APPENDIX B

NOISE

This page intentionally left blank

Appendix B-1

Sound, Noise, and Potential Effects

This page intentionally left blank

B.1 SOUND, NOISE, AND POTENTIAL EFFECTS

B.1.1 Introduction

This appendix discusses sound and noise and their potential effects on the human and natural environment. **Section B.1.2** provides an overview of the basics of sound and noise. **Section B.1.3** defines and describes the different metrics used to describe noise. The largest section, **Section B.1.4**, reviews the potential effects of noise, focusing on effects on humans but also addressing effects on property values, terrain, structures, and animals. **Section B.1.5** contains the list of references cited. **Appendix B-2** contains data used in the noise modeling process. A number of noise metrics are defined and described in this appendix. Some metrics are included for the sake of completeness when discussing each metric and to provide a comparison of cumulative noise metrics.

B.1.2 Basics of Sound

B.1.2.1 Sound Waves and Decibels

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

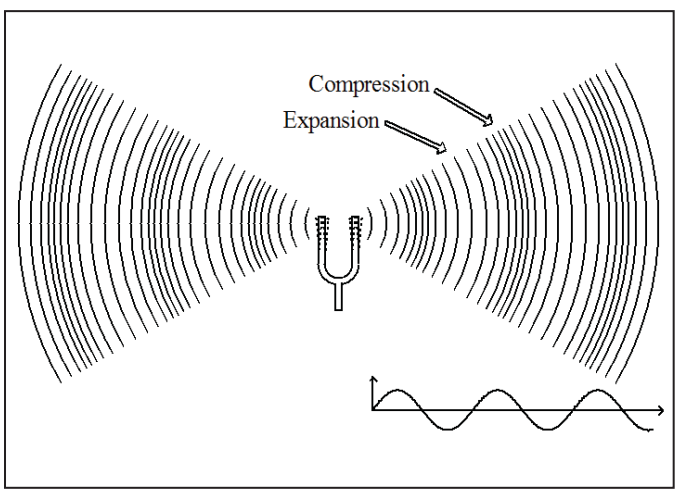


Figure B-1. Sound Waves from a Vibrating Tuning Fork.

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

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

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

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

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

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

60 dB + 60 dB = 63 dB, and
80 dB + 80 dB = 83 dB.

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

60.0 dB + 70.0 dB = 70.4 dB.

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

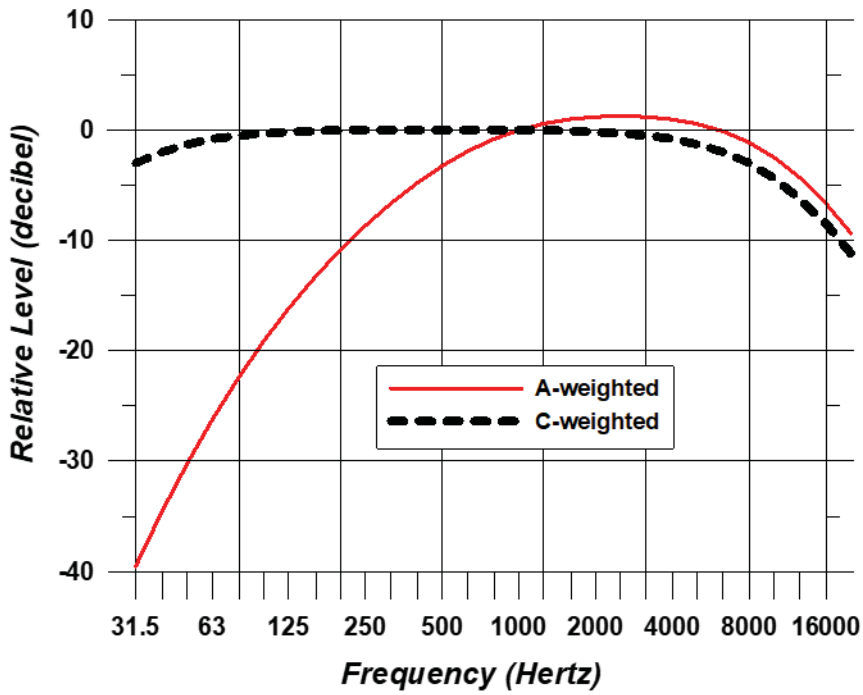
The minimum change in the sound level of individual events that an average human ear can detect is about 3 dB. On average, a person perceives a change in sound level of about 10 dB as a doubling (or halving) of the sound's loudness. This relation holds true for loud and quiet sounds. A decrease in sound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

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

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

Very loud or impulsive sounds, such as explosions or sonic booms, can sometimes be felt and cause secondary effects, such as shaking of a structure or rattling of windows. These types of sounds can add to

annoyance and are best measured by C-weighted sound levels, denoted dBC. C-weighting is nearly flat throughout the audible frequency range and includes low frequencies that may not be heard but cause shaking or rattling. C-weighting approximates the human ear's sensitivity to higher intensity sounds.



