0.14		0.19	
	TOTAL		4.90		6.85	0.20	9.50	0.55
Carrier Break (800')	03	03O1						0.02
	07	07O1	2.43		9.29		6.65	
	13	13O1						0.01
	21	21O1						
	25	25O1						
	31	31O1						
	TOTAL		2.43		9.29		6.65	0.04
Touch & Go	03	03T2	0.14		0.06		0.17	
	07	07T2	0.60		0.27		0.74	
	13	13F2	0.39		0.18		0.49	
	21	21T2	0.01		0.01		0.02	
	25	25T2	0.06		0.03		0.08	
	31	31T2	0.02		0.01		0.03	
	TOTAL		1.23		0.56		1.52	
FCLP	03	03F1	0.08		0.05	0.01	0.17	0.10
		03F2	0.08		0.04	0.01	0.16	0.10
		03F3	0.08		0.04	0.01	0.16	0.10
	07	07F1	0.02		0.01	0.00	0.04	0.02
		07F2	0.02		0.01	0.00	0.04	0.02
		07F3	0.02		0.01	0.00	0.04	0.02
	13	13F1	0.08		0.04	0.01	0.16	0.10
		13F2	0.08		0.05	0.01	0.17	0.10
		13F3	0.08		0.04	0.01	0.16	0.10
	TOTAL		0.55		0.30	0.06	1.10	0.66
GCA Pattern	03	03G1	0.14	0.02	0.10		0.06	0.04
	07	07G1						
	13	13G1	0.01	0.00	0.01		0.01	0.00
	21	21G1	0.01		0.00		0.00	
	25	25G1	0.02		0.01		0.01	
	31	31G1	0.01		0.01		0.00	
	TOTAL		0.18	0.03	0.13		0.07	0.04
Grand Total - Patterns Counted as 1			17.62	0.06	36.85	0.87	37.74	2.58
GrandTotal - Patterns Counted as 2			19.58	0.08	37.83	0.93	40.42	3.28

Table 3-6. Modeled CY07 AAD Aircraft Operations at NAF Key West (concluded)

Operation Type	Runway	Flight Track	E-2/C-2		F-5E		Helos		TOTAL		
			0700-2200	2200-0700	0700-2200	2200-0700	0700-2200	2200-0700	0700-2200	2200-0700	Total
Departure	03	03D1	0.03		0.00				0.32	0.01	0.32
		03D2	0.53		0.06				5.07	0.12	5.19
		03D3	0.10		0.01				0.95	0.02	0.97
	07	07D1	0.15		0.02				1.41	0.03	1.44
		07D2	2.34		0.26		0.24	0.02	22.81	0.56	23.37
		07D3	0.44		0.05				4.23	0.10	4.33
	13	13D1	1.91		0.21		0.24	0.02	18.66	0.46	19.12
	21	21D1	0.06		0.01				0.58	0.01	0.59
	25	25D1	0.15		0.02		0.24	0.02	1.68	0.06	1.74
		25D2	0.15		0.02		0.24	0.02	1.68	0.06	1.74
	31	31D1	0.12		0.01				1.15	0.03	1.18
	TOTAL		5.97		0.66		0.97	0.09	58.54	1.46	59.99
Straight-In Arrivals	03	03A1	0.18	0.02	0.01		0.24	0.02	1.50	0.14	1.64
	07	07A1	1.11	0.10	0.05				7.88	0.60	8.48
	13	13A1	0.10	0.01	0.00		0.24	0.02	0.93	0.09	1.01
	21	21A1	0.05	0.00	0.00		0.24	0.02	0.59	0.03	0.61
	25	25A1	0.13	0.01	0.01				0.91	0.03	0.95
	31	31A1	0.05	0.00	0.00		0.24	0.02	0.59	0.05	0.63
	TOTAL		1.61	0.14	0.07		0.97	0.09	12.39	0.93	13.32
Overhead Break (1500')	03	03O1	0.10		0.02				2.46	0.49	2.95
	07	07O1	0.46		0.07				10.97		10.97
	13	13O1	0.30		0.05				7.16	0.26	7.43
	21	21O1	0.01		0.00				0.22		0.22
	25	25O1	0.05		0.01				1.12		1.12
	31	31O1	0.02		0.00				0.45		0.45
	TOTAL		0.93		0.15				22.38	0.75	23.14
Carrier Break (800')	03	03O1	1.53						1.53	0.02	1.56
	07	07O1	0.77		0.44				21.22		21.22
	13	13O1	1.53						1.53	0.01	1.55
	21	21O1									
	25	25O1									
	31	31O1									
	TOTAL		3.84		0.44				24.29	0.04	24.33
Touch & Go	03	03T2	0.03						0.54		0.54
	07	07T2	0.14						2.39		2.39
	13	13F2	0.09						1.56		1.56
	21	21T2	0.00						0.05		0.05
	25	25T2	0.01						0.24		0.24
	31	31T2	0.01						0.10		0.10
	TOTAL		0.28						4.87		4.87
FCLP	03	03F1	1.76	0.45					2.05	0.56	2.62
		03F2	1.70	0.44					1.99	0.55	2.54
		03F3	1.70	0.44					1.99	0.55	2.54
	07	07F1	0.39	0.10					0.46	0.13	0.58
		07F2	0.38	0.10					0.44	0.12	0.56
		07F3	0.38	0.10					0.44	0.12	0.56
	13	13F1	1.70	0.45					1.99	0.56	2.55
		13F2	1.76	0.44					2.05	0.55	2.60
		13F3	1.70	0.44					1.99	0.55	2.54
	TOTAL		11.48	2.96					13.42	3.68	17.10
GCA Pattern	03	03G1	0.08	0.04	0.01				1.23	0.10	1.33
	07	07G1									
	13	13G1	0.01	0.00	0.00				0.11	0.01	0.12
	21	21G1	0.00		0.00				0.05		0.05
	25	25G1	0.01		0.00				0.16		0.16
	31	31G1	0.01		0.00				0.08		0.08
	TOTAL		0.11	0.04	0.01				1.64	0.11	1.75
Grand Total - Patterns Counted as 1			24.22	3.14	1.32		1.94	0.17	137.54	6.97	144.50
GrandTotal - Patterns Counted as 2			36.09	6.14	1.33		1.94	0.17	157.47	10.75	168.22

3.3 Flight Profiles, Noise and Climatological Data

Flight profiles consist of aircraft power settings, altitudes above ground level (AGL), and airspeeds along each flight track. Flight profiles for the modeled aircraft types were obtained from a mix of sources, mostly from recent and related noise studies[7,8,9,10] and partially from the BASEOPS default profile database for transient aircraft.[1,2] NAF Key West Airfield Operations Manual (Doc. No. 3710.2Q)[4] was used to extract required procedure specifications. These required procedures were applied to the modeled aircraft profiles. Reference noise data exists in the NOISEFILE database for all of the modeled aircraft types.

F-15 flight profiles were modeled using the F-15A model aircraft. F-16 operations were modeled with the F-16C aircraft with a GE-100 engine. In CY01, the common source of F-16 traffic was from NAF Roosevelt Roads[7] and NAF JRB Fort Worth.[9] A-4 aircraft were modeled as A-4C with flight profiles derived from the most recent aircraft noise study conducted for NAF Roosevelt Roads.[7] Appendices D, E, and F depict the flight profiles modeled for the F-15, F-16 and A-4 aircraft.

In order to provide the most up-to-date noise data for this noise study, Wyle coordinated the aircraft flight profile data used in this study with other noise studies currently being conducted at naval air stations serving as home bases to aircraft deployed to NAF Key West. In June of 2001, Wyle personnel visited NAS Oceana to interview F/A-18C/D and F/A-18E/F pilots about flight parameters for flight operations at NAS Oceana. These profile descriptions were further refined from comments provided by key personnel at the Strike Fighter Wing, Atlantic, in November 2001. Additional revisions were made based on input from the Strike Fighter Wing Atlantic Commodore during the same month. Appendices B and C provide graphical illustrations of F/A-18 C/D and F/A-18E/F flight profiles modeled in this study for NAF Key West. Similarly, recent flight profile data collected for the E-2 aircraft based at NS Norfolk Chambers Field was incorporated into this study. This E-2 profile data was collected and validated by based squadrons at NS Norfolk Chambers Field in October of 2001. Appendix G provides graphical illustrations of the E-2 flight profiles modeled in this study for NAF Key West.

These flight profile parameters were modeled for NAF Key West in accordance with the local course rules outlined in the NAF's most current Airfield Operations Manual (Doc. No. 3710.2Q)[4]. Wyle presented this input to NAF Key West ATC personnel for review/validation, and concurrence with the flight profile conditions outlined in Appendices B through G was received from the NAF in December of 2002. Reported power settings were modeled where applicable, except when NOISEMAP 7.0 does not allow for that particular setting to be modeled. In such case, the closest power setting was modeled instead of that reported.

Climatological information was obtained from the Oceanography Command, which is a tenant of the NAF.[5] Since weather is an important factor in the propagation of noise, NOISEMAP requires input of the daily average temperature and relative humidity for each month to determine the appropriate values in order to properly represent acoustical values for those aircraft operations being modeled. The monthly temperatures and humidity are shown in Figure 3-10. The average monthly temperature and humidity used for the modeling of forecast CY07 conditions at the NAF are the same as those reported during CY01 (see WR 02-19).[16] Thus, the average temperature an relative humidity modeled for this study are 78 degrees Fahrenheit and 73 percent RH, respectively.

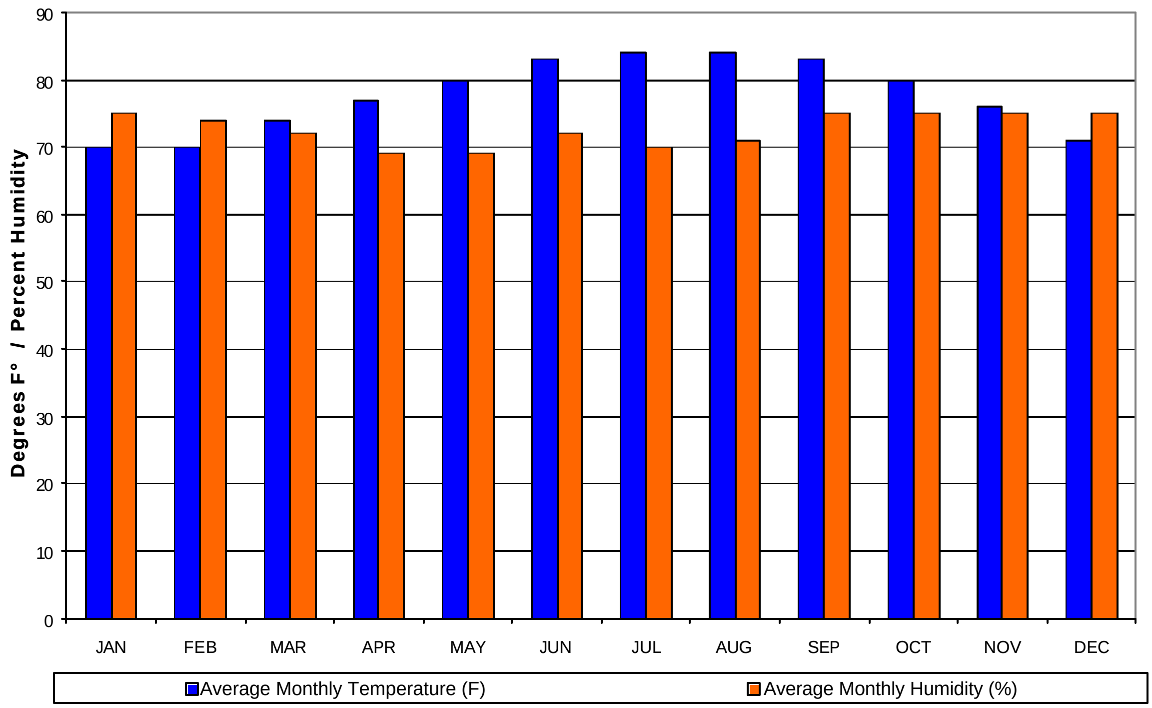

Figure 3-10. Monthly Temperatures and Relative Humidity for CY01 at NAF Key West

The 2001 wind data obtained from the NAF shows that the prevailing winds at NAF Key West generally blow from the east (0 to 180 degrees) at an average speed of 10 knots. This is consistent with the runway utilization percentages provided by the airfield and shown in Table 3-4. These conditions reported for CY01 conditions (see WR 02-19)[16] are expected to be the same as those forecast for CY07. Figure 3-11 shows prevailing wind direction and runway utilization distribution (utilization for arrival and departure operations).

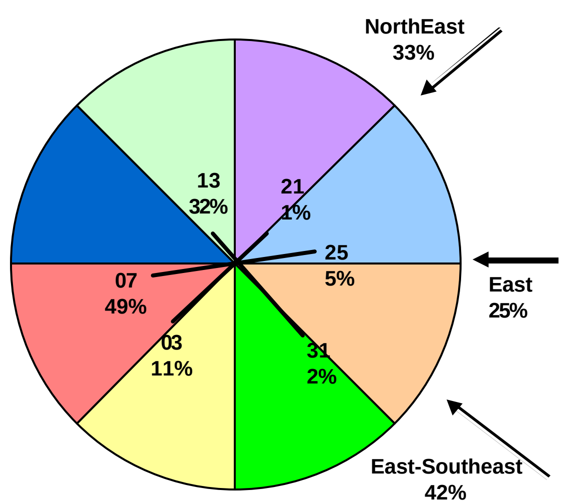

Figure 3-11. Comparison of Prevailing Wind Direction and Runway Utilization for NAF Key West CY01 Conditions

3.4 Pre-Flight and Maintenance Run-Up Operations

NOISEMAP models fixed-wing aircraft pre-flight run-ups that occur at the threshold of the runway prior to brake-release. Table 3-7 lists the modeled duration and power settings for the pre-flight run-ups of the representative aircraft types. Preflight run-up information was gathered from recent aircraft noise studies[7,8,9,10] conducted for the installations from which the modeled aircraft originate as reported in the deployment schedule provided by NAF Key West Fleet Liaison. Additional updates and refinements to the pre-flight run-ups were received for F/A-18 and E-2 aircraft in December of 2001 as part of the latest noise studies conducted for NAS Oceana and NS Norfolk Chambers Field. The settings and durations contained in the BASEOPS database for transient aircraft were applied to the C-9 aircraft.

Table 3-7. Pre-Flight Run-Up Data

Representative Aircraft Type	Duration @ Power Setting
A-4	30 sec. @ 85% NC
F-15	None
F-16	1 sec. @ 103% NC
F-18	10 sec. @ 80% N2
E-2C	30 sec. @ 4600 ESHP
C-9	5 sec. @ 2.0 EPR

Source: NAS Key West and references 1, 2

Notes:
(1) Occur at runway ends on runway heading prior to each departure
(2) durations are per engine
NC= compressor RPM; EPR=engine pressure ratio
ESHP= effective shaft horsepower

Maintenance run-up data was provided by the NAF Fleet Liaison and other military units surveyed under this effort. Table 3-8 lists the modeled AAD run-up activity for forecast CY07 conditions.[5] No out-of-frame maintenance run-ups are expected to be conducted at the NAF. Figure 2-2 shows the maintenance run-up locations identified in Table 3-8. The NAF utilizes two outdoor run-up areas, A and B, located near Runway ends 03 and 31.

F/A-18C/D/E/F aircraft conducted a total of 421 annual low power run-up events at power settings of 80% NC (modeled at 80% NC). F/A-18C/D/E/F aircraft also conducted a total of 57 annual run-ups at high power (modeled at 95% NC).

EA-6B and AV-8B aircraft are expected to conduct a total of 190 annual low power run-up events (115 for EA-6B and 75 for AV-8B) at power settings of about 80% NC. EA-6B aircraft are forecast to conduct about 5 run-ups at high power (modeled at 99% NC), whereas AV-8B aircraft are forecast to conduct about 15 high power run-ups (modeled at 95% NC) in CY07.

Due to data contained in NOISEFILE, not all "reported" power settings could be modeled. Table 3-8 lists both the reported and modeled power settings.

Table 3-8. Modeled Forecast (CY07) Single-Engine Maintenance Run-Up Events

A/C Type	Location		Maintenance Run-up Events				Reported Power Setting	Modeled Power Setting	Duration (mn)
			Annual		AAD				
	Name	I.D.	0700-2200	2200-0700	0700-2200	2200-0700			
F/A-18 C/D	In-frame Outdoor High-power Run-up Area	A	15		0.04		100% NC	95% NC	45
	Line	B	50	50	0.14	0.14	80% NC	80% NC	30
F/A-18 E/F	In-frame Outdoor High-power Run-up Area	A	42	0	0.12	0	100% NC	95% NC	30
	Line	B	193	128	0.53	0.35	80% NC	80% NC	30
EA-6B	In-frame Outdoor High-power Run-up Area	A	5		0.01		100% NC	99% NC	45
	Line	B	15	100	0.04	0.27	80% NC	80% NC	30
AV-8B	In-frame Outdoor High-power Run-up Area	A	15		0.04		100% NC	95% NC	45
	Line	B	25	50	0.07	0.14	80% NC	80% NC	30

3.5 Noise Exposure

Using the data described in Sections 3.1 through 3.4, NOISEMAP 7.0 was used to calculate and plot the 60 dB through 85 dB DNL contours for AAD operations. The DNL contours are shown in Figure 3-12.

The 60-dB DNL contour extends about 4 statute miles to the north of NAF Key West over the Gulf of Mexico and about 5 statute miles to the east-northeast of the NAF mid-field point, predominantly over water. The 60-dB DNL contour also extends about 6 statute miles to the west/southwest of the NAF mid-field point over Key West and about 9 statute miles to the southwest of the NAF over water. The shape of the 60-dB contour to the north of the NAF is the result of daily F/A-18 aircraft departures on flight track 03D2 (see Figure 3-4). The primary contributor of the contour shape extending over Key West, southwest of the NAF, is mainly due to arrival operations on flight track 07A1. On the other hand, the 65-dB DNL contour extends approximately 3 statute miles to the north of the NAF over the Gulf of Mexico and Route 1. The 65-dB DNL contour also extends about 2.8 statute miles to the west of the NAF mid-field point over portions of Key West and about 4.5 statute miles to the southwest of the NAF centerfield over water and parts of the coastal areas of Key West. The resulting DNL noise contours for forecast CY07 operations, as illustrated in Figure 3-12, were modeled using the topography algorithms of NOISEMAP 7.0. The CY07 DNL contours, therefore, take into account the terrain specifications (water versus ground) in the vicinity of the NAF[14].

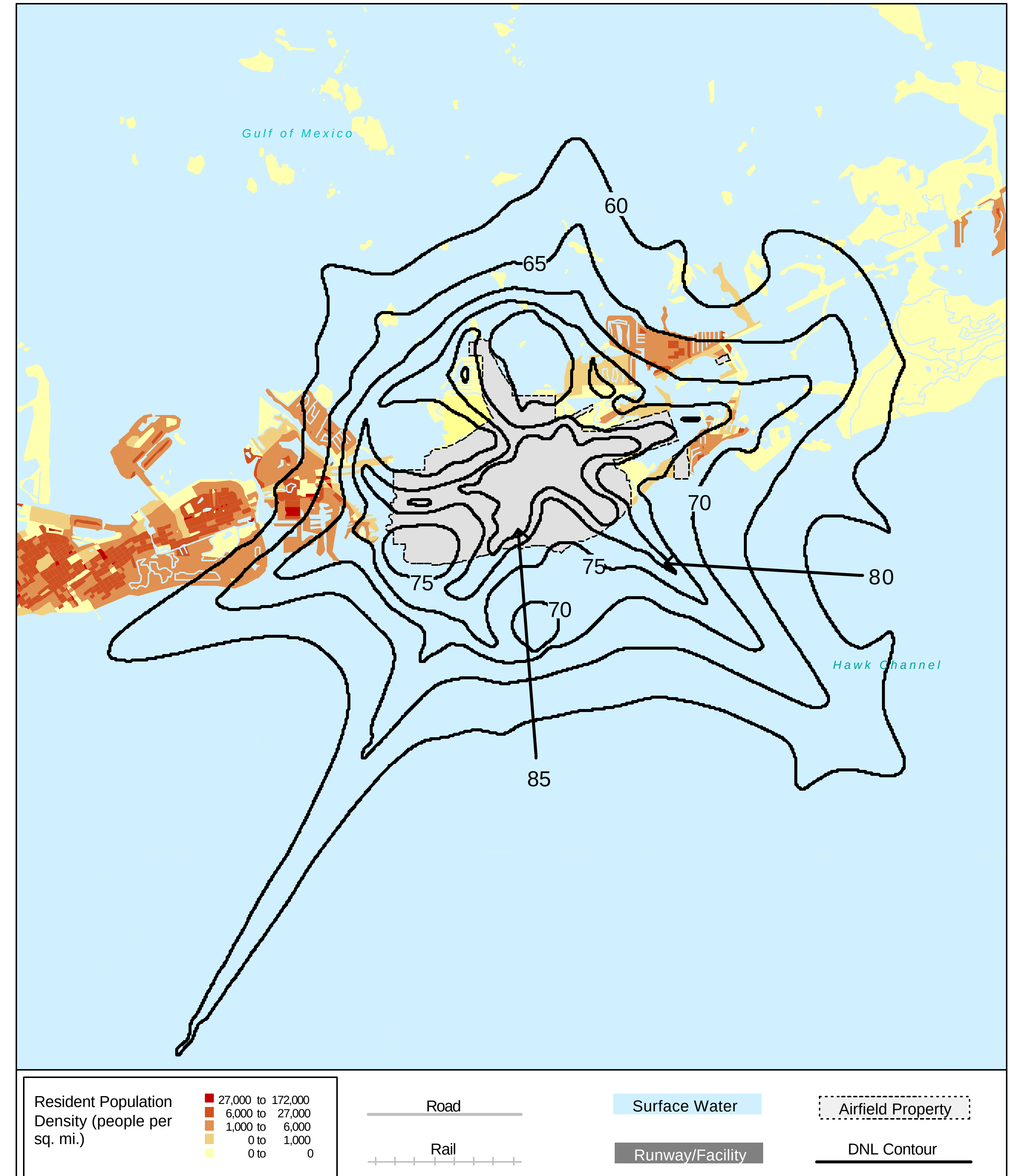

Figure 3-12 DNL Contours for Forecast CY07 Average Annual Day (AAD) Aircraft Operations at NAF Key West

Source: USGS DRG and Color IR NHAPS Boca Chica - 1994/95, StreetInfo 1993, Census 2000 PL94-171 Redistricting Tables & TIGER/Line files

Table 3-9 shows the impacts of forecast CY07 aircraft operations at NAF Key West in terms of acreage and estimated populations within the calculated AAD contours at 5-dB increments in comparison with estimated impact calculations for existing CY01 conditions modeled in Wyle Research Report WR 02-19.[16] It also contains subtotals of acreage and population within the 65–75 dB DNL contour band and within the 75 dB DNL contour. The population data was derived from block-level US Census 2000 data by extracting and merging the Census Bureau's Summary File 1 (SF1) tabular data set with their corresponding TIGER/Line geographical data set. The impact area excludes the area defined by the NAF boundary. Population impact is calculated as the summed proportion of populations associated with census blocks that fall within individual noise contours. The calculation assumes that populations are distributed regularly across individual census blocks. This assumption is not expected to impact the calc ulations heavily because census blocks, as the smallest indivisible geographical unit of census tabulation, are large-scale geographical features that can produce highly accurate calculations. The data was imported into MapInfo®, a Geographic Information System, along with the NOISEMAP 7.0 calculated contours. The total area outside the NAF boundary and the number of residents within each contour were then calculated for comparison purposes. Recall that the populations calculated with the above data are estimates and are most useful in determining relative change in population impact between different noise contours.

Table 3-9. Comparison of Estimated Land Area and Population Within Aircraft Noise Exposure Contours for CY01 and CY07 Conditions at NAF Key West

DNL Band	Item	CY01 Impact	CY07 Impact	Difference
60-65	Total Acres	8,260	13,980	5,720
	Population	3,437	3,839	402
65-70	Total Acres	6,422	7,140	718
	Population	931	3,435	2,504
70-75	Total Acres	4,051	6,371	2,320
	Population	542	1,174	632
75-80	Total Acres	1,633	3,966	2,333
	Population	20	341	321
80+	Total Acres	1,234	2,503	1,269
	Population	0	1	1
Summary of Exposure				
65-75	Total Acres	10,473	13,511	3,038
	Population	1,473	3,094	1,621
75+	Total Acres	2,867	6,469	3,602
	Population	21	342	321

Exposed population based on reported 2000 Census

Per Table 3-9, the forecast CY07 65–75 dB DNL contour band contains 13,511 acres in total area and an estimated exposed population of 3,038 based on the 2000 population densities. The forecast CY07 75+ dB DNL contour is estimated to contain 6,469 acres of total area with an estimated exposed population of 342 compared to 21 people impacted by the same DNL under existing CY01 conditions (see Wyle Report WR 02-19).[16]

In comparing existing CY01 and forecasted CY07 Average Annual Day 65 and 75 dB DNL contours in Figure 3-13, it is clear that the CY07 DNL contours are larger than those modeled for CY01 in all quadrants around the NAF. This would be expected due the forecasted 15% increase in F/A-18C/D/E/F operations and especially the increase in nighttime (2200-0700) operations which carry a 10-dB penalty. Recall that the 10-dB penalty for nighttime operations says that one nighttime operation has the same noise impact as ten daytime operations. The larger CY07 contours generally result from the following:

- The addition of F/A-18C/D nighttime departures and the increase in F/A-18E/F daytime departures on Runway 07, flight track 07D2 result in an increase in the 65 dB DNL contour east-northeast of the NAF.
- The increase of F/A-18E/F nighttime and daytime departures on Runway 13, flight track 13D1 result in an increase in the 65 dB DNL contour southeast of the NAF.
- The increase in F/A-18C/D/E/F daytime and nighttime straight-in arrivals, GCA Box and overhead break operations to Runway 03, flight tracks 03O1, 03A1, and 03G1 result in the sharp projection of the 65-dB DNL contour southwest of the NAF.
- The increase in F/A-18C/D/E/F arrival operations on Runway 07, flight track 07A1 result in the sharp projection of the 65 dB contour west-southwest of the NAF.

Other changes in aircraft mix, number of daytime and nighttime operations, and runway/flight track utilization all contributed to the overall changes in DNL contours from CY01 to forecasted CY07 conditions, but changes in the F/A-18C/D/E/F numbers remain a major factor for most all DNL contour increases for NAF Key West.

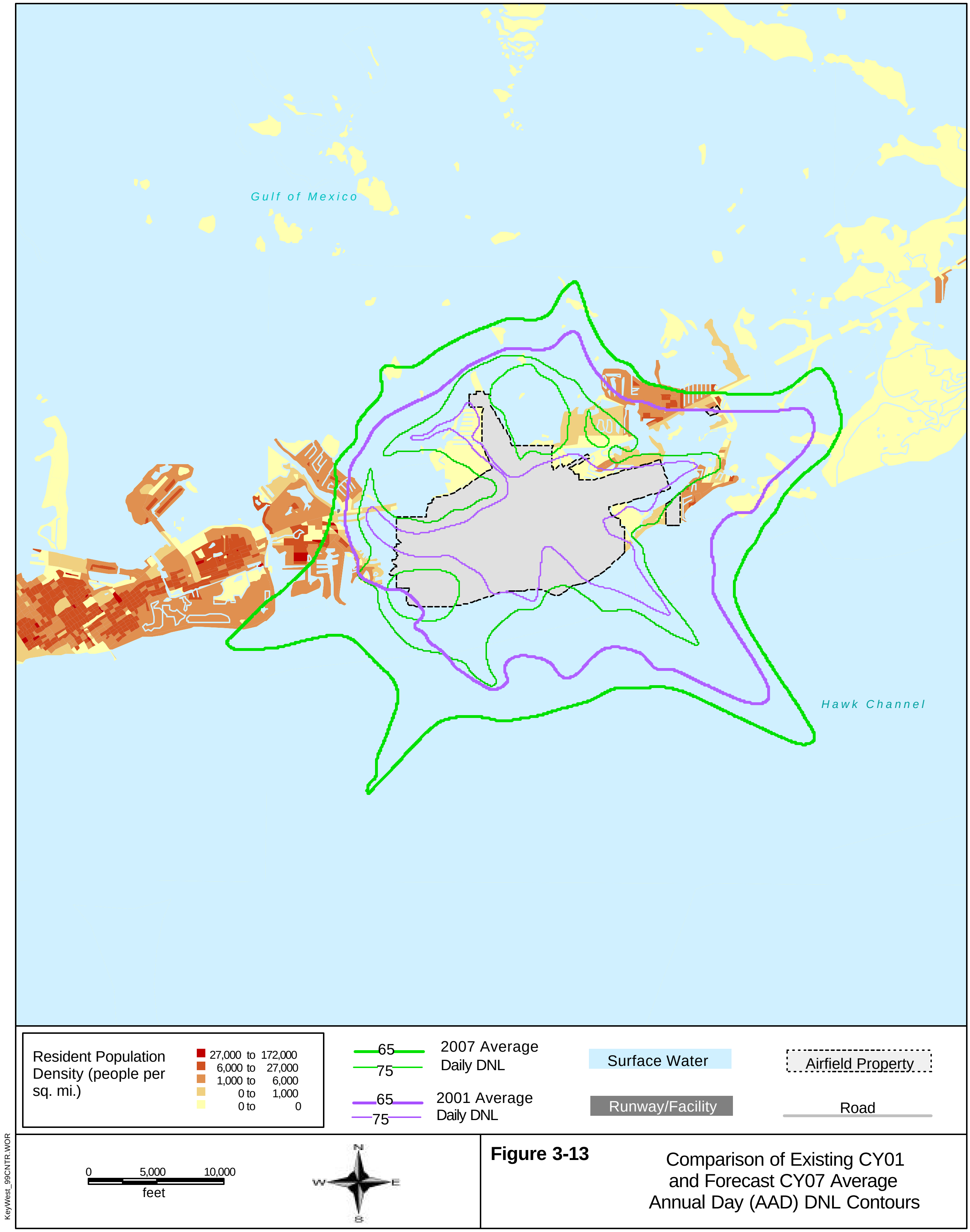

Figure 3-13 Comparison of Existing CY01 and Forecast CY07 Average Annual Day (AAD) DNL Contours

Source: USGS DRG and Color IR NHAPS Boca Chica - 1994/95, StreetInfo 1993, Census 2000 PL94-171 Redistricting Tables & TIGER/Line files

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APPENDIX A

DISCUSSION OF NOISE AND ITS EFFECT ON THE ENVIRONMENT

A.1 NOISE

A.1.1 General

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

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

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

The loudest sounds which can be detected comfortably by the human ear have intensities which are 1,000,000,000,000 times larger than those of sounds which can just be detected. Because of this vast range, any attempt to represent the intensity of sound using a linear scale becomes very unwieldy. As a result, a logarithmic unit known as the decibel (abbreviated dB) is used to represent the intensity of a sound. Such a representation is called a sound level.

A sound level of 0 dB is approximately the threshold of human hearing and is barely audible under extremely quiet listening conditions. Normal speech has a sound level of approximately 60 dB. Sound levels above about 120 dB begin to be felt inside the human ear as discomfort and eventually pain at still higher levels.

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

60 dB + 60 dB = 63 dB, and

80 dB + 80 dB = 83 dB.

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

60.0 dB + 70.0 dB = 70.4 dB.

Because the addition of sound levels behaves differently than that of ordinary numbers, such addition is often referred to as "decibel addition" or "energy addition". The latter term arises from the fact that what we are really doing when we add decibel values is first converting each decibel value to its corresponding acoustic energy, then adding the energies using the normal rules of addition, and finally converting the total energy back to its decibel equivalent.

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

The minimum change in the sound level of individual events which an average human ear can detect is about 3 dB. A change in sound level of about 10 dB is usually perceived by the average person as a doubling (or halving) of the sound's loudness, and this relation holds true for loud sounds and for quieter sounds. A decrease in sound level of 10 dB actually represents a 90 percent decrease in sound intensity but only a 50 percent decrease in perceived loudness because of the nonlinear response of the human ear (similar to most human senses).

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

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

In this document all sound levels are A-weighted sound levels and the adjective "A-weighted" has been omitted.

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

A.1.2 Noise Metrics

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

Recently, however, various federal agencies involved in environmental noise mitigation have agreed on common metrics for environmental impact analysis documents, and both the Department of Defense and the Federal Aviation Administration have specified those which should be used for federal aviation noise assessments. These metrics are as follows.

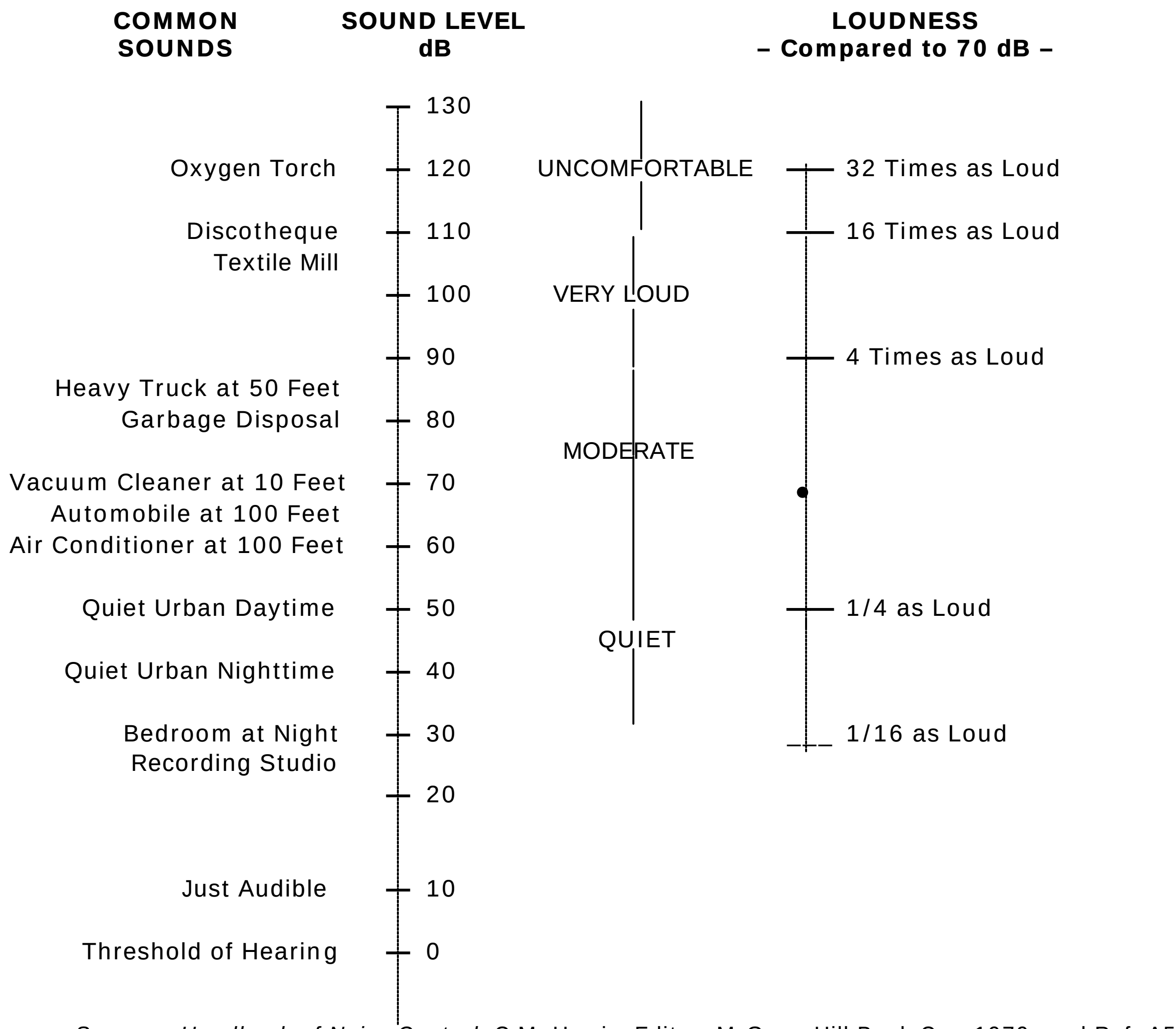
A.1.2.1 Maximum Sound Level

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

The maximum sound levels of typical events are shown in Figure A-1. The maximum sound level is important in judging the interference caused by a noise event with conversation, TV or radio listening, sleep, or other common activities.

A.1.2.2 Sound Exposure Level

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



Source: *Handbook of Noise Control*, C.M. Harris, Editor, McGraw-Hill Book Co., 1979, and Ref. A5.

Figure A-1. Typical A-Weighted Sound Levels of Common Sounds.

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

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

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

A.1.2.3 Day-Night Average Sound Level

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

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

Ignoring the 10-decibel nighttime adjustment for the moment, Day-Night Average Sound Level may be thought of as the continuous A-weighted Sound Level which would be present if all of the variations in sound level which occur over a 24-hour period were smoothed out so as to contain the same total sound energy.

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

As noted earlier for Sound Exposure Level, Day-Night Average Sound Level does not represent the sound level heard at any particular time, but rather represents the total sound exposure. Scientific studies and social surveys which have been conducted to appraise community annoyance to all types of environmental noise have found the Day-Night Average Sound Level to be the best measure of that annoyance. Its use is endorsed by the scientific community (References A1 through A5).

There is, in fact, a remarkable consistency in the results of attitudinal surveys about aircraft noise conducted in different countries to find the percentages of groups of people who express various degrees of annoyance when exposed to different levels of Day-Night Average Sound Level. This is illustrated in Figure A-2, which summarizes the results of a large number of social surveys relating community responses to various types of noises, measured in Day-Night Average Sound Level.

Reference A6, from which Figure A-2 was taken, was published in 1978. A more recent study has reaffirmed this relationship (Reference A7). In general, correlation coefficients of 0.85 to 0.95 are found between the percentages of <u>groups</u> of people highly annoyed and the level of average noise exposure. The correlation coefficients for the annoyance of <u>individuals</u> are relatively low, however, on the order of 0.5 or less. This is not surprising, considering the varying personal factors which influence the manner in which individuals react to noise. Nevertheless, findings substantiate that community annoyance to aircraft noise is represented quite reliably using Day-Night Average Sound Level.

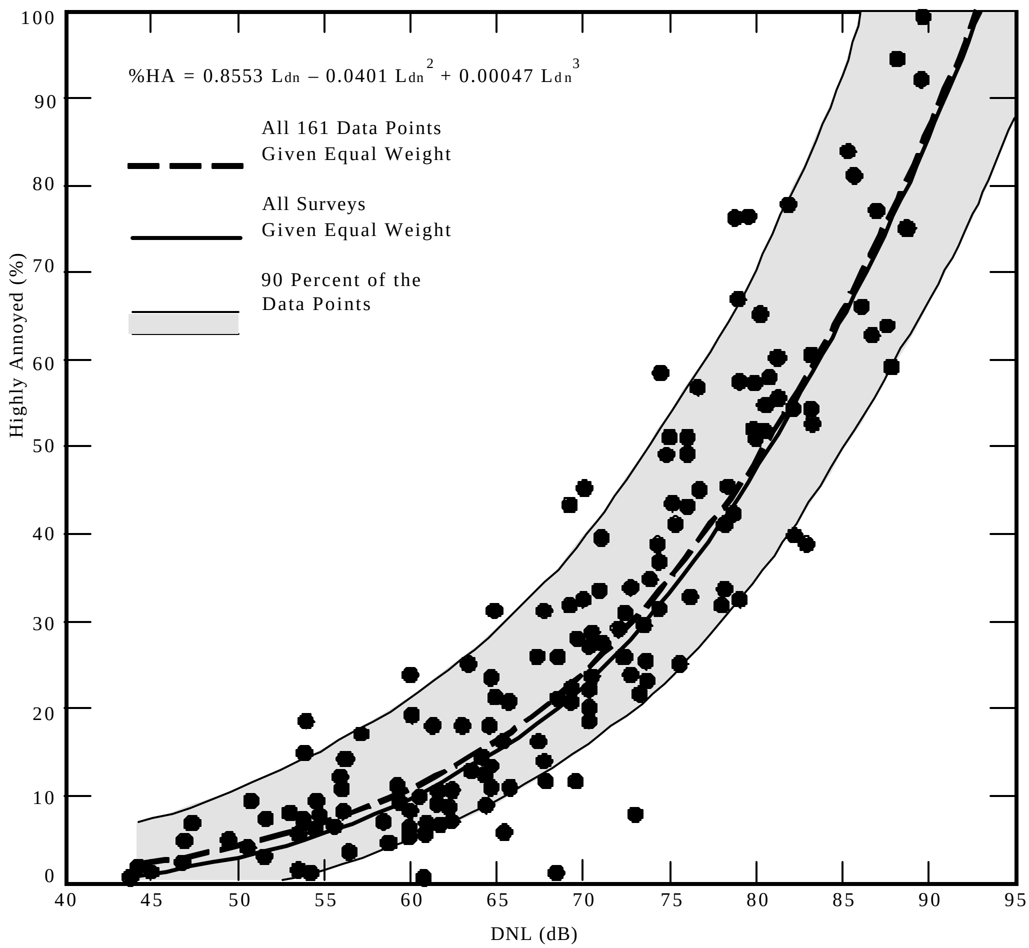


Figure A-2. Community Surveys of Noise Annoyance (Schulz, 1978)

This relation between community annoyance and time-average sound level has been confirmed, even for infrequent aircraft noise events. Reference A8 reported the reactions of individuals in a community to daily helicopter overflights, ranging from one to 32 per day. The stated reactions to infrequent helicopter overflights correlated quite well with the daily time-average sound levels over this range of numbers of daily noise events.

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

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

As a simple example of this characteristic, consider a case in which only one aircraft overflight occurs in daytime during a 24-hour period, creating a sound level of 100 dB for 30 seconds. During the remaining 23 hours, 59 minutes, and 30 seconds of the day, the ambient sound level is 50 dB. The Day-Night Average Sound Level for this 24-hour period is 65.5 dB. Assume, as a second example, that ten such 30-second overflights occur in daytime hours during the next 24-hour period, with the same ambient sound level of 50 dB during the remaining 23 hours and 55 minutes of the day. The Day-Night Average Sound Level for this 24-hour period is 75.4 dB. Clearly, the averaging of noise over a 24-hour period does not ignore the louder single events and tends to emphasize both the sound levels and number of those events. This is the basic concept of a time-average sound metric, and specifically the Day-Night Average Sound Level.

A.1.2.4 Onset-Rate Adjusted Day-Night Average Sound Level

Aircraft operations along low-altitude Military Training Routes (MTRs) and in Military Operating Areas (MOAs) and Restricted Areas/Ranges generate a noise environment different from other community noise environments. Overflights can be highly sporadic, ranging from many (e.g., ten per hour) to few (less than one per week). This situation differs from most community noise environments in which noise tends to be continuous or patterned.

Individual military overflight events also differ from typical community noise events, because of the low-altitude and high-airspeed characteristics of military aircraft. These characteristics result in aircraft that exhibit a rate of increase in sound level (onset rate) of up to 30 dB per second. The Day-Night Average Sound Level metric is adjusted to account for the "surprise" effect of the onset rate of aircraft noise on humans with an adjustment ranging up to 11 dB added to the normal Sound Exposure Level (Reference A9). Onset rates between 15 to 150 dB per second require an adjustment of from 0 to 11 dB, while onset rates below 15 dB per second require no adjustment. The adjusted Day-Night Average Sound Level is designated as Onset-Rate Adjusted Day-Night Average Sound Level (abbreviated L_{dnr}). Because of the sporadic occurrences of aircraft overflights along MTRs, in MOAs and Restricted Areas/Ranges, the number of average daily operations is determined from the calendar month with the highest number of operations in each area. This monthly average is denoted L_{dnmr} .

A.2 NOISE EFFECTS

A.2.1 Hearing Loss

Noise-induced hearing loss is probably the best defined of the potential effects of human exposure to excessive noise. Federal workplace standards for protection from hearing loss allow a time-average level of 90 dB over an 8-hour work period, or 85 dB averaged over a 16-hour period. Even the most protective criterion (no measurable hearing loss for the most sensitive portion of the population at the ear's most sensitive frequency, 4000 Hz, after a 40-year exposure) suggests a time-average sound level of 70 dB over a 24-hour period. Since it is unlikely that airport neighbors will remain outside their homes 24 hours per day for extended periods of time, there is little possibility of hearing loss below a Day-Night Average Sound Level of 75 dB, and this level is extremely conservative.

A.2.2 Nonauditory Health Effects

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

> "The nonauditory effects of chronic noise exposure, when noise is suspected to act as one of the risk factors in the development of hypertension, cardiovascular disease, and other nervous disorders, have never been proven to occur as chronic manifestations at levels below these criteria (an average of 75 dBA for complete protection against hearing loss for an eight-hour day). At the 1988 International Congress on Noise as a Public Health Problem, most studies attempting to clarify such health effects did not find them at levels below the criteria protective of noise-induced hearing loss, and even above these criteria, results regarding such health effects were ambiguous. Consequently, one comes to the conclusion that establishing and enforcing exposure levels protecting against noise-induced hearing loss would not only solve the noise-induced hearing loss problem but also any potential nonauditory health effects in the work place." (Reference A10; parenthetical wording added for clarification.)

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

For example, in an often-quoted paper, two UCLA researchers apparently found a relation between aircraft noise levels under the approach path to Los Angeles International Airport (LAX) and increased mortality rates among the exposed residents by using an average noise exposure level greater than 75 dB for the "noise-exposed" population (Reference A11). Nevertheless, three other UCLA professors analyzed those same data and found no relation between noise exposure and mortality rates (Reference A12).

As a second example, two other UCLA researchers used this same population near LAX to show a higher rate of birth defects in 1970–1972 when compared with a control group residing away from the airport (Reference A13). Based on this report, a separate group at the U.S. Centers for Disease Control performed a more thorough study of populations near Atlanta's Hartsfield International Airport (ATL) for 1970–1972 and found no relation in their study of 17 identified categories of birth defects to aircraft noise levels above 65 dB (Reference A14).

In summary, there is no scientific basis for a claim that potential health effects exist for aircraft time-average sound levels below 75 dB.

A.2.3 Annoyance

The primary effect of aircraft noise on exposed communities is one of annoyance. Noise annoyance is defined by the U.S. Environmental Protection Agency as any negative subjective reaction on the part of an individual or group (Reference A3). As noted in the discussion of Day-Night Average Sound Level above, community annoyance is best measured by that metric.

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

1. provides a valid basis for comparing and assessing community noise effects,

2. represents a noise exposure level which is normally dominated by aircraft noise and not other community or nearby highway noise sources, and
3. reflects the FAA's threshold for grant-in-aid funding of airport noise mitigation projects.

The U.S. Department of Housing and Urban Development also established a Day-Night Average Sound Level standard of 65 dB for eligibility for federally guaranteed home loans.

For this environmental study, levels of Day-Night Average Sound Level equal to and greater than 65 dB were used for assessing community noise impact.

A.2.4 Speech Interference

Speech interference associated with aircraft noise is a primary cause of annoyance to individuals on the ground. The disruption of routine activities such as radio or television listening, telephone use, or family conversation gives rise to frustration and agravation. The quality of speech communication is also important in classrooms, offices, and industrial settings and can cause fatigue and vocal strain in those who attempt to communicate over the noise. Research has shown that "whenever intrusive noise exceeds approximately 60 dB indoors, there will be interference with speech communication" (Reference A5).