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

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

B.1.2.2 Sound Levels and Types of Sounds

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

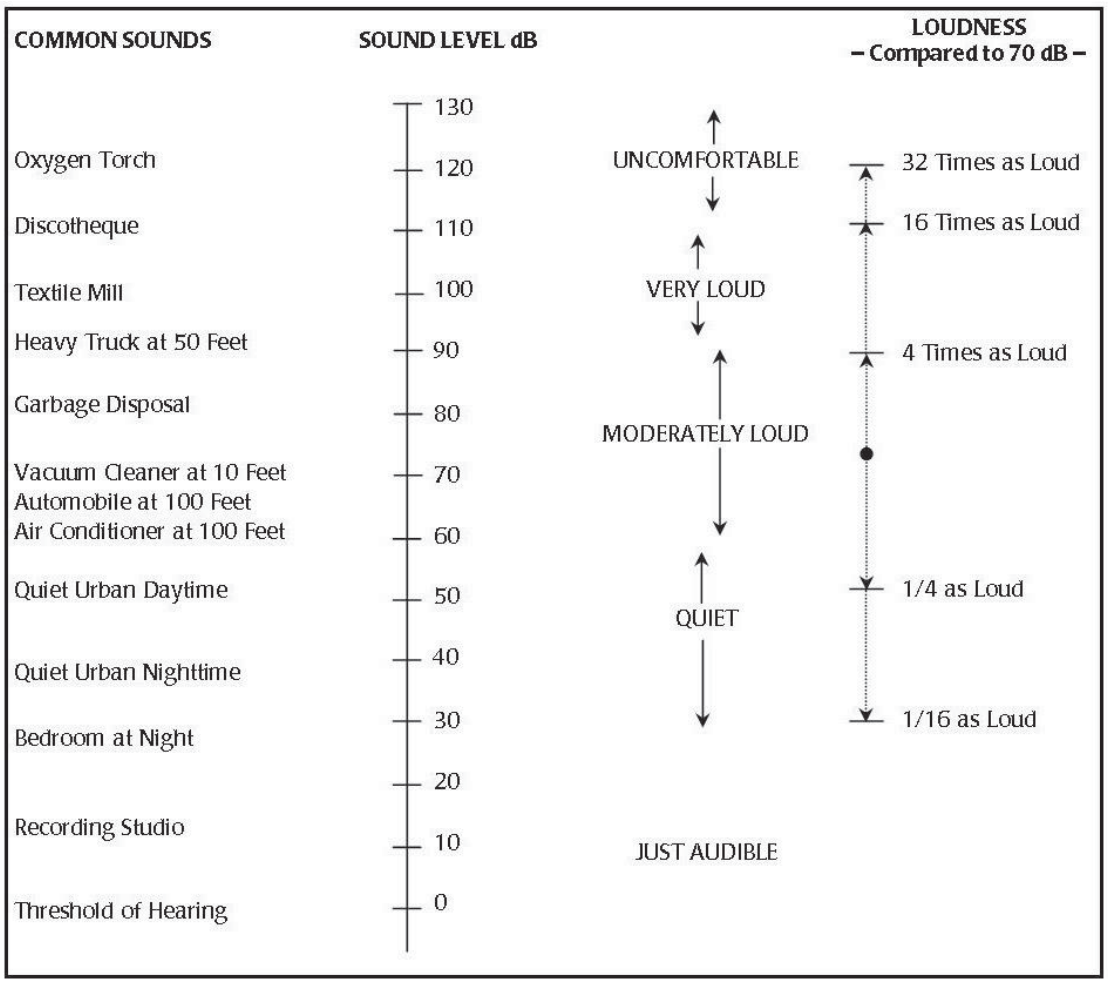
Sound becomes noise when it is unwelcome and interferes with normal activities, such as sleep or conversation. Noise is unwanted sound. Noise can become an issue when its level exceeds the ambient or background sound level. Ambient noise in urban areas typically varies from 60 to 70 dB but can be as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

Figure B-3 shows A-weighted sound levels from common sources. Some sources, like the air conditioner and vacuum cleaner, are continuous sounds whose levels are constant for some time. Some sources, like the automobile and heavy truck, are the maximum sound during an intermittent event like a vehicle pass-by. Some sources like "urban daytime" and "urban nighttime" are averages over extended periods. A variety of noise metrics have been developed to describe noise over different time periods. These are discussed in detail in **Section B.1.3**.