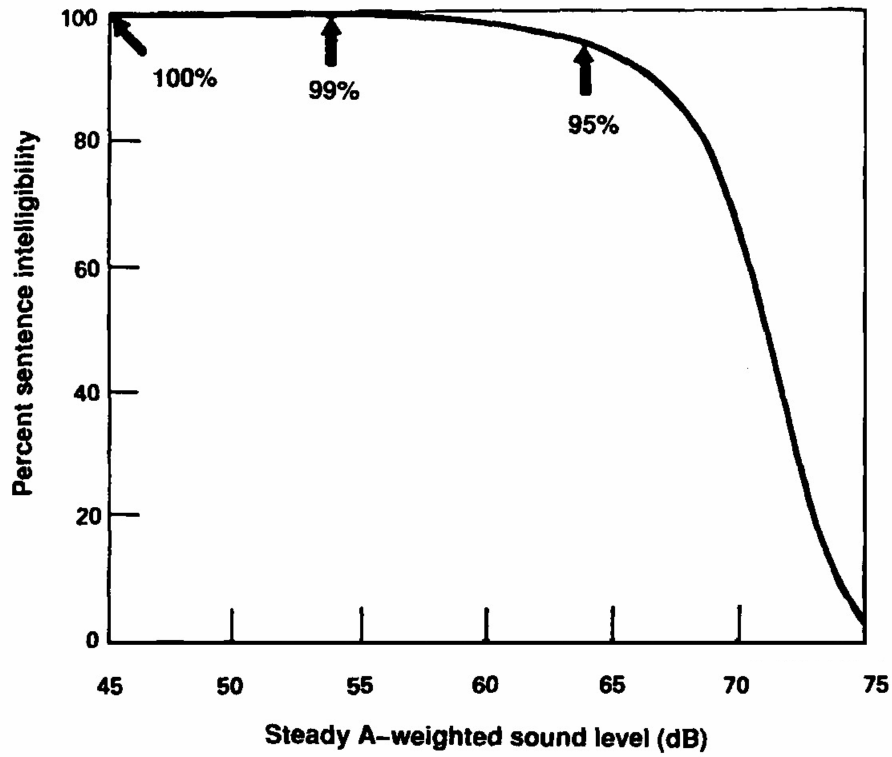


Figure A-3. Normal Voice Sentence Intelligibility as a Function of the Steady Background Sound Level in an Outdoor Situation (Reference A3)

Indoor speech interference, per Reference A3, can be expressed as a percentage of sentence intelligibility among two people speaking in relaxed conversation approximately 1 meter apart in a typical* living room or bedroom. The percentage of sentence intelligibility is a non-linear function of the (steady) indoor background A-weighted sound level as shown in Figure A-3. Sentence intelligibility is greater than 99 percent for background levels below 54 dB and less than 10 percent for background levels above 73 dB. Note that the function is especially sensitive to changes in sound level between 65 dB and 75 dB. As an example of the sensitivity, a 1 dB increase in background sound level from 70 dB to 71 dB yields a 14 percent decrease in sentence intelligibility.

* "Typical" is defined as a room with about 300 sabins of sound absorption which, according to Reference A3, is representative of living rooms and bedrooms.

A.2.5 Sleep Disturbance

Sleep disturbance is another source of annoyance associated with aircraft noise. This is especially true because of the intermittent nature and content of aircraft noise, which is more disturbing than continuous noise of equal energy and neutral meaning.

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

In terms of average daily noise levels, some guidance is available to judge sleep disturbance. The U.S. Environmental Protection Agency identified an indoor DNL of 45 dB as necessary to protect against sleep interference (Reference A3). Assuming a conservative structural noise insulation of 20 dB for typical dwellings, 45 dB corresponds to an outdoor DNL of 65 dB as minimizing sleep interference.

In June 1997, the Federal Interagency Committee on Aviation Noise (FICAN) reviewed the sleep disturbance issue and presented a sleep disturbance dose-response prediction curve (Reference A15), which was based on data from field studies in References A16 through A19, as the recommended tool for analysis of potential sleep disturbance for residential areas. Figure A-4 shows this curve which, for an indoor Sound Exposure Level of 60 dB, predicts that a maximum of approximately 5 percent of the residential populaton exposed are expected to be behaviourally awakened. FICAN cautions that this curve should only be applied to long-term adult residents.

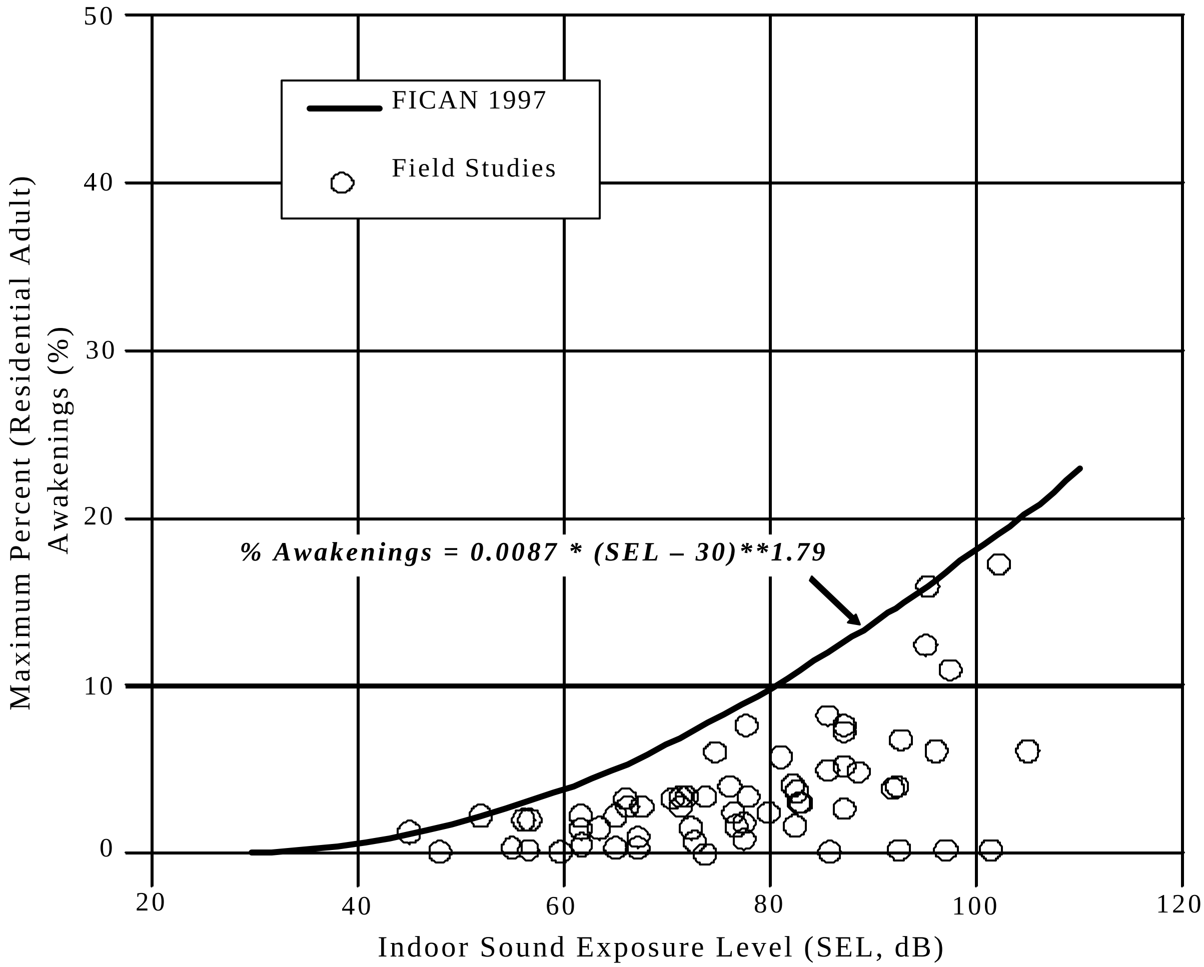


Figure A-4. Sleep-disturbance Dose-response Relationship

A.2.6 Noise Effects on Domestic Animals and Wildlife

Animal species differ greatly in their responses to noise. Each species has adapted, physically and behaviorally, to fill its ecological role in nature, and its hearing ability usually reflects that role. Animals rely on their hearing to avoid predators, obtain food, and communicate with and attract other members of their species. Aircraft noise may mask or interfere with these functions. Secondary effects may include nonauditory effects similar to those exhibited by humans – stress, hypertension, and other nervous disorders. Tertiary effects may include interference with mating and resultant population declines.

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

In the absence of definitive data on the effect of noise on animals, the Committee on Hearing, Bioacoustics, and Biomechanics of the National Research Council has proposed that protective noise criteria for animals be taken to be the same as for humans (Reference A16).

A.2.7 Effects on Noise-Induced Vibration Structures and Humans

The sound from an aircraft overflight travels from the exterior to the interior of the house in one of two ways: through the solid structural elements and directly through the air. Figure A-5 illustrates the sound transmission through a wall constructed with a brick exterior, stud framing, interior finish wall, and absorbent material in the cavity. The sound transmission starts with noise impinging on the wall exterior. Some of this sound energy will be reflected away and some will make the wall vibrate. The vibrating wall radiates sound into the airspace, which in turn sets the interior finish surface vibrating, with some energy lost in the airspace. This surface then radiates sound into the dwelling interior. As the figure shows, vibrational energy also bypasses the air cavity by traveling through the studs and edge connections.

Normally, the most sensitive components of a structure to airborne noise are the windows and, infrequently, the plastered walls and ceilings. An evaluation of the peak sound pressures impinging on the structure is normally sufficient to determine the possibility of damage. In general, at sound levels above 130 dB, there is the possibility of structural damage. While certain frequencies (such as 30 hertz for window breakage) may be of more concern than other frequencies, conservatively, only sounds lasting more than one second above a sound level of 130 dB are potentially damaging to structural components (Reference A20).

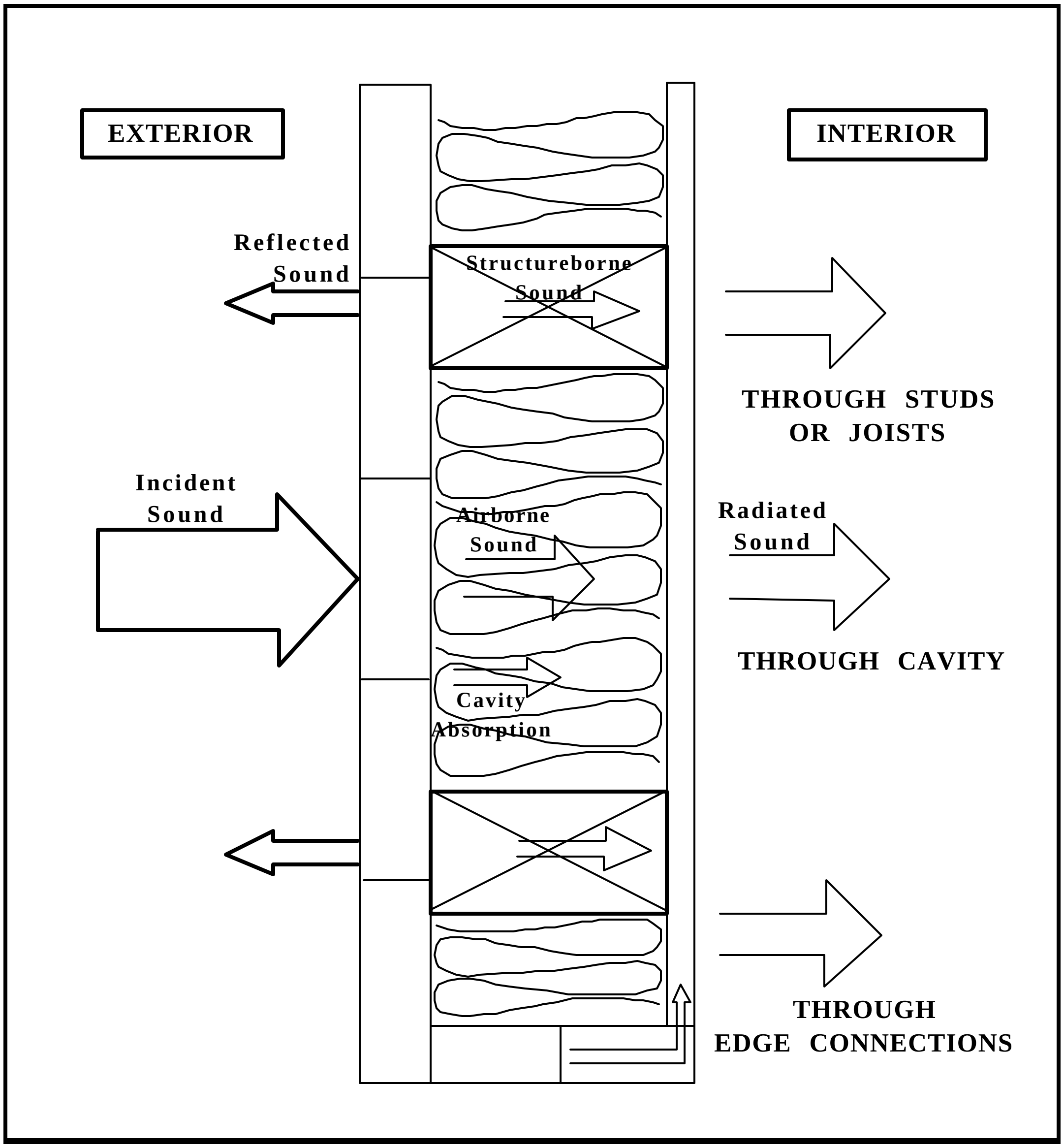


Figure A-5. Pictorial Representation of Sound Transmission Through Built Construction

In terms of average acceleration of wall or ceiling vibration, the thresholds for structural damage (Reference A21) are:

- 0.5 m/s/s – is the threshold of risk of damage to sensitive structures (i.e., ancient monuments, etc.).
- 1.0 m/s/s – is the threshold of risk of damage to normal dwellings (i.e., houses with plaster ceiling and walls).

Noise-induced structural vibration may also cause annoyance to dwelling occupants because of induced secondary vibrations, or "rattle", of objects within the dwelling – hanging pictures, dishes, plaques, and bric-a-brac. Loose window panes may also vibrate noticeably when exposed to high levels of airborne noise, causing homeowners to fear breakage. In general, such noise-induced vibrations occur at sound levels above those considered normally compatible with residential land use. Thus assessments of noise exposure levels for compatible land use should also be protective of noise-induced secondary vibrations.

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

1. Type of excitation: steady state, intermittent, or impulsive vibration.
2. Frequency of the excitation. ISO 2631-2 (Reference A21) recommends a frequency range of 1 to 80 Hz for the assessment of vibration on humans.
3. Orientation of the body with respect to the vibration.
4. The use of the occupied space (i.e., residential, workshop, hospital).
5. Time of day.

Table A-1 lists the whole-body vibration criteria from Reference A21 for one-third octave frequency bands from 1 to 80 Hz.

Table A-1

Vibration Criteria for the Evaluation of Human Exposure to Whole-Body Vibration

Frequency (Hz)	RMS Acceleration (m/s/s)		
	Combined Criteria Base Curve	Residential Night	Residential Day
1	0.0036	0.0050	0.0072
1.25	0.0036	0.0050	0.0072
1.6	0.0036	0.0050	0.0072
2	0.0036	0.0050	0.0072
2.5	0.0037	0.0052	0.0074
3.15	0.0039	0.0054	0.0077
4	0.0041	0.0057	0.0081
5	0.0043	0.0060	0.0086
6.3	0.0046	0.0064	0.0092
8	0.0050	0.0070	0.0100
10	0.0063	0.0088	0.0126
12.5	0.0078	0.0109	0.0156
16	0.0100	0.0140	0.0200
20	0.0125	0.0175	0.0250
25	0.0156	0.0218	0.0312
31.5	0.0197	0.0276	0.0394
40	0.0250	0.0350	0.0500
50	0.0313	0.0438	0.0626
63	0.0394	0.0552	0.0788
80	0.0500	0.0700	0.1000

Source: Reference A21.

A.2.8 Noise Effects on Terrain

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

A.2.9 Noise Effects on Historical and Archaeological Sites

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

One study involved the measurements of sound levels and structural vibration levels in a superbly restored plantation house, originally built in 1795, and now situated approximately 1,500 feet from the centerline at the departure end of Runway 19L at Washington Dulles International Airport (IAD). These measurements were made in connection with the proposed scheduled operation of the supersonic Concorde airplane at Dulles (Reference A22). There was special concern for the building's windows, since roughly half of the 324 panes were original. No instances of structural damage were found. Interestingly, despite the high levels of noise during Concorde takeoffs, the induced structural vibration levels were actually less than those induced by touring groups and vacuum cleaning.

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

A.3 REFERENCES

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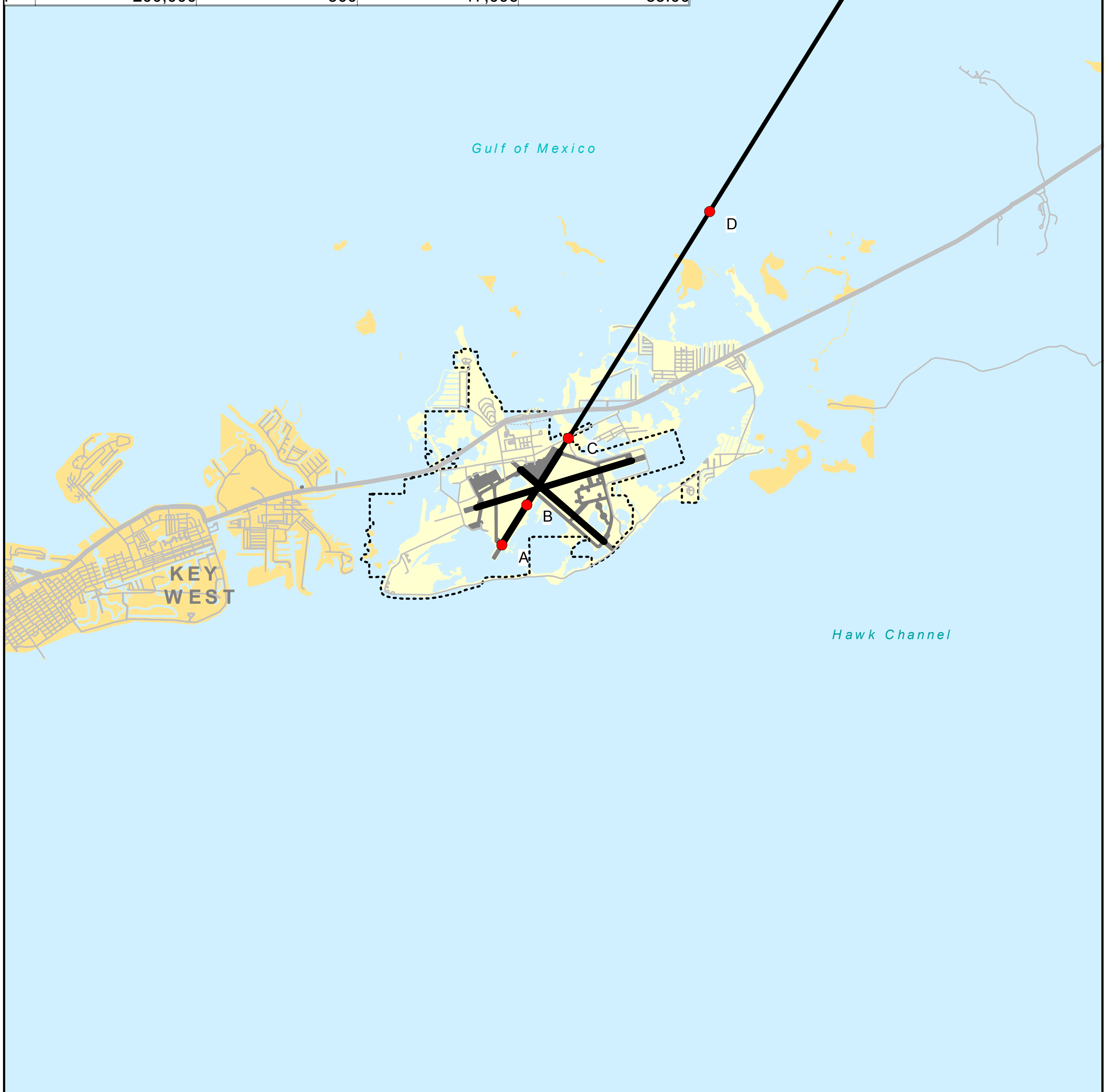
APPENDIX B

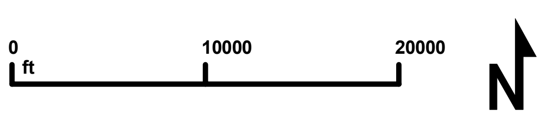
Modeled F/A-18 C/D Aircraft Flight Profiles

ID	CUMU_DIST	AIRSPEED	ALTITUDE	POWER
A	1	0	6	95.10
B	3,000	150	6	96.70
C	8,000	250	1,006	96.50
D	25,000	300	4,006	94.00
E	82,000	300	17,006	85.00
F	200,000	300	17,006	85.00



Flight Track

Flight Profile Point

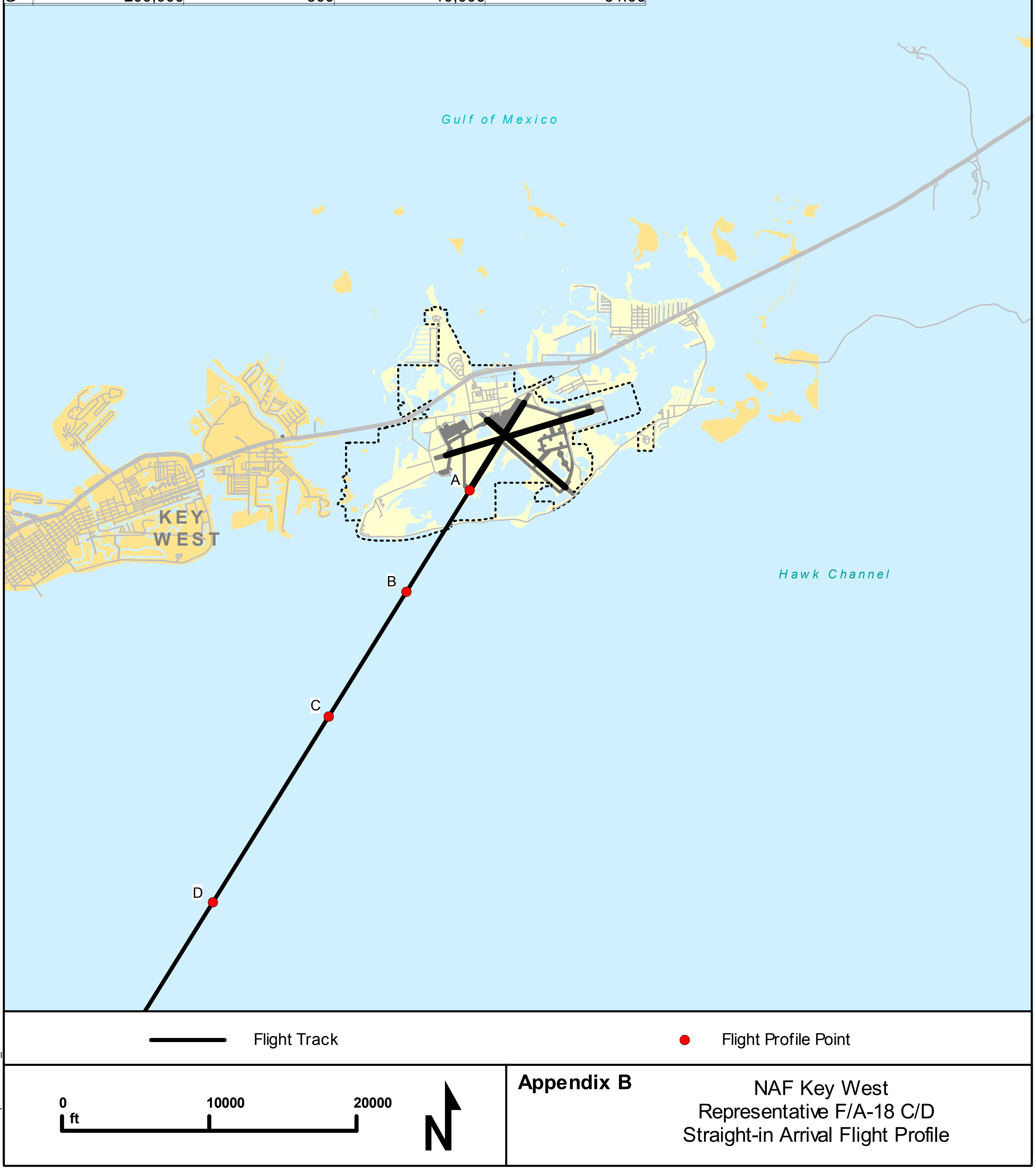


Appendix B

NAF Key West
Representative F/A-18 C/D
Departure Flight Profile

Profiles.opx Profile_F18CD50103D1.wor 11/08/2002

ID	CUMU_DIST	AIRSPEED	ALTITUDE	POWER
A	1	135	56	88.00
B	8,125	140	506	88.00
C	18,125	140	1,206	88.00
D	33,000	250	2,006	88.00
E	101,000	250	5,006	81.00
F	121,000	300	10,006	81.00
G	200,000	300	10,006	84.00



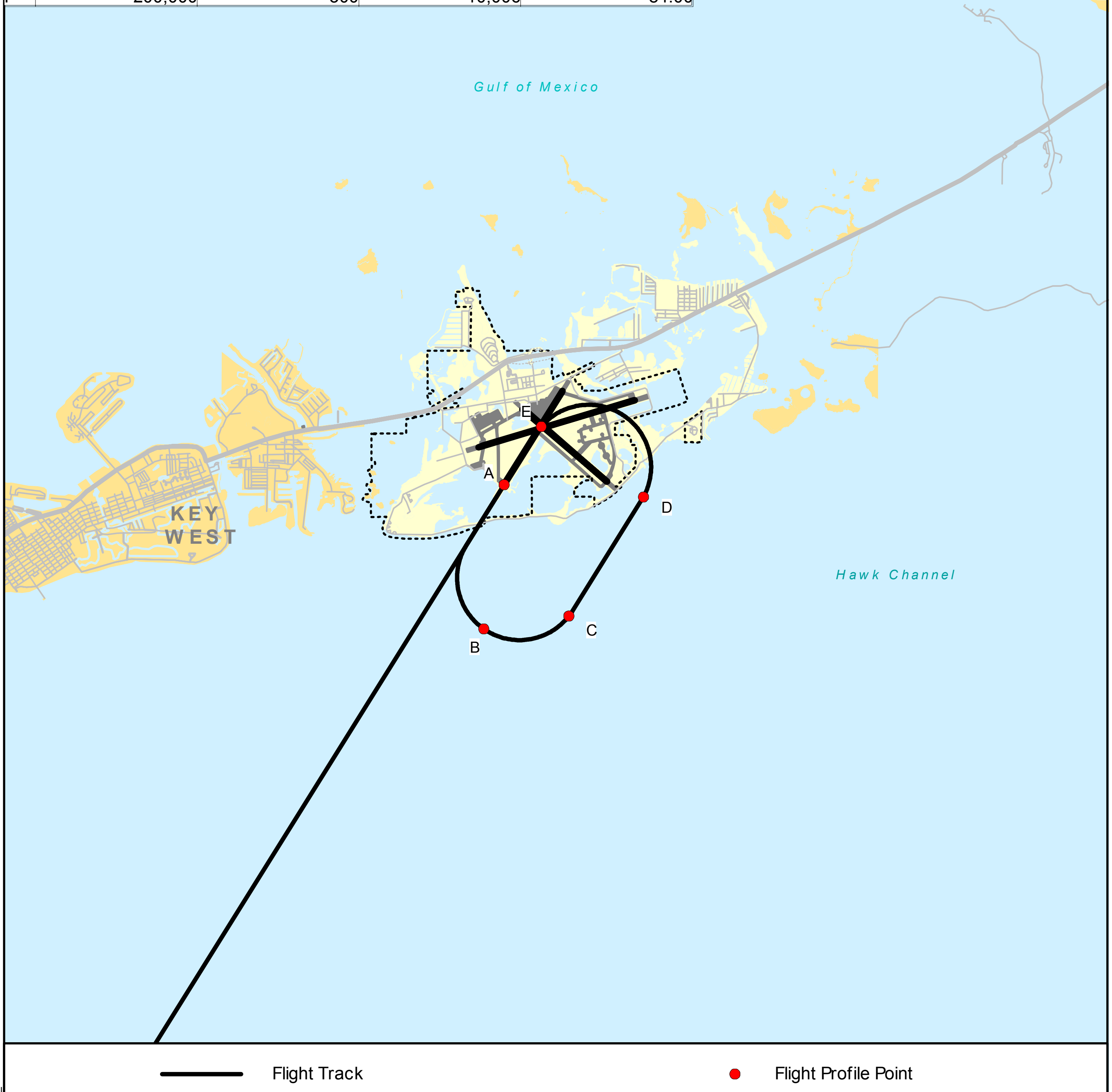
Appendix B

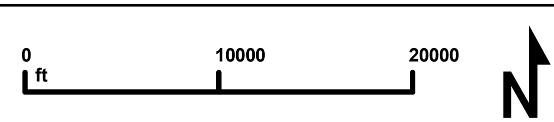
NAF Key West
Representative F/A-18 C/D
Straight-in Arrival Flight Profile

Profiles.opx Profile_F18CD51203A1.wor 11/08/2002

wyle laboratories

ID	CUMU_DIST	AIRSPEED	ALTITUDE	POWER
A	1	135	56	88.00
B	10,500	140	506	88.00
C	16,500	140	1,006	81.00
D	25,404	140	1,006	87.00
E	37,000	300	1,506	78.50
F	86,000	300	3,006	83.00
G	141,000	300	3,006	84.00
H	166,000	300	10,006	81.00
I	200,000	300	10,006	84.00

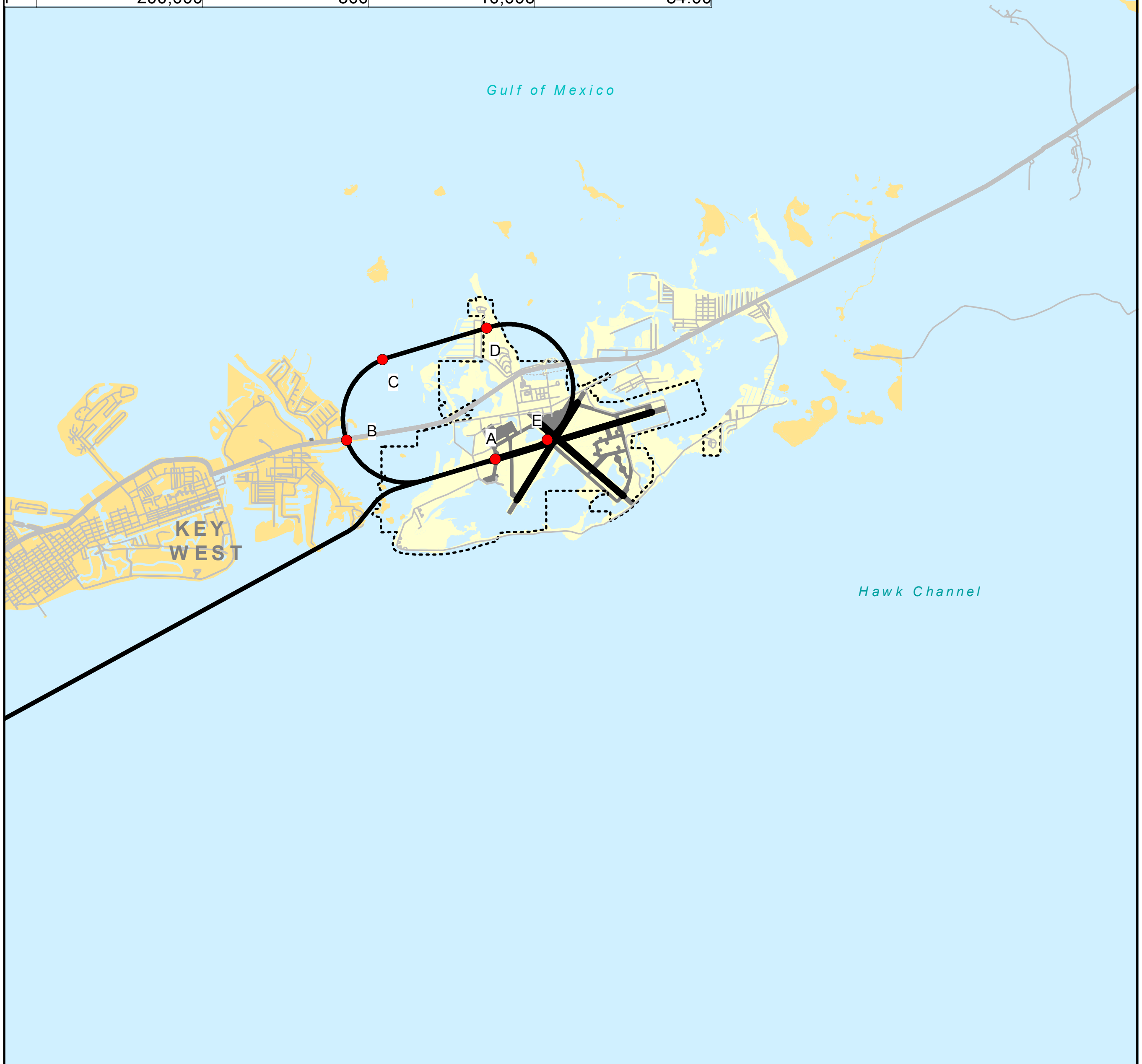




Appendix B

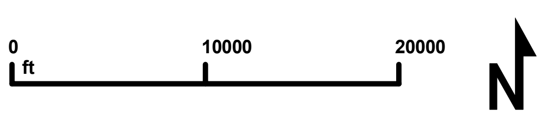
NAF Key West
Representative F/A-18 C/D
Overhead Break Arrival Flight Profile

ID	CUMU_DIST	AIRSPEED	ALTITUDE	POWER
A	1	135	56	88.00
B	10,500	140	506	88.00
C	16,500	140	606	81.00
D	23,200	140	606	87.00
E	34,500	300	806	78.50
F	86,000	300	3,006	81.00
G	141,000	300	3,006	84.00
H	166,000	300	10,006	81.00
I	200,000	300	10,006	84.00



Flight Track

Flight Profile Point

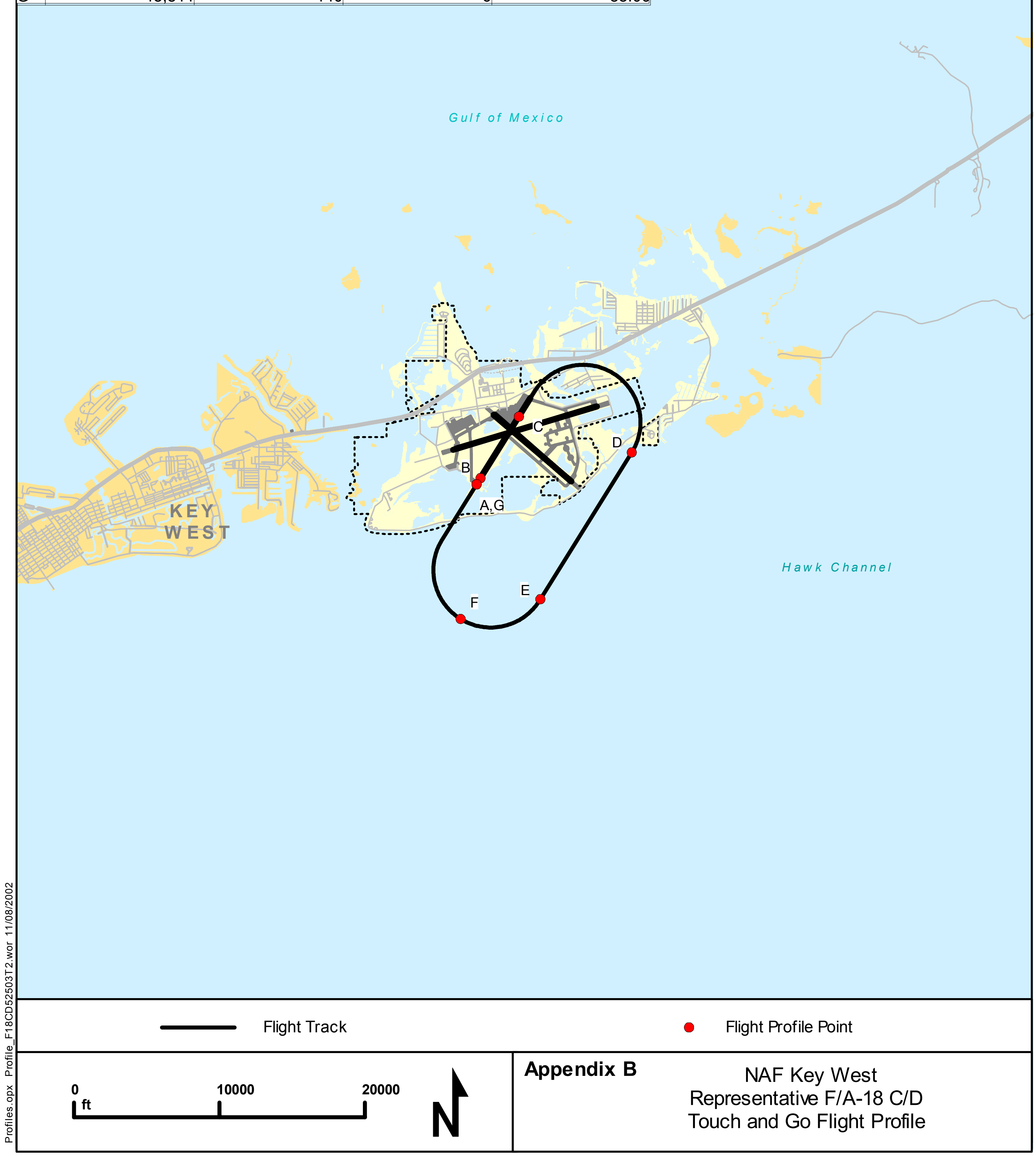


Appendix B

NAF Key West
Representative F/A-18 C/D
Carrier Break Arrival Flight Profile

Profiles.opx Profile_F18CD52407O1.wor 11/08/2002

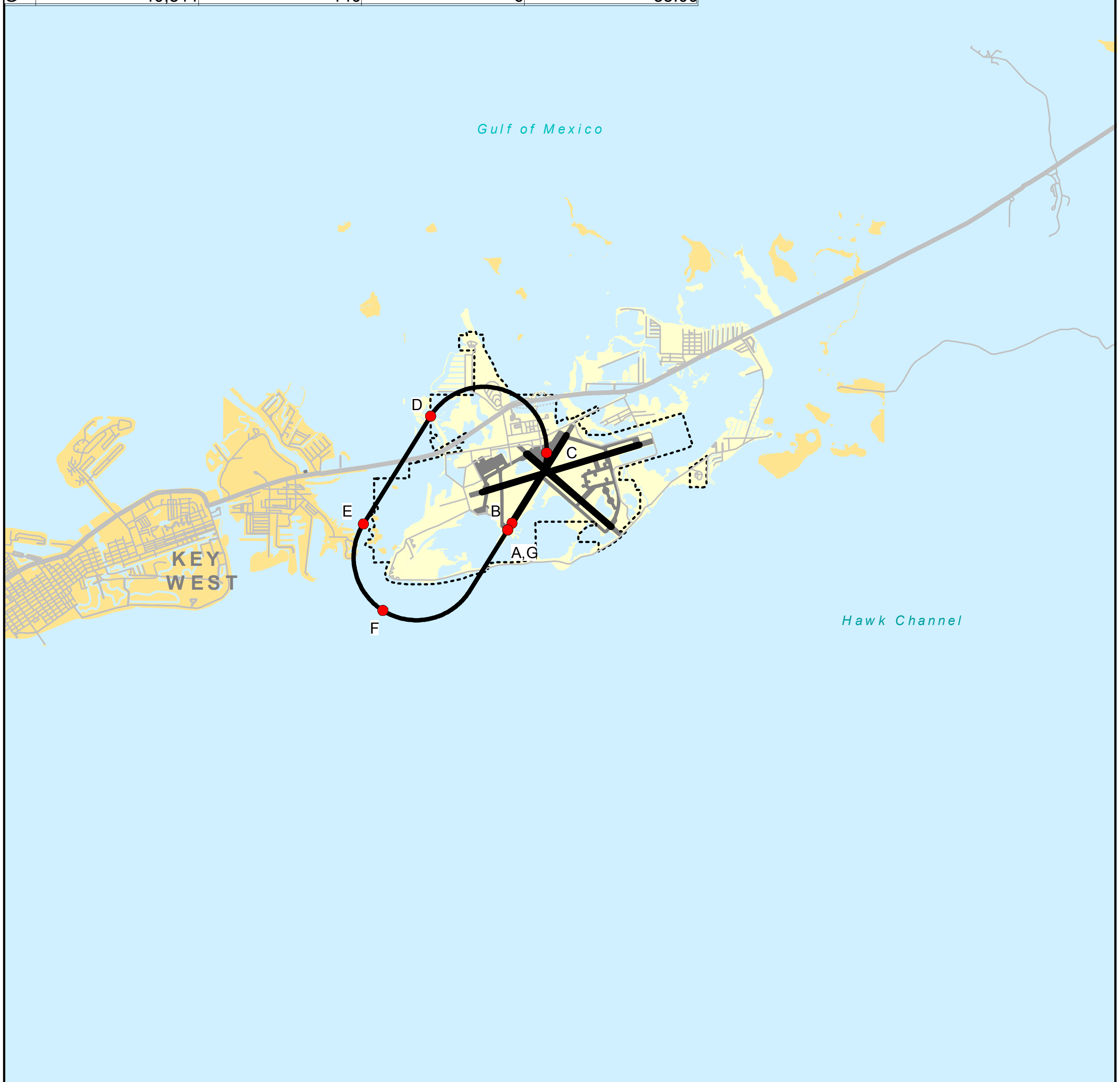
ID	CUMU_DIST	AIRSPEED	ALTITUDE	POWER
A	1	140	6	96.50
B	500	150	6	96.50
C	5,493	150	606	87.00
D	19,906	140	606	87.00
E	31,800	140	606	81.00
F	38,100	140	406	88.00
G	48,811	140	6	88.00



Appendix B

NAF Key West
Representative F/A-18 C/D
Touch and Go Flight Profile

ID	CUMU_DIST	AIRSPEED	ALTITUDE	POWER
A	1	140	6	96.50
B	500	150	6	96.50
C	5,493	150	606	87.00
D	15,881	140	606	87.00
E	23,881	140	606	81.00
F	30,072	140	406	88.00
G	40,811	140	6	88.00



Flight Track   Flight Profile Point

0 ft 10000 20000
N

Appendix B

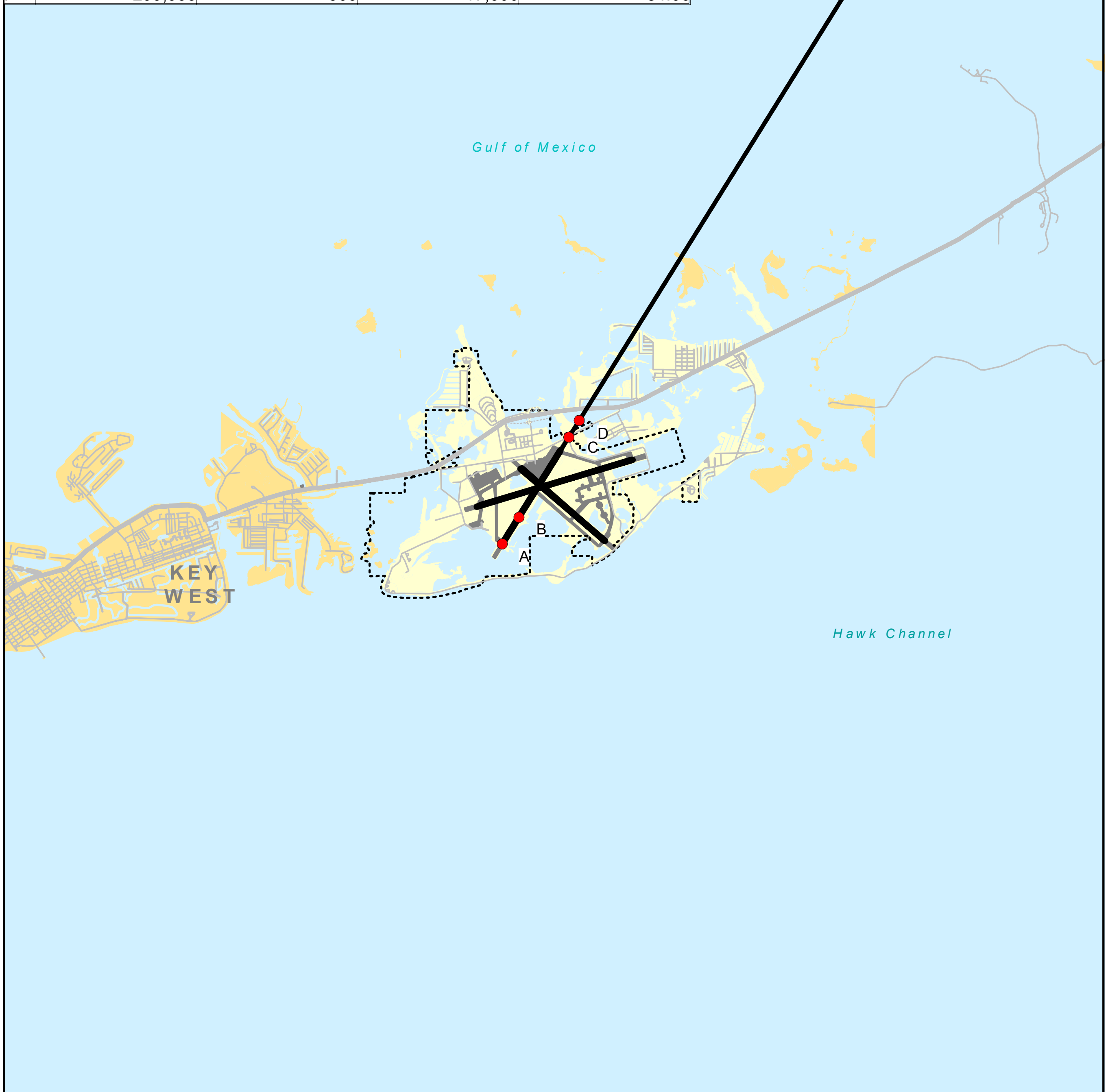
NAF Key West
Representative F/A-18 C/D
FCLP Flight Profile

Profiles.opx Profile_F18CD53103F1.wor 11/08/2002

APPENDIX C

MODELED F/A-18 E/F AIRCRAFT FLIGHT PROFILES

ID	CUMU_DIST	AIRSPEED	ALTITUDE	POWER
A	1	0	22	97.00
B	2,000	135	22	97.00
C	8,000	250	1,022	96.00
D	9,250	300	1,500	95.00
E	59,000	300	17,000	84.00
F	299,999	300	17,000	84.00