Aircraft noise consists of two major types of sound events: flight (including takeoffs, landings, and flyovers) and stationary, such as engine maintenance run-ups. The former is intermittent and the latter primarily

continuous. Noise from aircraft overflights typically occurs beneath main approach and departure paths, in local air traffic patterns around the airfield, and in areas near aircraft parking ramps and staging areas. As aircraft climb, the noise received on the ground drops to lower levels, eventually fading into the background or ambient levels.

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



Source: Harris, 1979

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

B.1.3 Noise Metrics

Noise metrics quantify sounds so they can be compared with each other and. with their effects, in a standard way. There are a number of metrics that can be used to describe a range of situations, from a particular

individual event to the cumulative effect of all noise events over a long time. This section describes the metrics relevant to environmental noise analysis.

B.1.3.1 Single Events

Maximum Sound Level

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

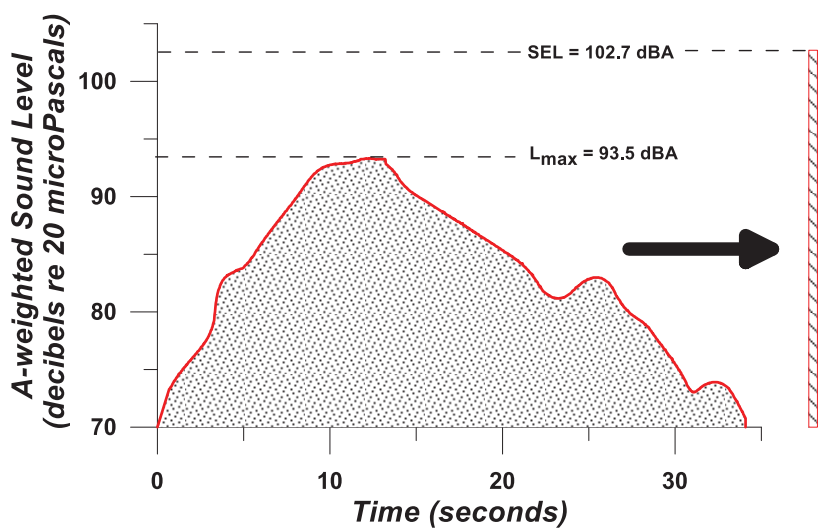
L_{max} is the maximum level that occurs over a fraction of a second. For aircraft noise, the "fraction of a second" is one-eighth of a second, denoted as "fast" response on a sound level measuring meter (ANSI, 1988). Slowly varying or steady sounds are generally measured over 1 second, denoted as "slow"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

Peak Sound Pressure Level

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

Sound Exposure Level

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



Source: Wyle Laboratories

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

Aircraft noise varies with time. During an aircraft overflight, noise starts at the background level, rises to a maximum level as the aircraft flies close to the observer, then returns to the background as the aircraft recedes into the distance. This is sketched on **Figure B-4**, which also indicates two metrics (L_{max} and SEL) that are described above. Over time there can be a number of events, not all the same. Because aircraft noise events last more than a few seconds, the SEL value is larger than L_{max}. It does not directly represent the sound level heard at any given time but rather the entire event. SEL provides a much better measure of aircraft flyover noise exposure than L_{max} alone.

Overpressure

The single event metrics commonly used to assess supersonic noise are overpressure in pounds per square foot and C-Weighted Sound Exposure Level (CSEL). Overpressure is the peak pressure at any location within the sonic boom footprint.

C-Weighted Sound Exposure Level

CSEL is SEL computed with C frequency weighting, which is similar to A-Weighting (discussed in **Section B.1.2.2**) except that C weighting places more emphasis on low frequencies below 1,000 hertz.