Flight Track   Flight Profile Point

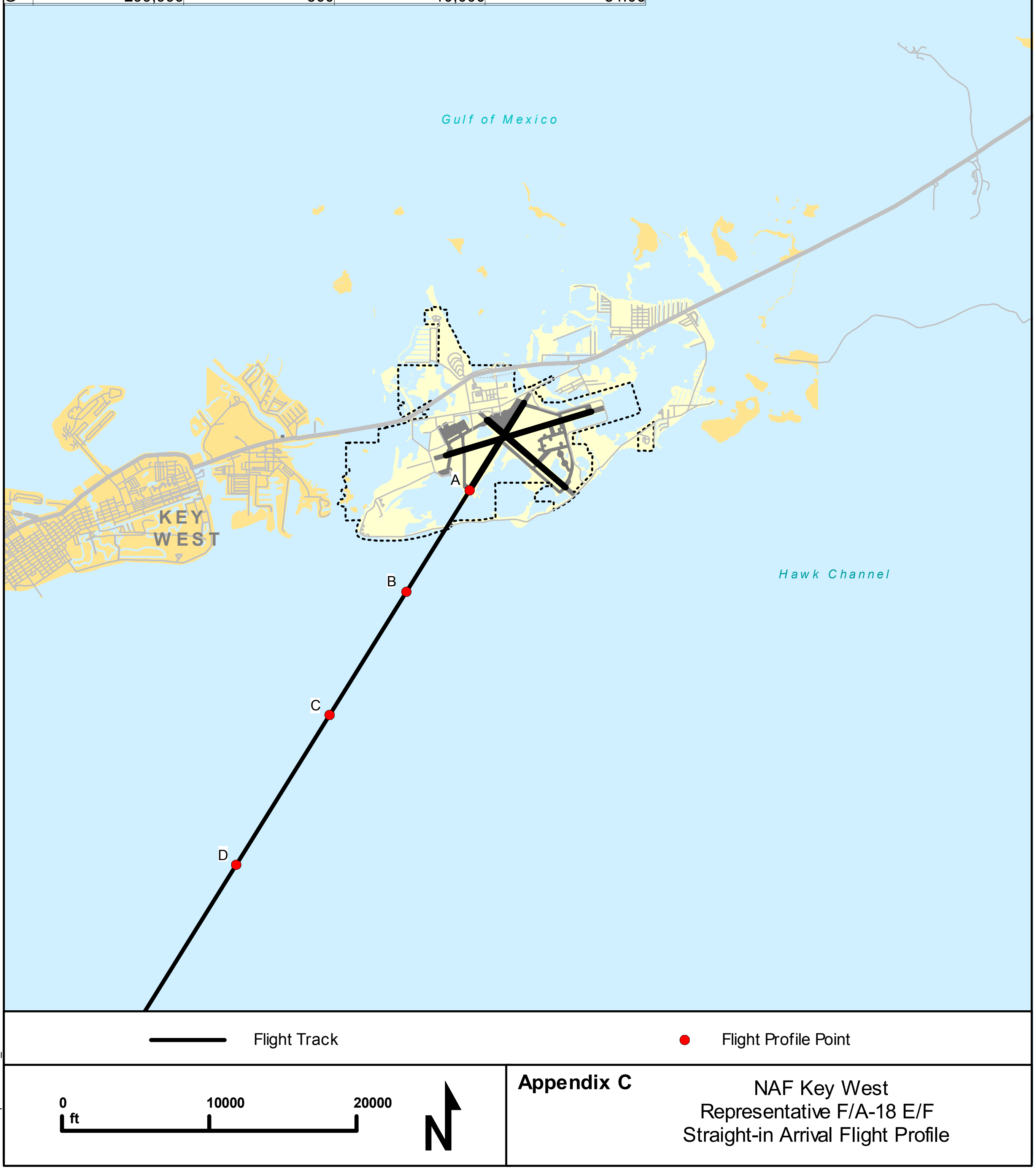
0 ft 10000 20000 N

Appendix C

NAF Key West
Representative F/A-18 E/F
Departure Flight Profile

Profiles.opx Profile_F18EF10103D1.wor 11/08/2002

ID	CUMU_DIST	AIRSPEED	ALTITUDE	POWER
A	1	130	72	85.00
B	8,125	130	522	85.00
C	18,000	130	1,222	85.00
D	30,000	250	2,000	80.00
E	97,000	300	5,000	80.00
F	121,000	300	10,000	75.00
G	299,999	300	10,000	84.00

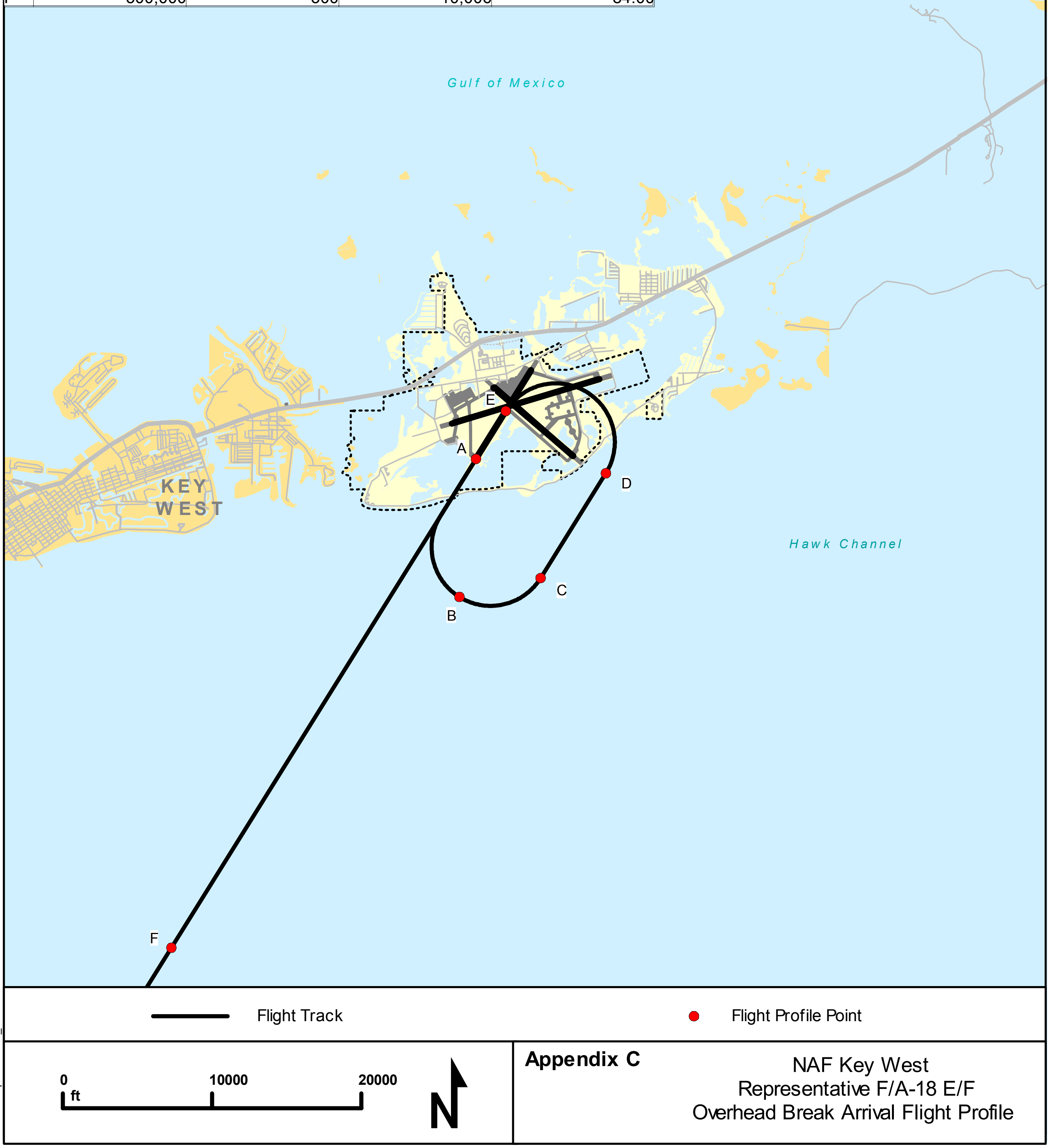


Appendix C

NAF Key West
Representative F/A-18 E/F
Straight-in Arrival Flight Profile

Profiles.opx Profile_F18EF11203A1.wor 11/08/2002

ID	CUMU_DIST	AIRSPEED	ALTITUDE	POWER
A	1	130	56	84.00
B	10,703	130	506	84.00
C	16,906	130	1,006	81.00
D	25,186	130	1,006	84.00
E	37,592	300	1,506	66.00
F	80,000	300	3,006	80.00
G	137,000	300	3,006	80.00
H	162,000	300	10,006	75.00
I	300,000	300	10,006	84.00

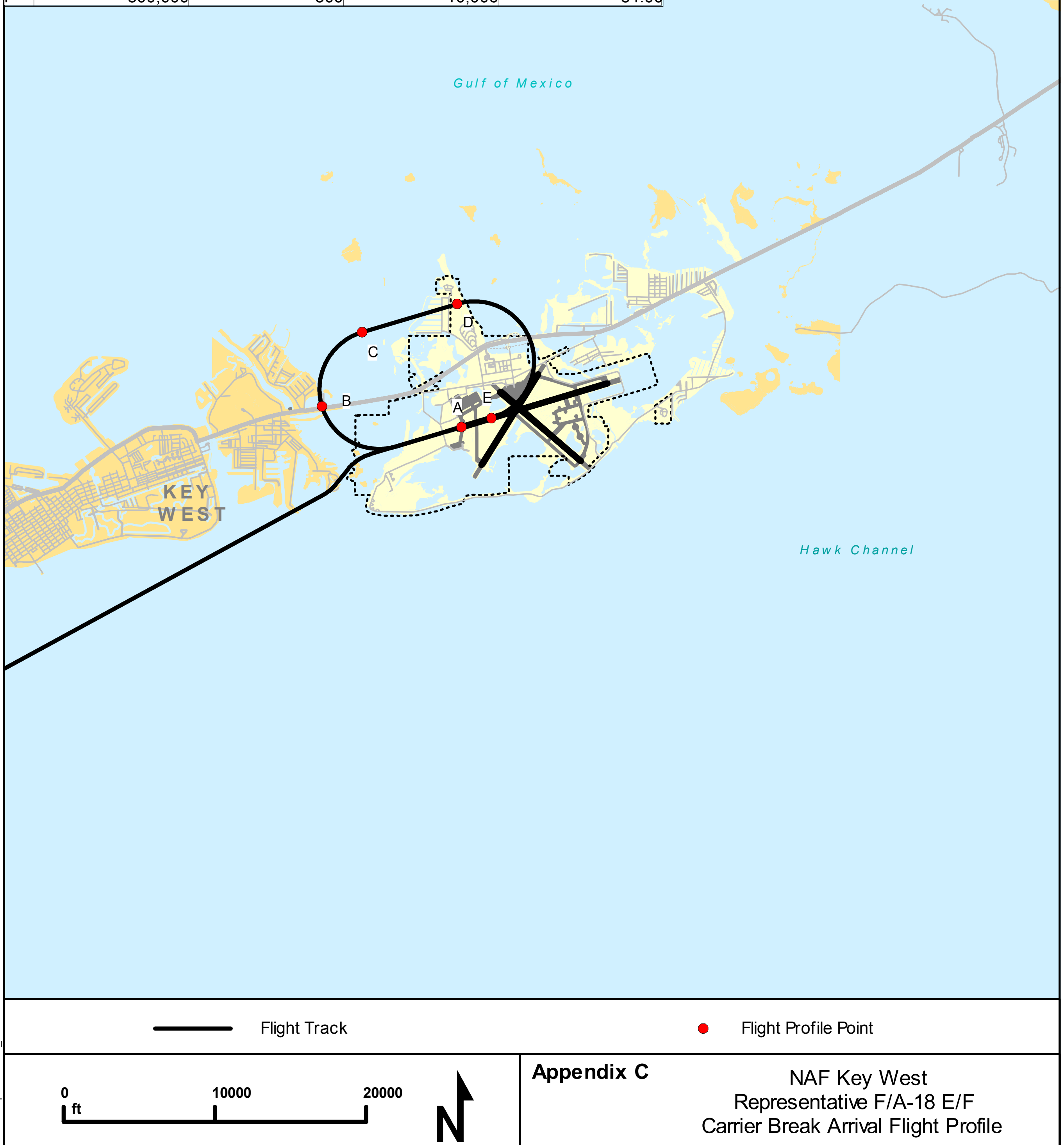


Appendix C

NAF Key West
Representative F/A-18 E/F
Overhead Break Arrival Flight Profile

Profiles.opx Profile_F18EF11803O1.wor 11/08/2002

ID	CUMU_DIST	AIRSPEED	ALTITUDE	POWER
A	1	130	56	84.00
B	10,703	130	506	84.00
C	16,906	130	606	81.00
D	23,466	130	606	84.00
E	35,872	300	806	66.00
F	80,000	300	3,006	80.00
G	137,000	300	3,006	80.00
H	162,000	300	10,006	75.00
I	300,000	300	10,006	84.00



Appendix C

NAF Key West
Representative F/A-18 E/F
Carrier Break Arrival Flight Profile

Profiles.opx Profile_F18EF124070 1.wor 11/08/2002

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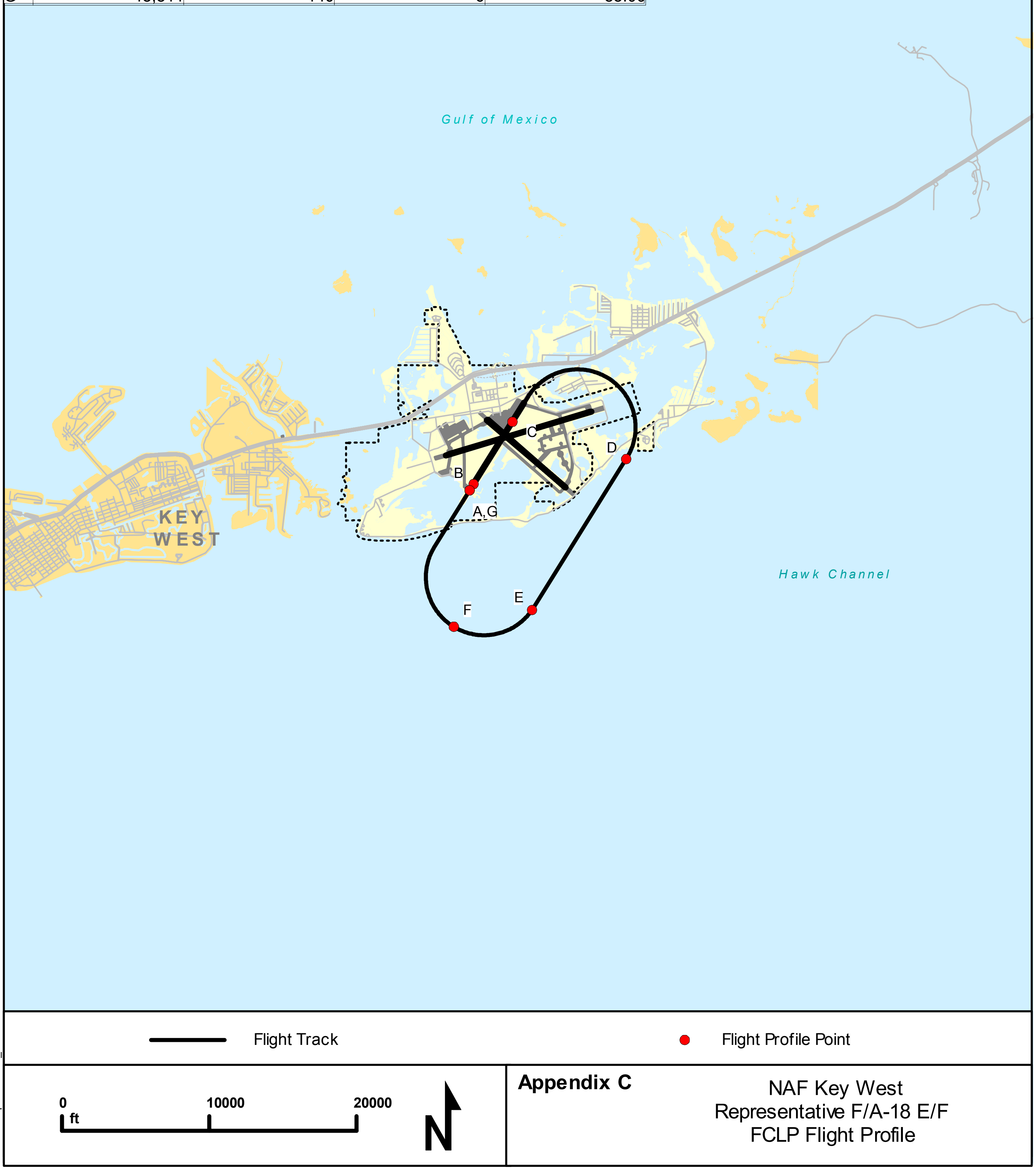
ID	CUMU_DIST	AIRSPEED	ALTITUDE	POWER
A	1	140	6	96.50
B	500	150	6	96.50
C	5,493	150	606	87.00
D	19,981	140	606	87.00
E	32,081	140	606	85.00
F	38,072	140	406	88.00
G	48,811	140	6	88.00



Appendix C

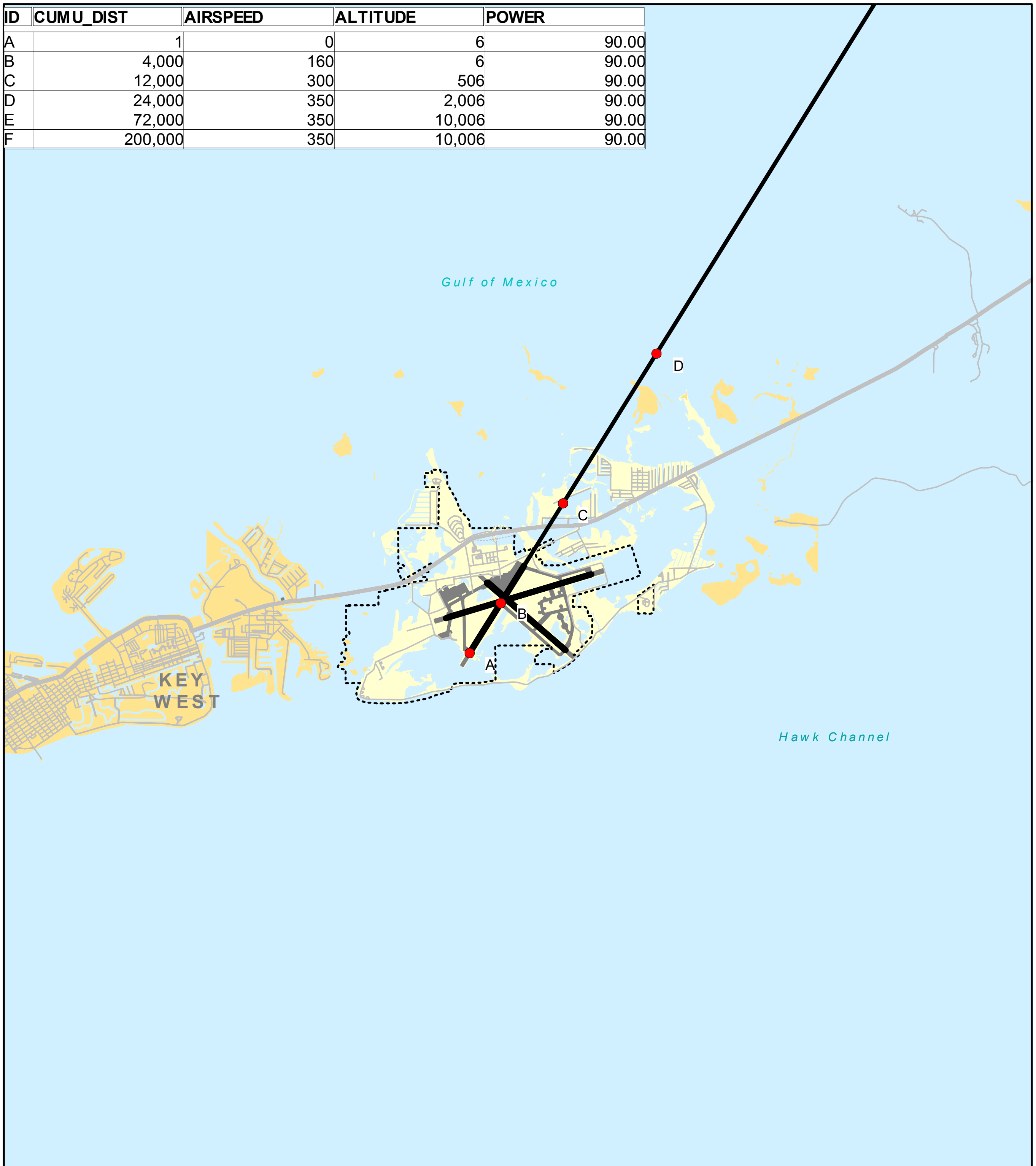
NAF Key West
Representative F/A-18 E/F
FCLP Flight Profile

Profiles.opx Profile_F18EF12503T2.wor 11/08/2002

APPENDIX D

MODELED F-15E AIRCRAFT FLIGHT PROFILES

ID	CUMU_DIST	AIRSPEED	ALTITUDE	POWER
A	1	0	6	90.00
B	4,000	160	6	90.00
C	12,000	300	506	90.00
D	24,000	350	2,006	90.00
E	72,000	350	10,006	90.00
F	200,000	350	10,006	90.00



Flight Track — Flight Profile Point

0 ft 10000 20000

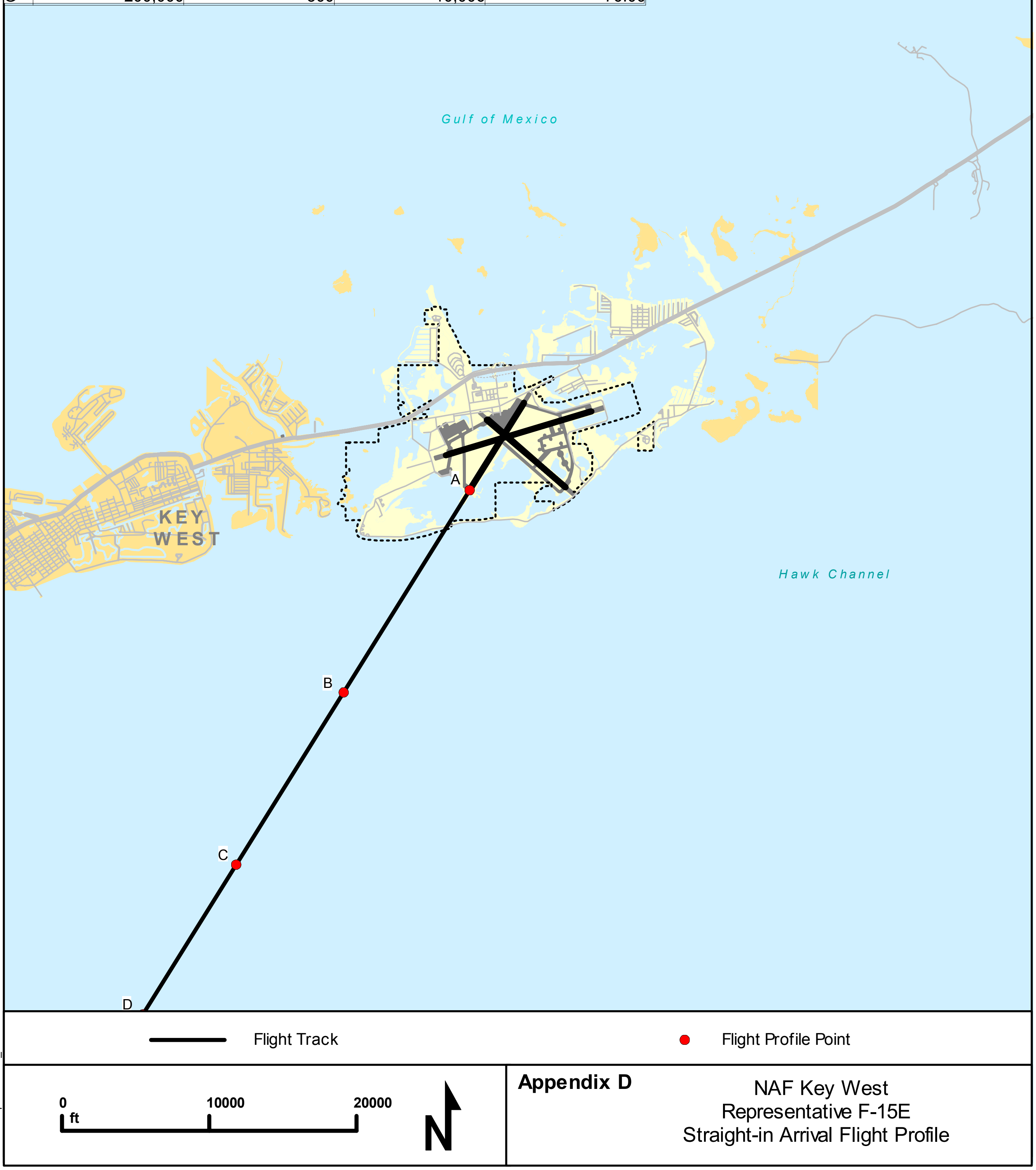
N

Appendix D

NAF Key West
Representative F-15E
Departure Flight Profile

Profiles.opx Profile_F15A30103D1.wor 11/08/2002

ID	CUMU_DIST	AIRSPEED	ALTITUDE	POWER
A	1	150	56	72.10
B	16,200	160	806	80.00
C	30,000	180	1,506	80.00
D	42,000	200	1,506	80.00
E	70,000	220	2,006	76.00
F	150,000	300	5,506	76.00
G	200,000	300	10,006	76.00

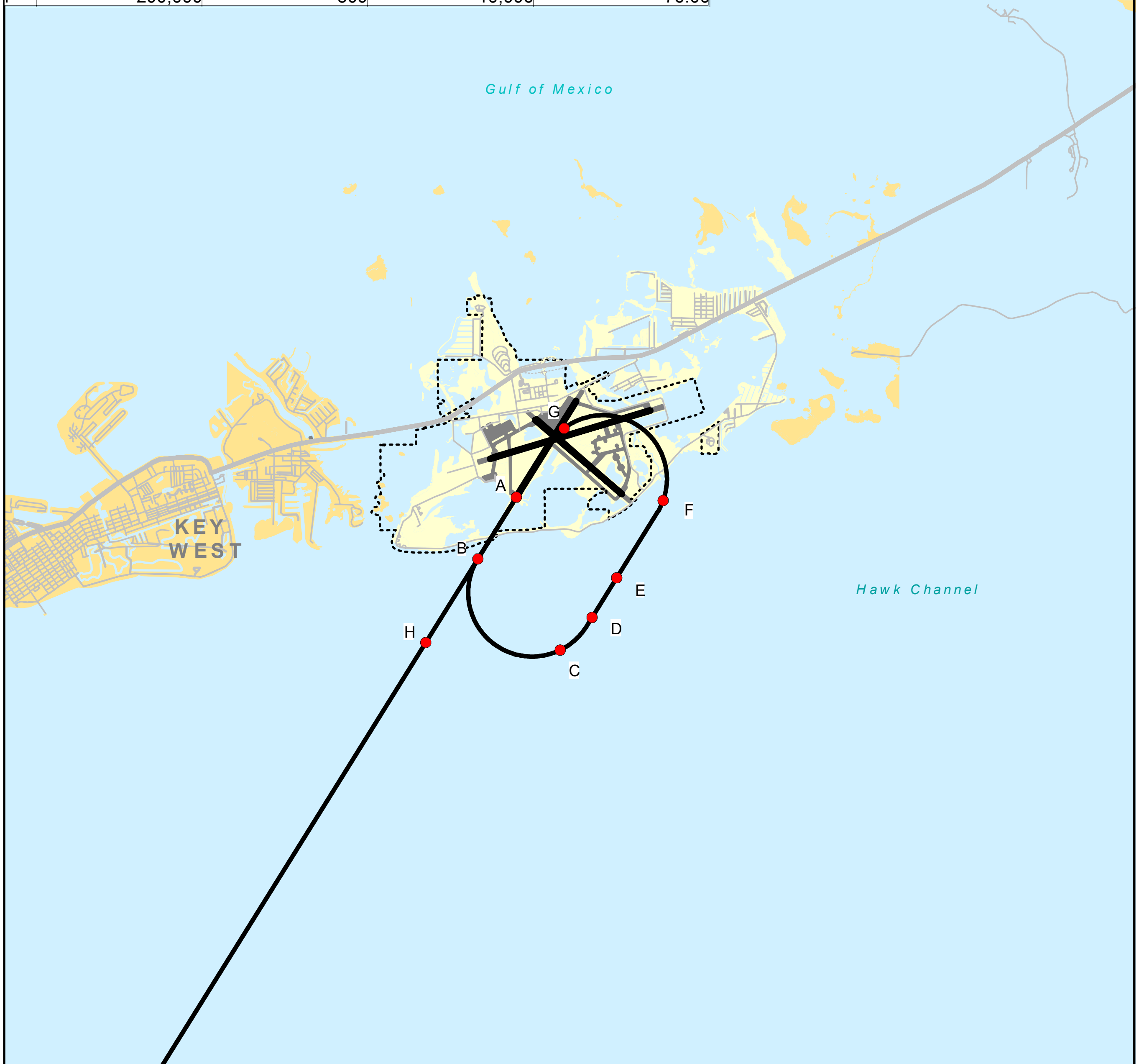


Appendix D

NAF Key West
Representative F-15E
Straight-in Arrival Flight Profile

Profiles.opx Profile_F15A31203A1.wor 11/08/2002

ID	CUMU_DIST	AIRSPEED	ALTITUDE	POWER
A	1	150	56	80.00
B	4,500	160	306	80.00
C	14,693	180	1,006	80.00
D	17,568	200	1,006	80.00
E	20,443	220	1,006	72.10
F	26,026	250	1,506	85.00
G	36,166	300	1,506	76.00
H	51,964	300	2,006	76.00
I	200,000	300	10,006	76.00



Flight Track — Flight Profile Point

0 ft 10000 20000

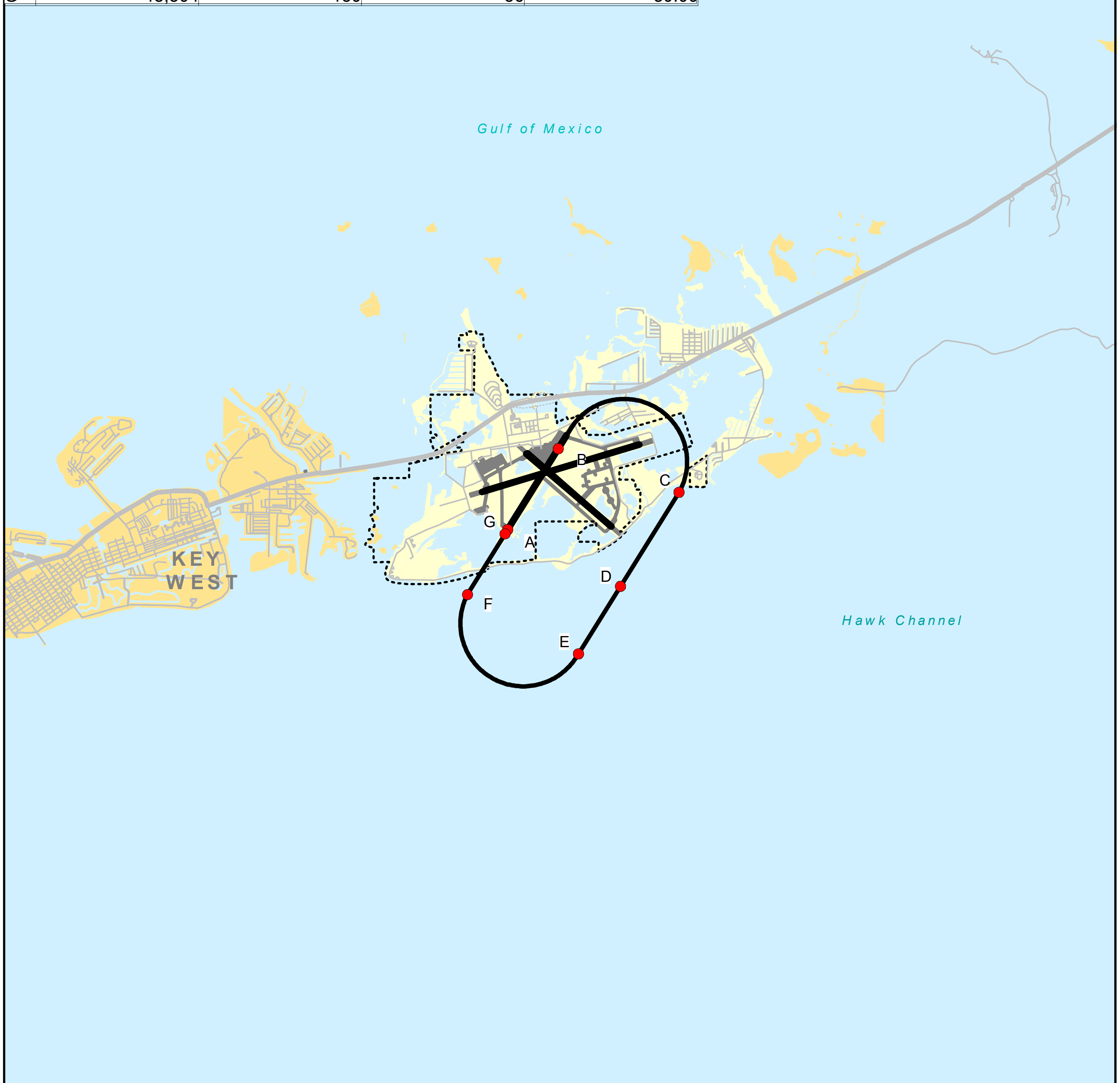
N

Appendix D

NAF Key West
Representative F-15E
Overhead Break Arrival Flight Profile

Profiles.opx Profile_F15A31803O1.wor 11/08/2002

ID	CUMU_DIST	AIRSPEED	ALTITUDE	POWER
A	1	150	56	90.00
B	6,000	250	206	90.00
C	19,723	240	1,006	72.10
D	26,693	220	1,006	80.00
E	31,693	180	1,006	80.00
F	44,004	160	306	80.00
G	48,504	150	56	80.00



Flight Track

Flight Profile Point

0 ft 10000 20000

N

Appendix D

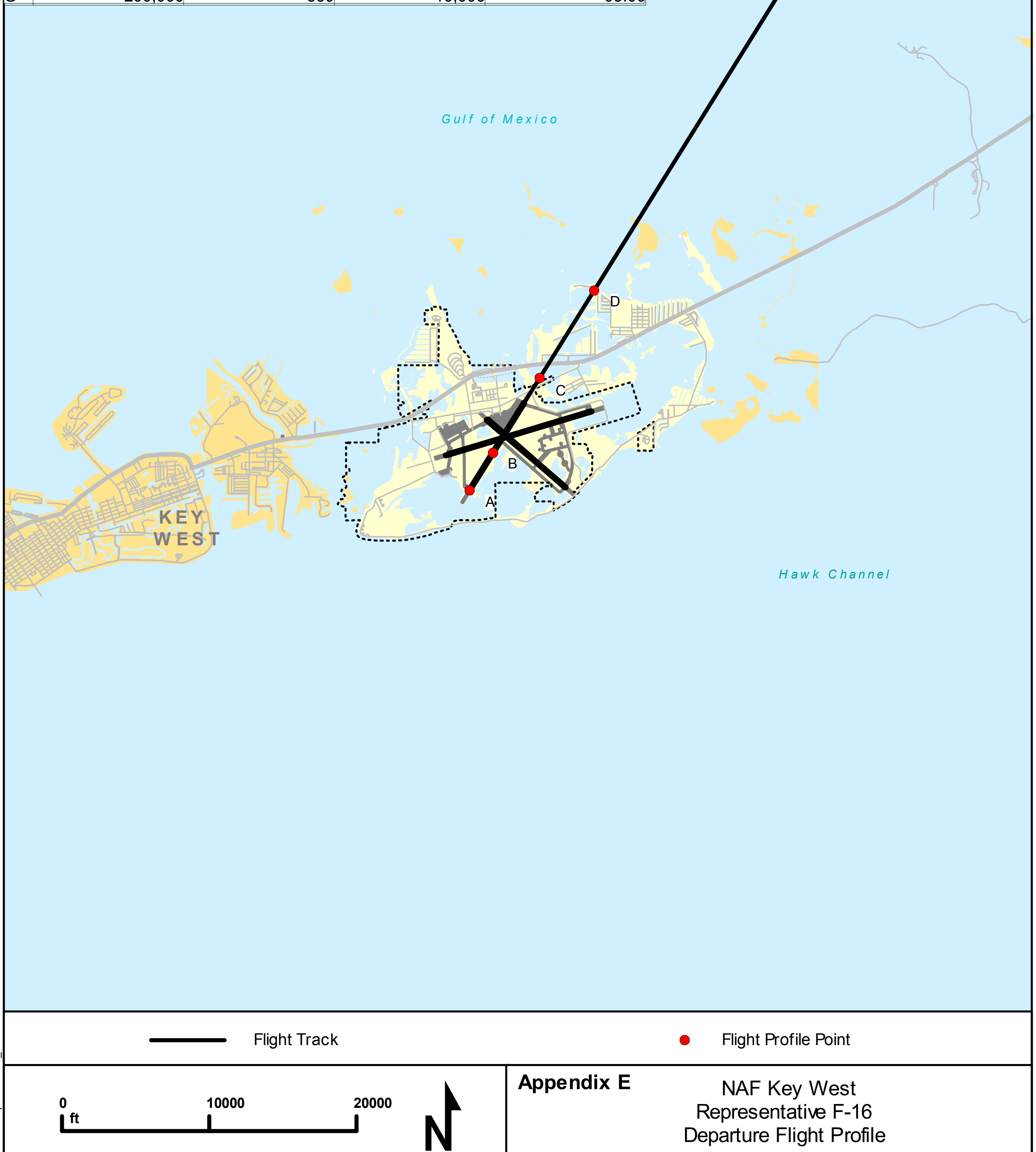
NAF Key West
Representative F-15E
Touch and Go Flight Profile

Profiles.opx Profile_F15A32403T2.wor 11/08/2002

APPENDIX E

MODELED F-16 AIRCRAFT FLIGHT PROFILES

ID	CUMU_DIST	AIRSPEED	ALTITUDE	POWER
A	1	0	6	103.00
B	3,000	150	6	105.00
C	9,000	300	506	93.00
D	16,000	350	706	93.00
E	55,000	350	5,006	93.00
F	100,000	350	10,006	93.00
G	200,000	350	10,006	93.00

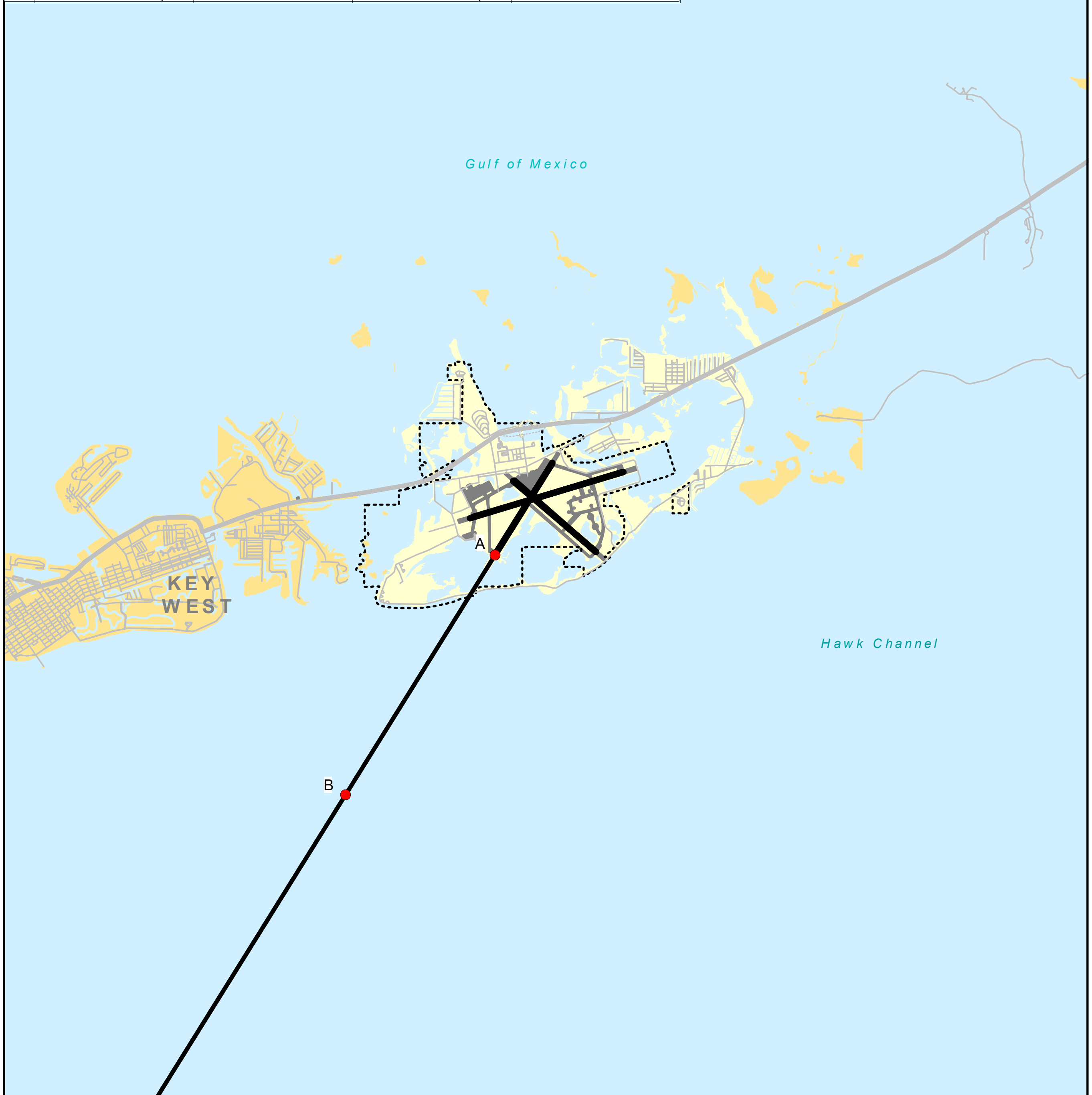


Profiles.opx Profile_F16C40103D1.wor 11/08/2002

Appendix E

NAF Key West
Representative F-16
Departure Flight Profile

ID	CUMU_DIST	AIRSPEED	ALTITUDE	POWER
A	1	140	56	83.00
B	18,228	180	2,006	85.00
C	66,300	250	2,706	85.00
D	128,800	300	5,006	85.00
E	200,000	300	5,006	85.00



Flight Track
Flight Profile Point

0 ft 10000 20000

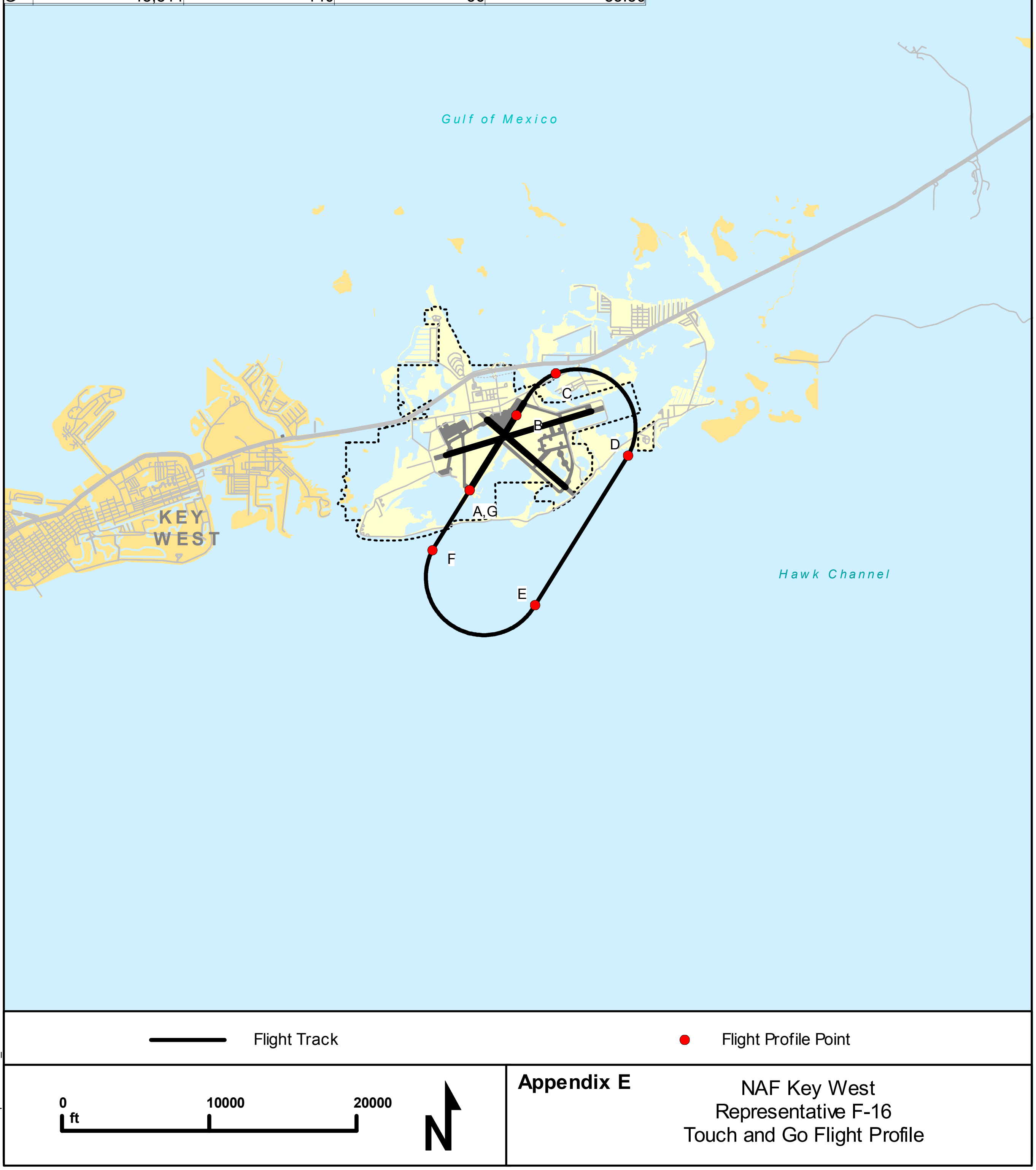
N

Appendix E

NAF Key West
Representative F-16
Straight-in Arrival Flight Profile

Profiles.opx Profile_F16C41203A1.wor 11/08/2002

ID	CUMU_DIST	AIRSPEED	ALTITUDE	POWER
A	1	140	6	104.00
B	6,000	200	6	104.00
C	10,000	250	606	104.00
D	19,723	250	1,006	85.00
E	31,693	200	1,006	83.50
F	44,004	170	306	83.50
G	48,811	140	56	83.50

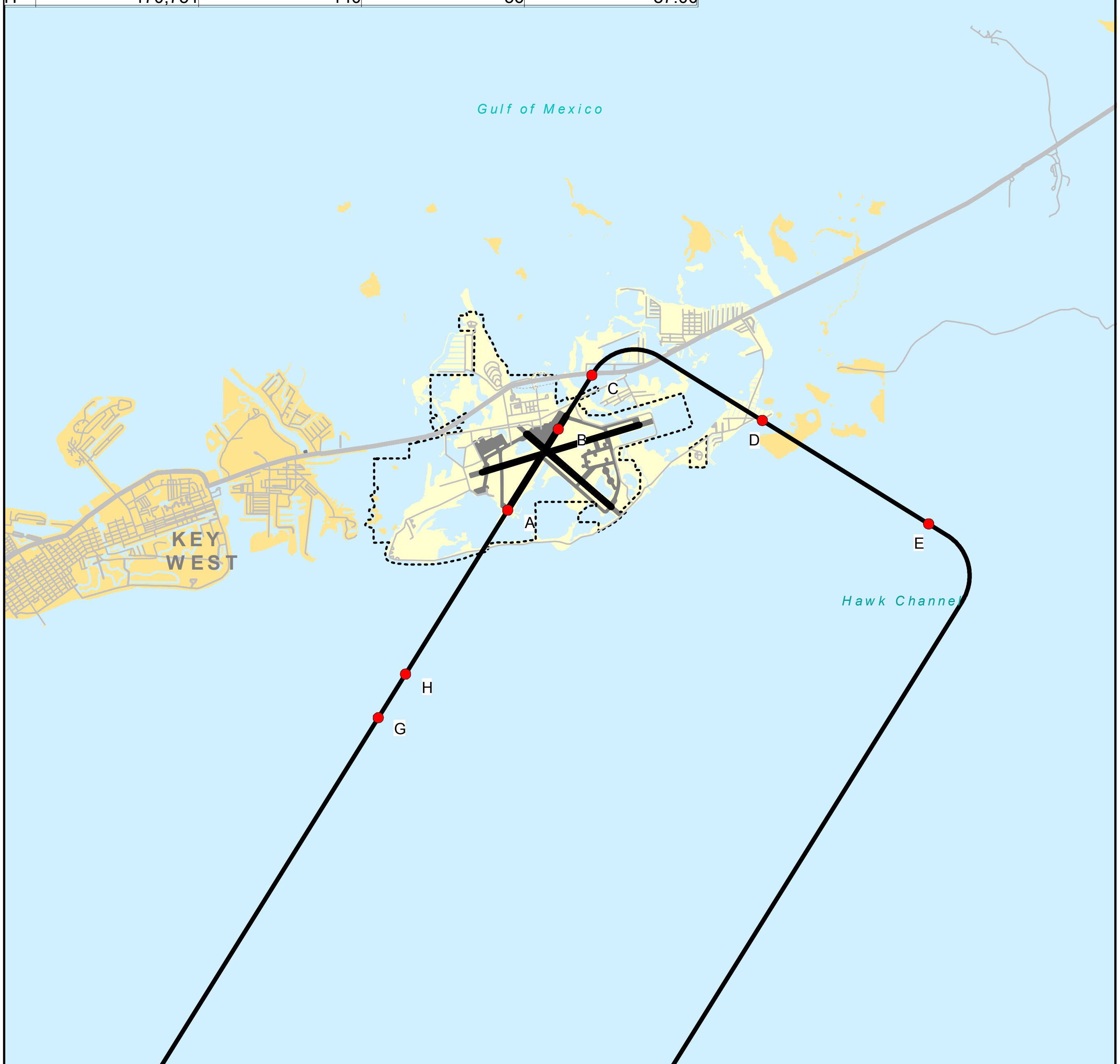


Appendix E

NAF Key West
Representative F-16
Touch and Go Flight Profile

Profiles.opx Profile_F16C41803T2.wor 11/08/2002

ID	CUMU_DIST	AIRSPEED	ALTITUDE	POWER
A	1	140	6	104.00
B	6,000	200	6	104.00
C	10,000	250	606	87.00
D	22,547	250	1,506	87.00
E	34,854	250	1,506	87.00
F	107,922	200	1,506	87.00
G	167,518	160	606	87.00
H	170,751	140	56	87.00