B.1.3.2 Cumulative Events

Equivalent Sound Level

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

The time period of an L_{eq} measurement is usually related to some activity and is given along with the value. The time period is often shown in parenthesis (e.g., L_{eq}[24] for 24 hours). The L_{eq} from 7:00 a.m. to 3:00 p.m. may give exposure of noise for a school day.

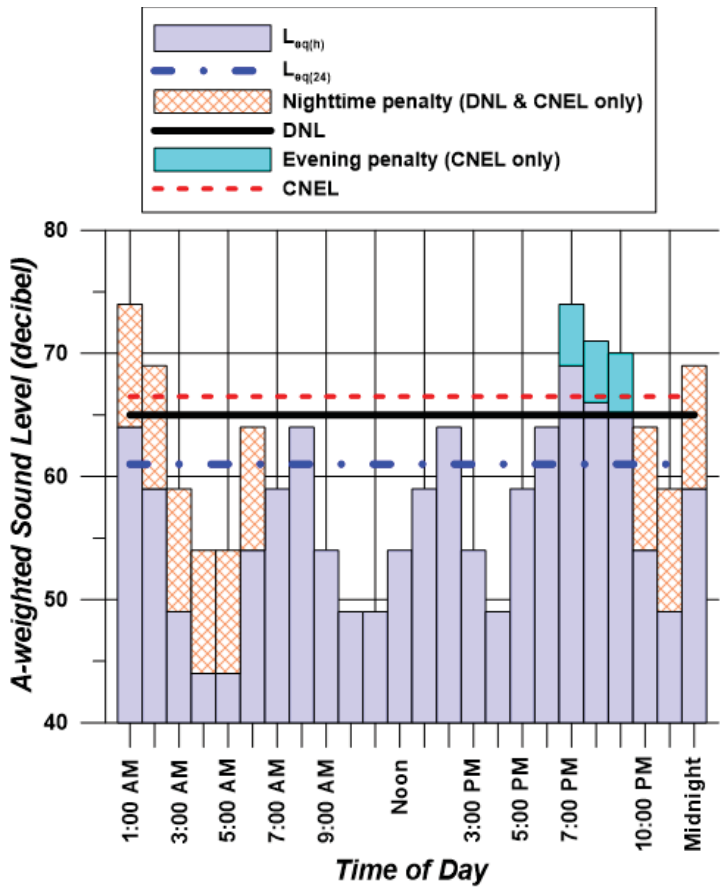
Figure B-5 gives an example of L_{eq}(24) using notional hourly average noise levels (L_{eq}[h]) for each hour of the day as an example. The L_{eq}(24) for this example is 61 dB.

Day-Night Average Sound Level and Community Noise Equivalent Level

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

Community Noise Equivalent Level (CNEL) is a variation of DNL specified by law in California (California Code of Regulations Title 21, Public Works) (Wyle Laboratories, 1970). CNEL has the 10-dB nighttime penalty for events between 10:00 p.m. and 7:00 a.m. but also includes a 4.8-dB penalty for events during the evening period of 7:00 p.m. to 10:00 p.m. The evening penalty in CNEL accounts for the added intrusiveness of sounds during that period. For airports and military airfields, DNL and CNEL represent the average sound level for annual average daily aircraft events.

Figure B-5 gives an example of DNL and CNEL using notional hourly average noise levels (L_{eq}[h]) for each hour of the day as an example. Note the L_{eq}(h) for the hours between 10:00 p.m. and 7:00 a.m. have a 10-dB penalty assigned. For CNEL, the hours between 7:00 p.m. and 10:00 p.m. have a 4.8-dB penalty assigned. The DNL for this example is 65 dB. The CNEL for this example is 66 dB.