Flight Track   Flight Profile Point

0 ft 10000 20000

N

Appendix E

NAF Key West
Representative F-16
GCA Flight Profile

Profiles.opx Profile_F16C42403G1.wor 11/08/2002

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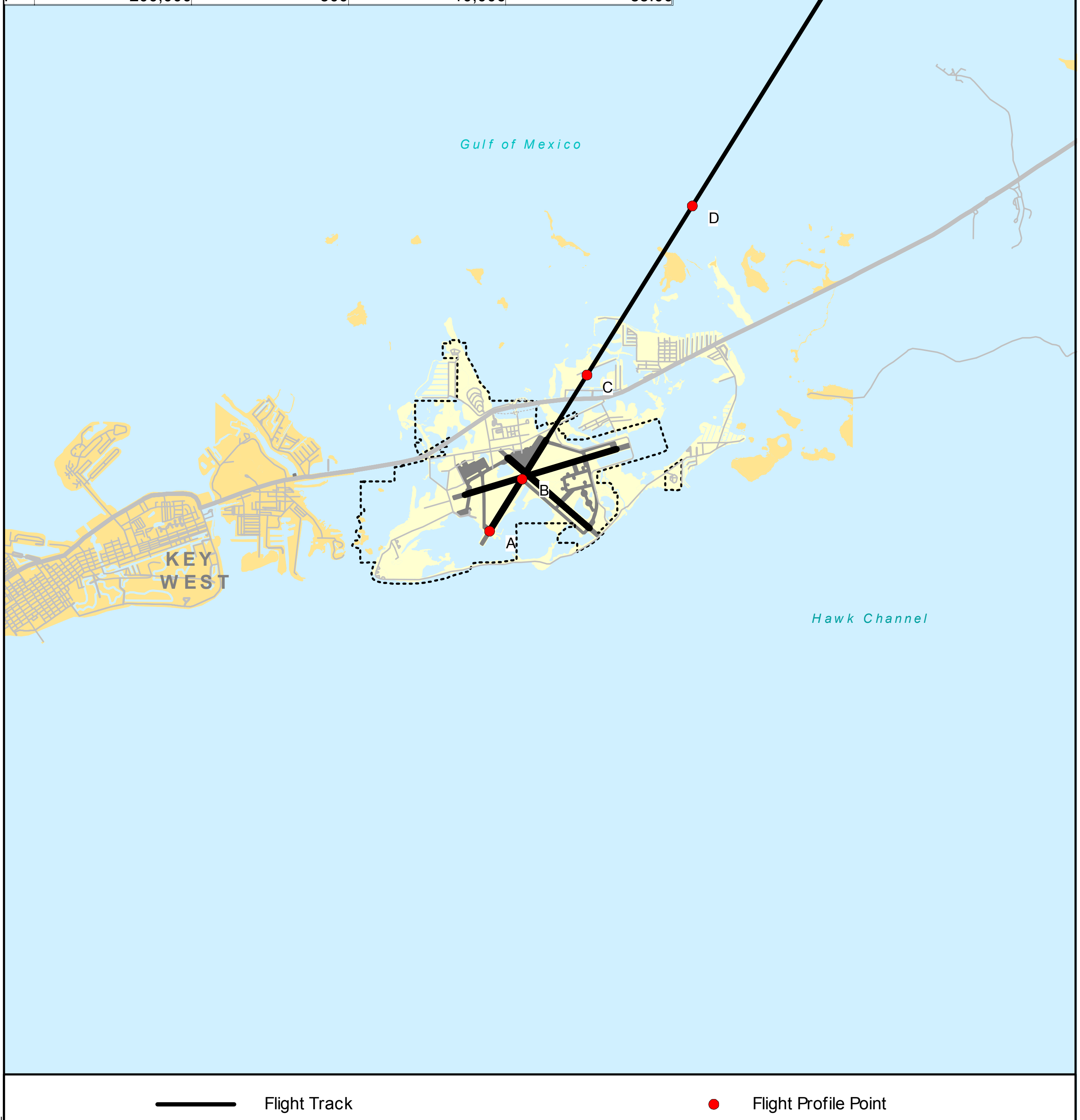
APPENDIX F

MODELED A-4C AIRCRAFT FLIGHT PROFILES

ID	CUMU_DIST	AIRSPEED	ALTITUDE	POWER
A	1	0	6	85.00
B	4,000	140	6	100.00
C	12,000	200	206	100.00
D	25,000	250	1,506	100.00
E	50,000	300	5,006	100.00
F	200,000	300	10,006	85.00



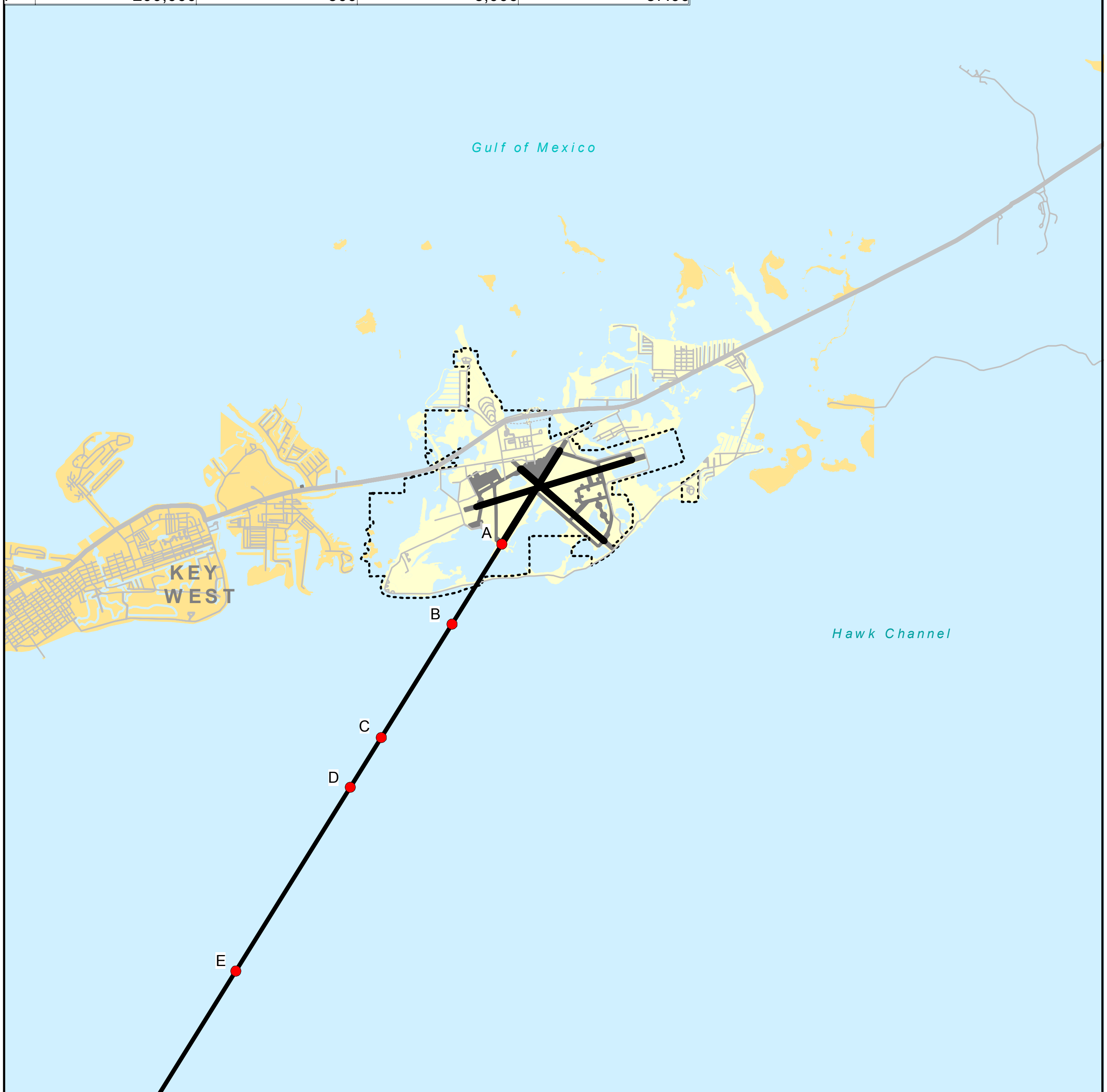
Appendix F

NAF Key West
Representative A-4C
Departure Flight Profile

Profiles.opx Profile_A4C60103D1.wor 11/08/2002

wyle laboratories

ID	CUMU_DIST	AIRSPEED	ALTITUDE	POWER
A	1	150	56	88.00
B	6,000	200	1,006	87.00
C	14,500	230	1,506	87.00
D	18,228	250	2,006	88.00
E	32,000	300	2,506	87.00
F	200,000	300	5,006	87.00



Flight Track   Flight Profile Point

0 ft 10000 20000

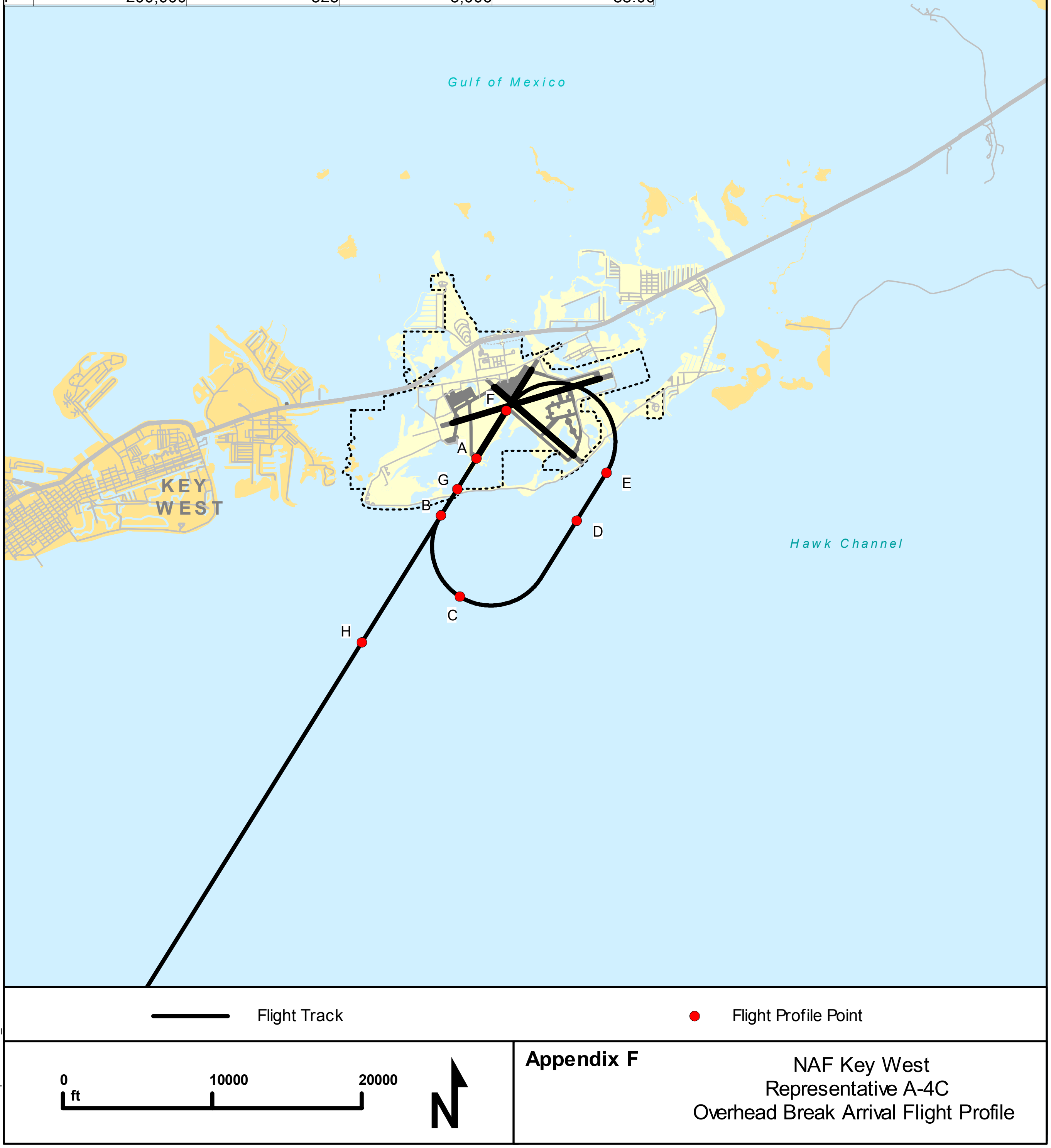
N

Appendix F

NAF Key West
Representative A-4C
Straight-in Arrival Flight Profile

Profiles.opx Profile_A4C61203A1.wor 11/08/2002

ID	CUMU_DIST	AIRSPEED	ALTITUDE	POWER
A	1	150	56	83.00
B	4,500	150	506	83.00
C	10,703	150	606	83.00
D	21,406	180	1,006	83.00
E	25,186	220	1,006	83.00
F	37,592	325	1,506	83.00
G	43,792	325	1,506	83.00
H	55,892	325	2,006	87.00
I	200,000	325	5,006	88.00

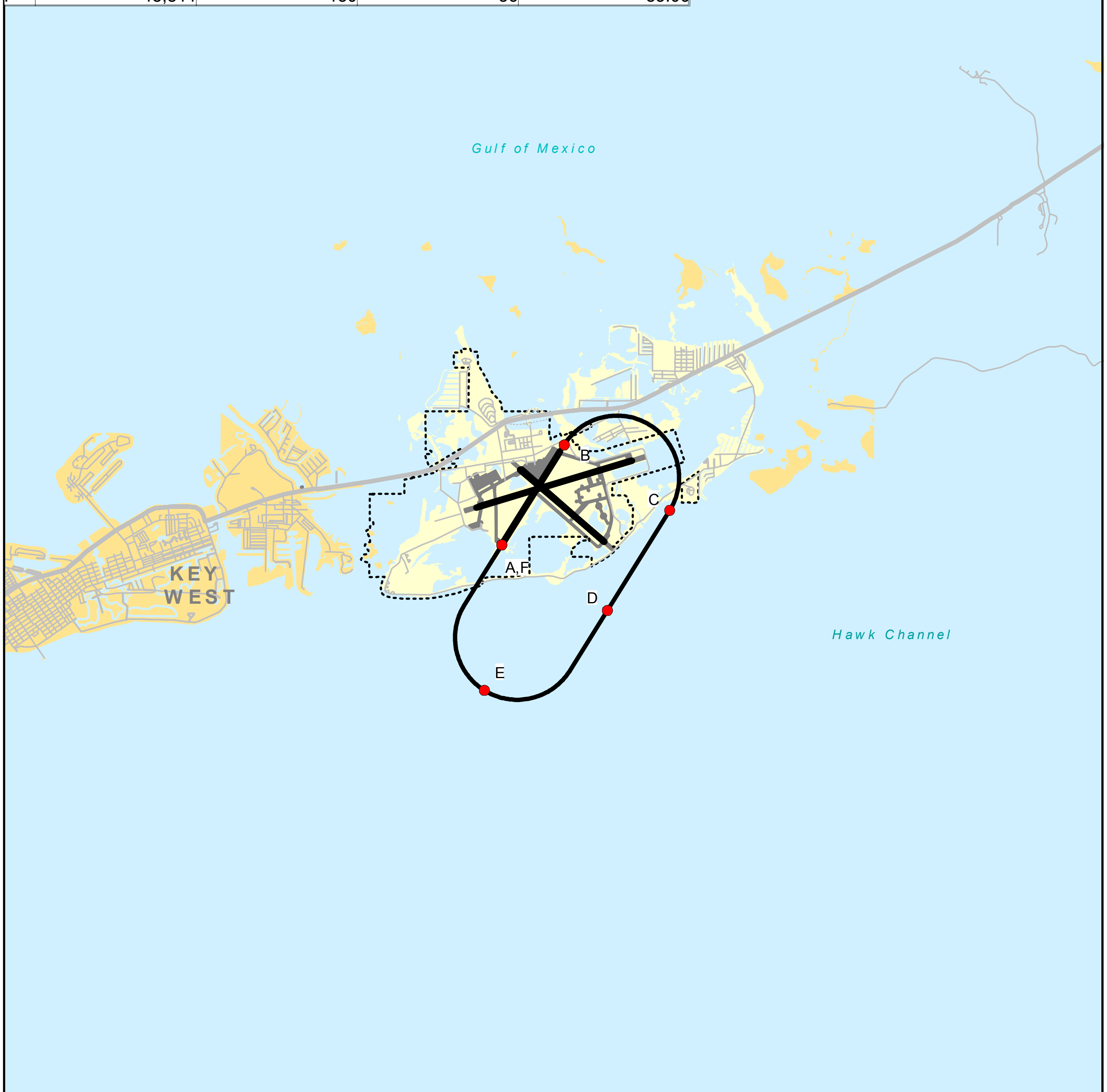


Profiles.opx Profile_A4C61803O1.wor 11/08/2002

Appendix F

NAF Key West
Representative A-4C
Overhead Break Arrival Flight Profile

ID	CUMU_DIST	AIRSPEED	ALTITUDE	POWER
A	1	150	6	87.00
B	7,500	180	656	87.00
C	19,906	180	1,006	83.00
D	27,406	180	1,006	83.00
E	38,109	150	606	83.00
F	48,811	150	56	83.00



Flight Track — Flight Profile Point

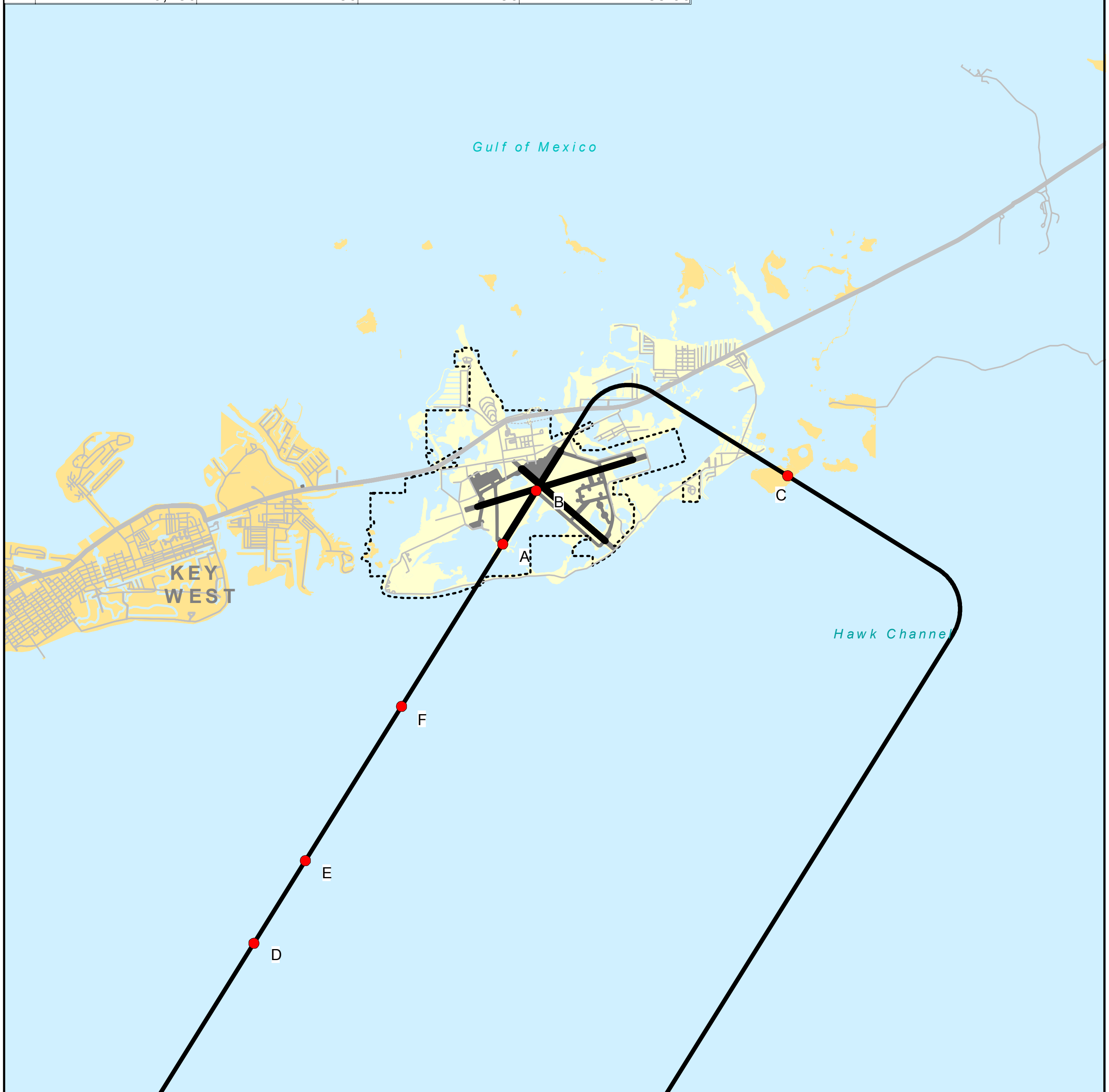
0 ft 10000 20000 N

Appendix F

NAF Key West
Representative A-4C
Touch and Go Flight Profile

Profiles.opx Profile_A4C62403T2.wor 11/08/2002

ID	CUMU_DIST	AIRSPEED	ALTITUDE	POWER
A	1	0	6	85.00
B	4,000	140	6	100.00
C	25,000	250	1,506	100.00
D	153,019	230	1,506	87.00
E	159,205	200	1,506	87.00
F	170,750	150	56	88.00