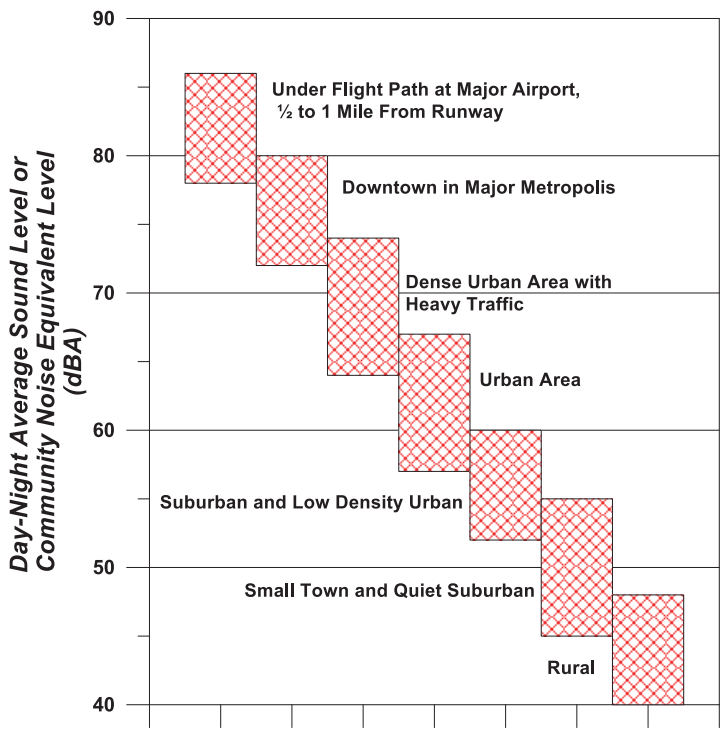
Source: Wyle Laboratories

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

Figure B-6 shows the ranges of DNL or CNEL that occur in various types of communities. Under a flight path at a major airport the DNL may exceed 80 dB while rural areas may experience DNL less than 45 dB. The decibel summation nature of these metrics causes the noise levels of the loudest events to control the 24-hour average. As a simple example, consider a case in which only one aircraft overflight occurs during the daytime over a 24-hour period, creating a sound level of 100 dB for 30 seconds. During the remaining 23 hours, 59 minutes, and 30 seconds of the day, the ambient sound level is 50 dB. The DNL for this 24-hour period is 65.9 dB. Assume, as a second example that 10 such 30-second overflights occur during daytime hours during the next 24-hour period, with the same ambient sound level of 50 dB during the remaining 23 hours and 55 minutes of the day. The DNL for this 24-hour period is 75.5 dB. Clearly, the averaging of noise over a 24-hour period does not ignore the louder single events and tends to emphasize both the sound levels and number of those events.

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

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



Source: DOD 1978.

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

Onset-Rate Adjusted Monthly Day-Night Average Sound Level and Onset-Rate Adjusted Monthly Community Noise Equivalent Level

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

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

In California, a variant of the L_{dnmr} includes a penalty for evening operations (7:00 p.m. to 10:00 p.m.) and is denoted Onset-Rate Adjusted Monthly Community Noise Equivalent Level ($CNEL_{mr}$).

B.1.3.3 Supplemental Metrics

Number-of-Events Above a Threshold Level

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

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

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

Time Above a Specified Level

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

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

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

B.1.4 Noise Effects

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

- annoyance;
- speech interference;
- sleep disturbance;
- noise effects on children; and
- noise effects on domestic animals and wildlife.

B.1.4.1 Annoyance

With the introduction of jet aircraft in the 1950s, it became clear that aircraft noise annoyed people and was a significant problem around airports. Early studies, such as those of Rosenblith et al. (1953) and Stevens et al. (1953) showed that effects depended on the quality of the sound, its level, and the number of flights.

Over the next 20 years considerable research was performed refining this understanding and setting guidelines for noise exposure. In the early 1970s, the USEPA published its "Levels Document" (USEPA, 1974) that reviewed the factors that affected communities. DNL (still known as L_{dn} at the time) was identified as an appropriate noise metric, and threshold criteria were recommended.