Flight Track   Flight Profile Point

0 ft 10000 20000

N

Appendix F

NAF Key West
Representative A-4C
GCA Flight Profile

Profiles.opx Profile_A4C63003G1.wor 11/08/2002

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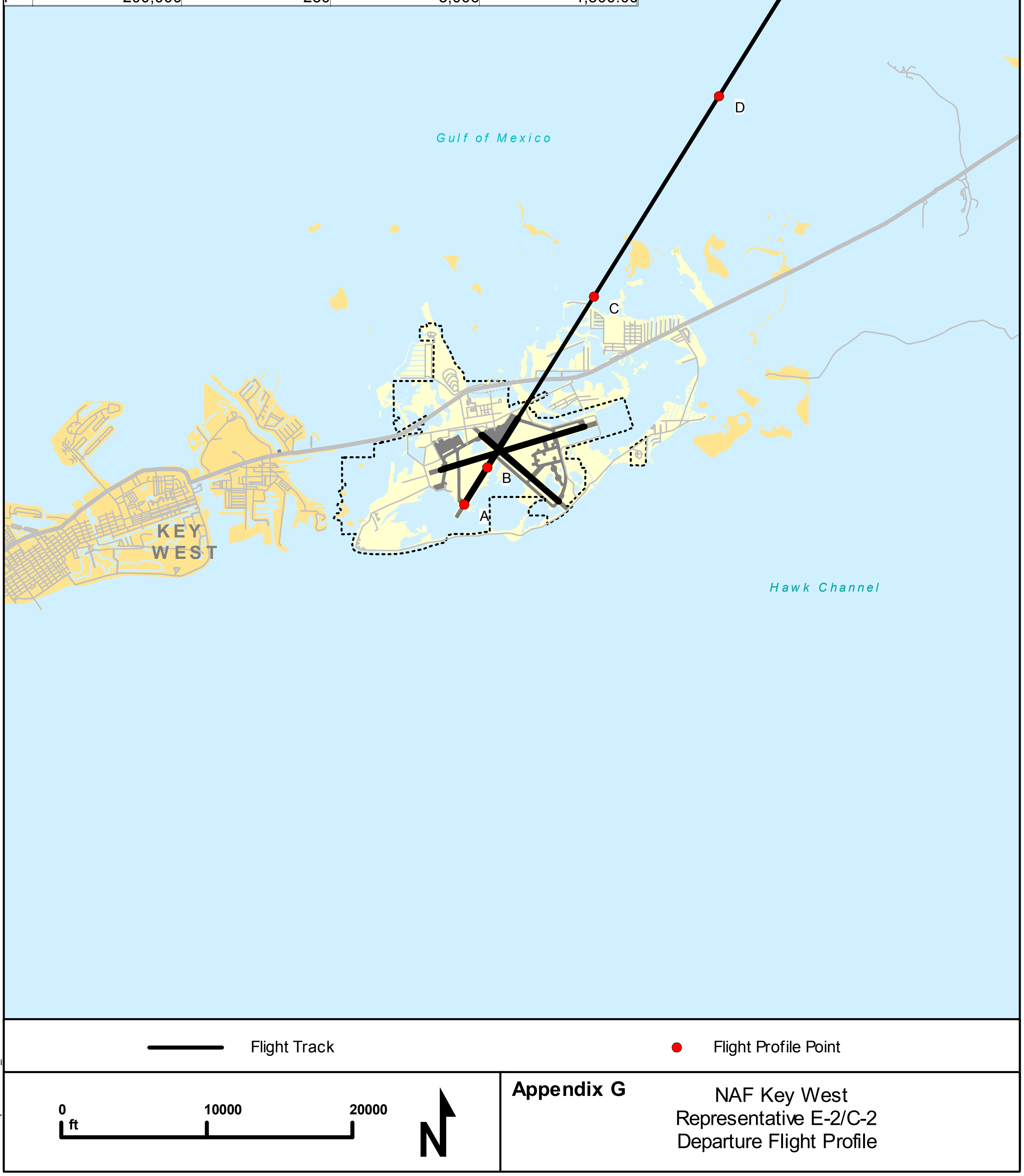
APPENDIX G

MODELED E-2/C-2 AIRCRAFT FLIGHT PROFILES

ID	CUMU_DIST	AIRSPEED	ALTITUDE	POWER
A	1	0	6	4,600.00
B	3,000	180	6	4,600.00
C	16,860	200	1,506	2,000.00
D	33,115	200	2,506	2,000.00
E	46,437	250	5,006	1,500.00
F	200,000	250	5,006	1,500.00

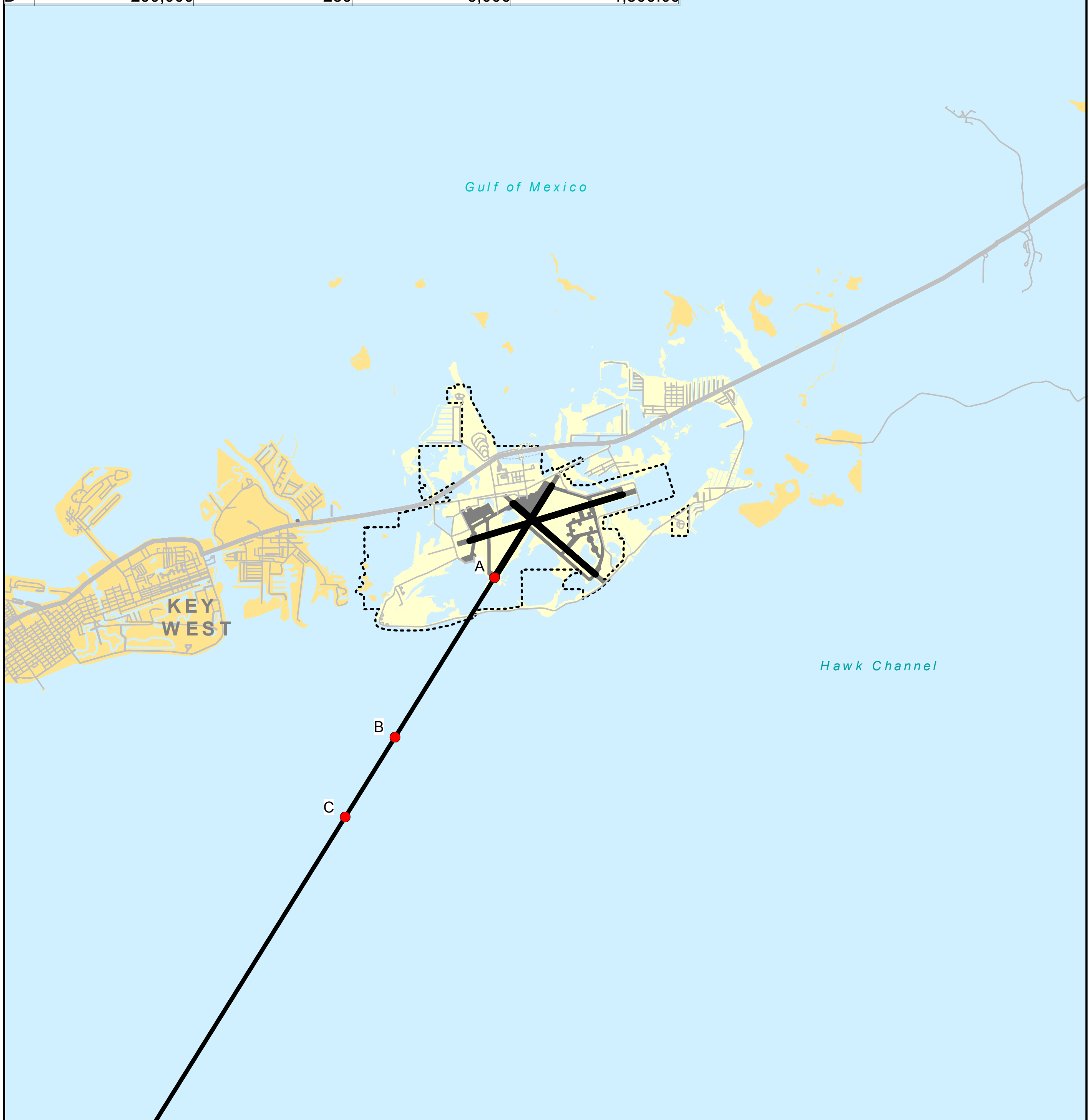


Appendix G

NAF Key West
Representative E-2/C-2
Departure Flight Profile

Profiles.opx Profile_E2C70103D1.wor 11/08/2002

ID	CUMU_DIST	AIRSPEED	ALTITUDE	POWER
A	1	120	56	1,300.00
B	12,152	120	2,006	1,300.00
C	18,228	250	3,006	1,500.00
D	200,000	250	5,006	1,500.00



Flight Track — Flight Profile Point

0 ft 10000 20000

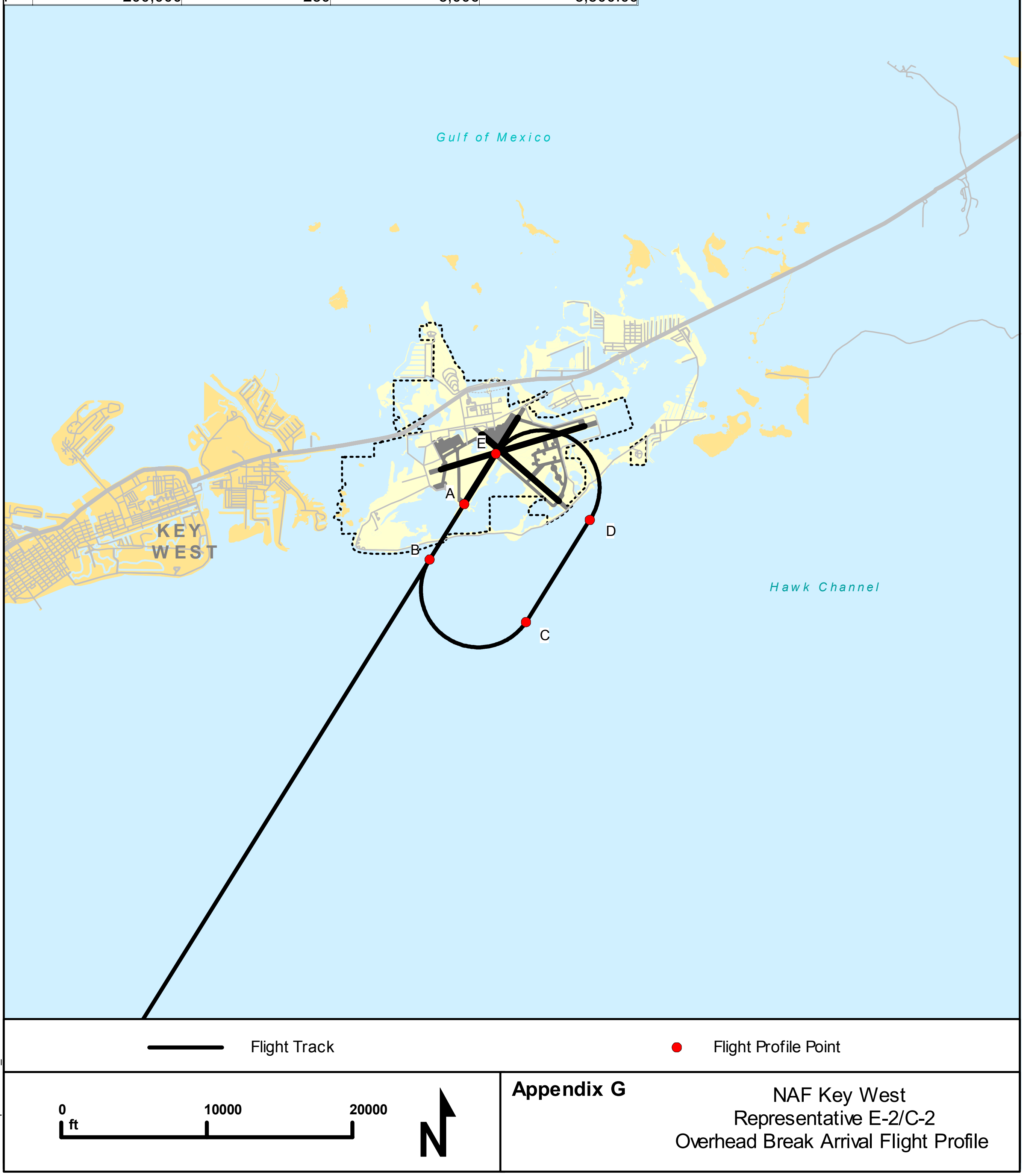
N

Appendix G

NAF Key West
Representative E-2/C-2
Straight-in Arrival Flight Profile

Profiles.opx Profile_E2C71203A1.wor 11/08/2002

ID	CUMU_DIST	AIRSPEED	ALTITUDE	POWER
A	1	120	56	1,300.00
B	4,500	120	506	1,300.00
C	16,752	120	1,006	1,300.00
D	25,032	120	1,006	1,500.00
E	37,284	250	1,506	3,500.00
F	200,000	250	5,006	3,500.00

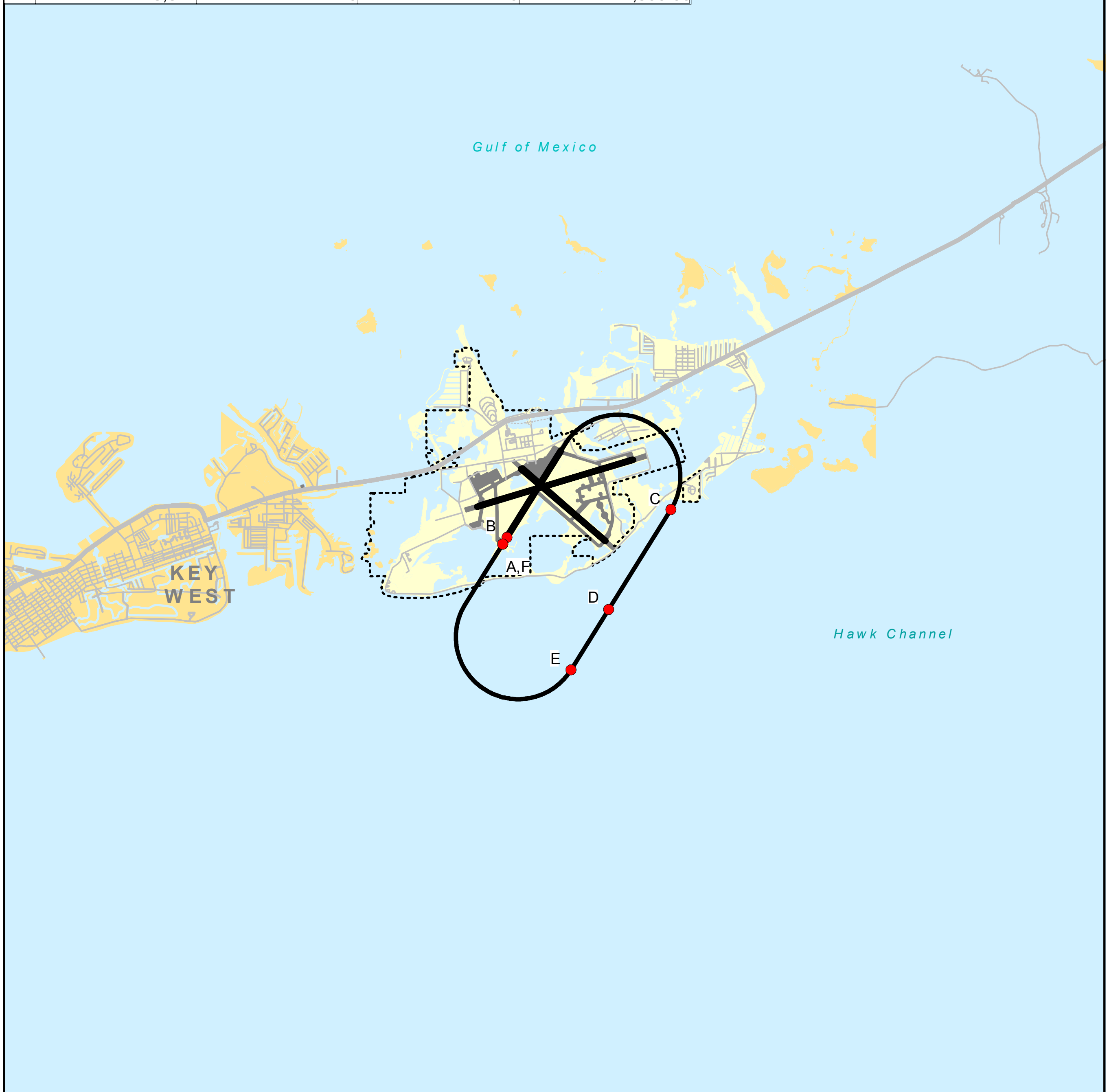


Profiles.opx Profile_E2C718030O1.wor 11/08/2002

Appendix G

NAF Key West
Representative E-2/C-2
Overhead Break Arrival Flight Profile

ID	CUMU_DIST	AIRSPEED	ALTITUDE	POWER
A	1	160	6	4,600.00
B	500	160	6	4,600.00
C	19,906	120	1,006	1,500.00
D	27,379	120	1,006	1,300.00
E	31,906	120	1,006	1,300.00
F	48,811	120	6	1,300.00



Flight Track — Flight Profile Point

0 ft 10000 20000

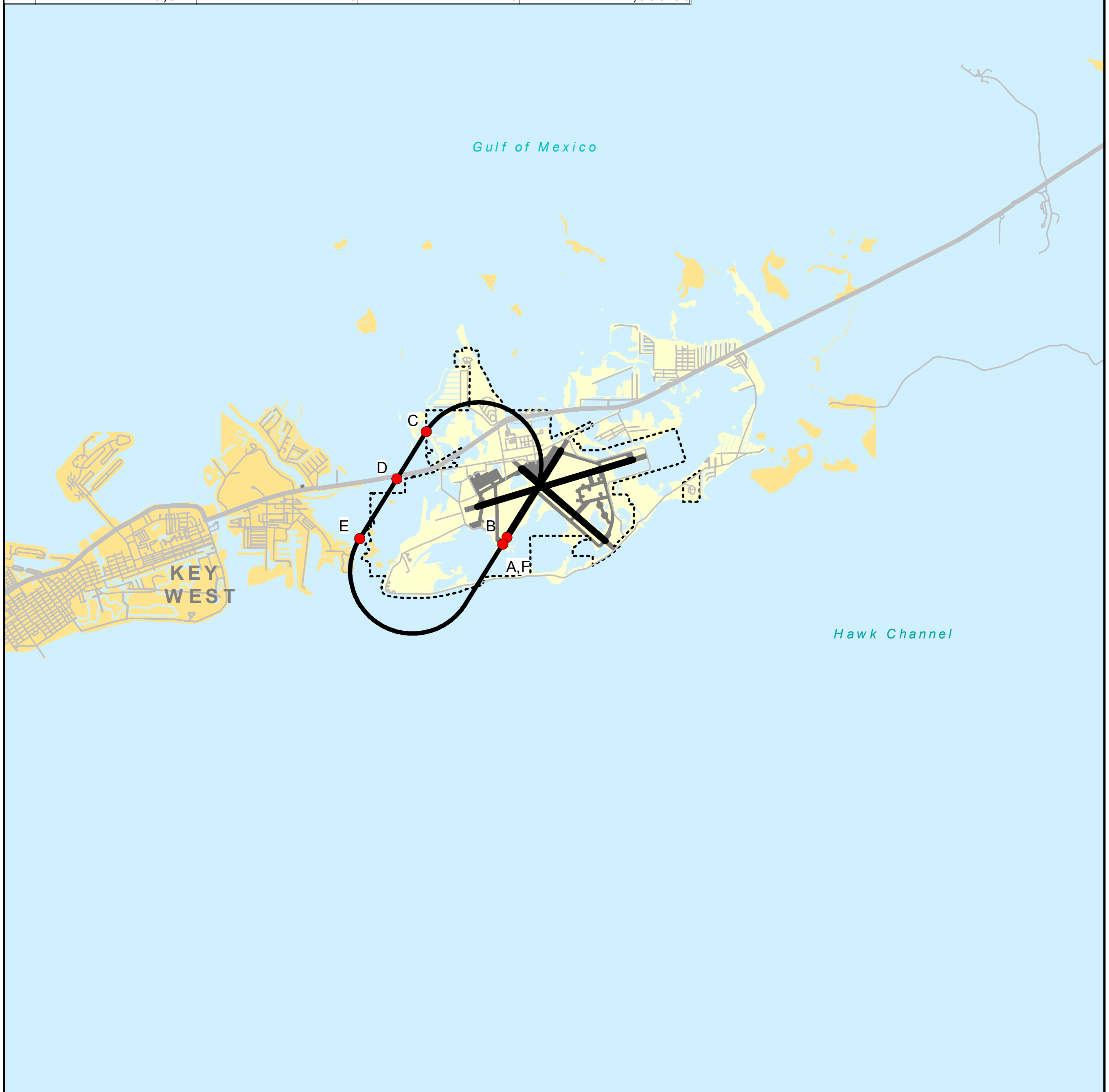
N

Appendix G

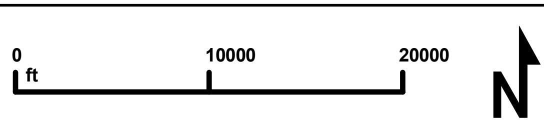
NAF Key West
Representative E-2/C-2
Touch and Go Flight Profile

Profiles.opx Profile_E2C72403T2.wor 11/08/2002

ID	CUMU_DIST	AIRSPEED	ALTITUDE	POWER
A	1	160	6	4,600.00
B	500	160	6	4,600.00
C	15,906	120	606	1,500.00
D	19,430	120	606	1,300.00
E	23,906	120	606	1,300.00
F	40,811	120	6	1,300.00



Flight Track   Flight Profile Point

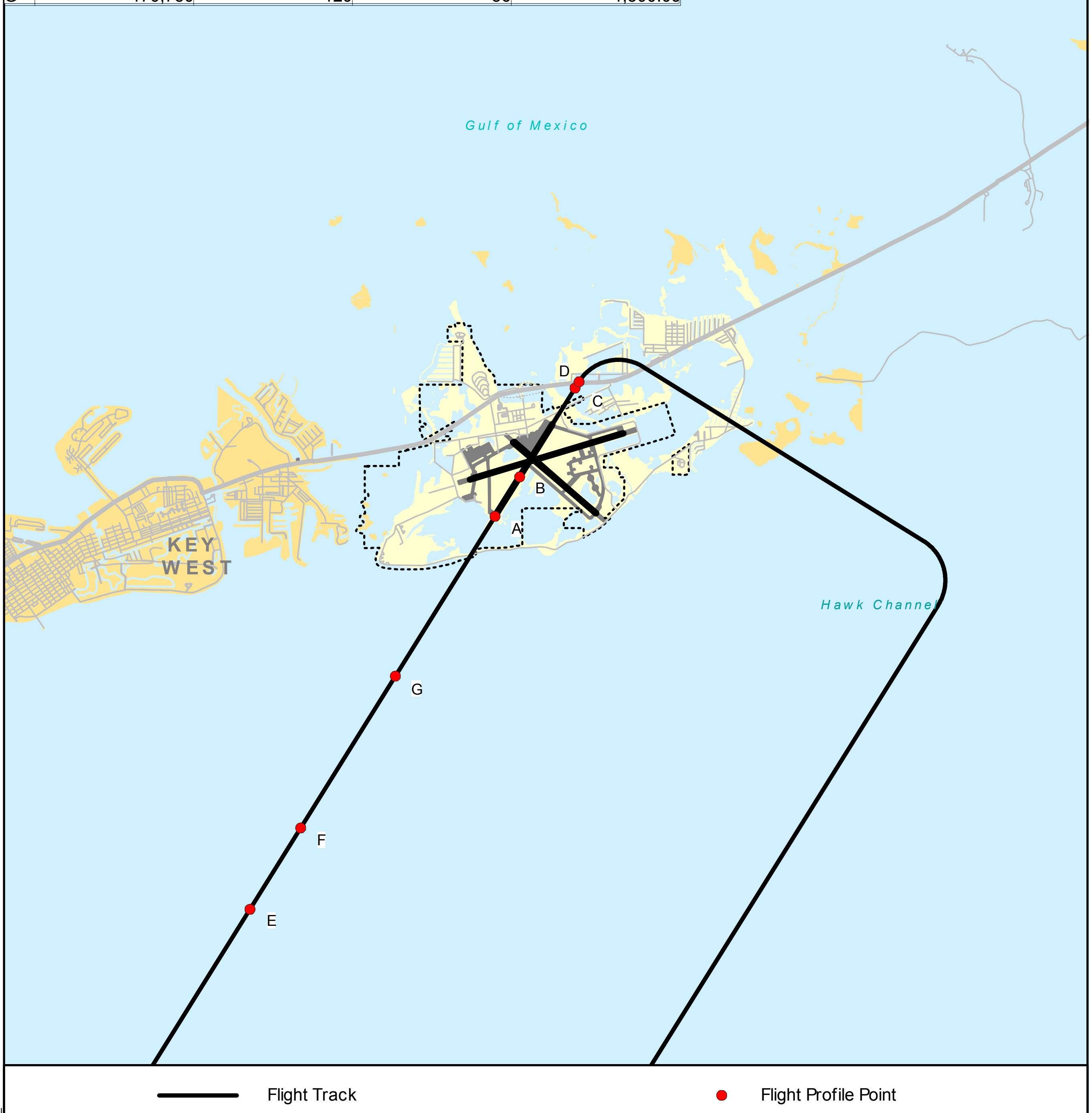


Appendix G

NAF Key West
Representative E-2/C-2
FCLP Flight Profile

Profiles.opx Profile_E2C73003F1.wor 11/08/2002

ID	CUMU_DIST	AIRSPEED	ALTITUDE	POWER
A	1	120	6	4,600.00
B	3,000	180	6	4,600.00
C	9,750	200	1,506	2,000.00
D	10,240	200	1,506	2,000.00
E	153,019	200	1,506	1,500.00
F	159,205	120	1,506	1,300.00
G	170,750	120	56	1,300.00



0 ft 10000 20000

N

Appendix G

NAF Key West
Representative E-2/C-2
GCA Flight Profile