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

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

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

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

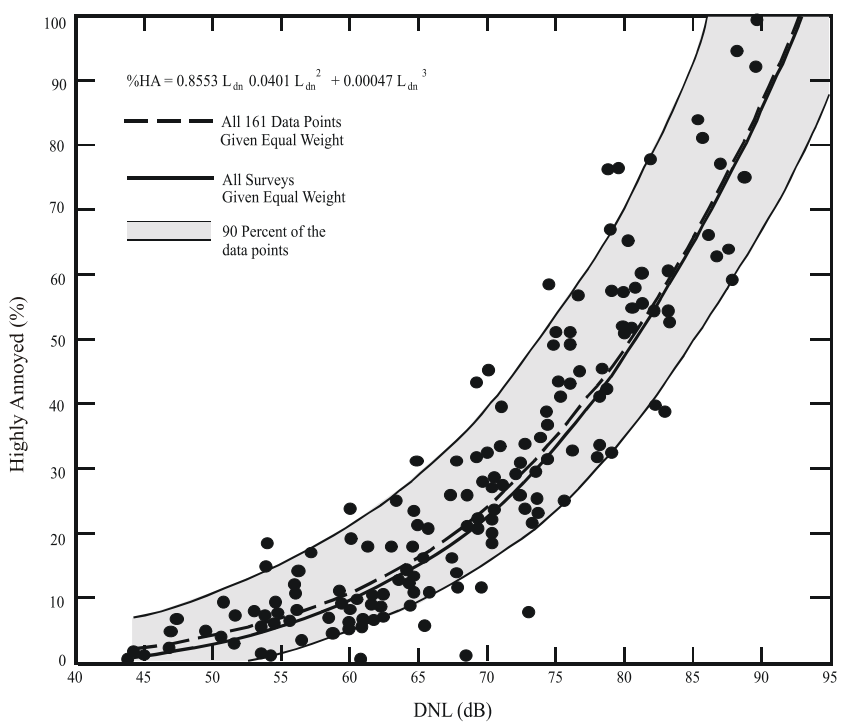


Figure B-7. Schultz Curve Relating Noise Annoyance to DNL (Schultz, 1978).

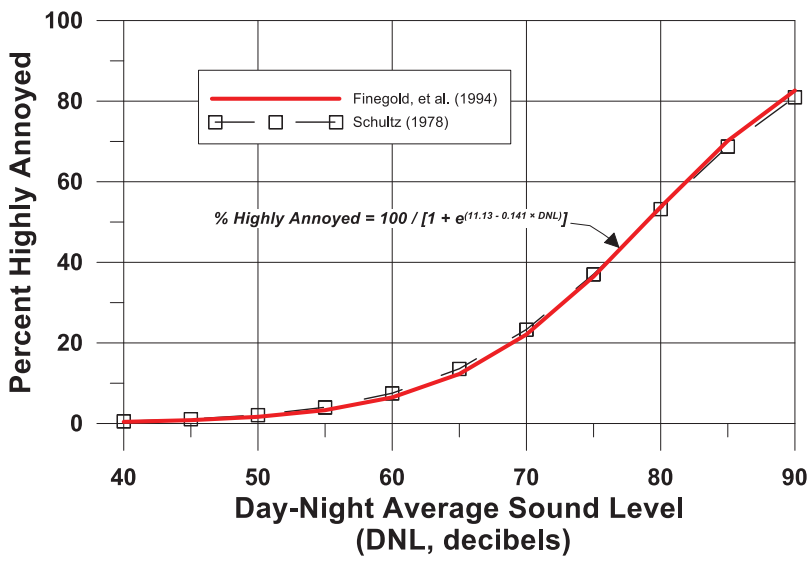


Figure B-8. Response of Communities to Noise; Comparison of Original Schultz (1978) with Finegold et al. (1994).

Table B-1
Nonacoustic Variables Influencing Aircraft Noise Annoyance

Emotional Variables
Feeling about the necessity or preventability of the noise
Judgement of the importance and value of the activity that is producing the noise
Activity at the time an individual hears the noise
Attitude about the environment
General sensitivity to noise
Belief about the effect of noise on health
Feeling of fear associated with the noise

Physical Variables
Type of neighborhood
Time of day
Season
Predicitabiltiy of the noise
Control over the noise source
Length of time individual is exposed to a noise.

Schreckenberg and Schuemer (2010) examined the importance of some of these factors on short term annoyance. Attitudinal factors were identified as having an effect on annoyance. In formal regression analysis, however, sound level (L_{eq}) was found to be more important than attitude. A series of studies at three European airports showed that less than 20 percent of the variance in annoyance can be explained by noise alone (Márki, 2013).

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

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

and Oudshoorn (2001) authors supplemented that investigation with further derivation of percent of population highly annoyed as a function of either DNL or DENL along with the corresponding 95 percent confidence intervals with similar results.

Table B-2
Percent Highly Annoyed for Different Transportation Noise Sources

Day-Night Average Sound Level (decibels)	Percent Highly Annoyed (%HA)			
	Miedema and Vos			Schultz Combined
	Air	Road	Rail	
55	12	7	4	3
60	19	12	7	6
65	28	18	11	12
70	37	29	16	22
75	48	40	22	36

Source: Miedema and Vos, 1998

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

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

The International Standard (ISO 1996:1-2016) update introduced the concept of Community Tolerance Level (L_{ct}) as the day-night sound level at which 50 percent of the people in a particular community are predicted to be highly annoyed by noise exposure. L_{ct} accounts for differences between sources and/or communities when predicting the percentage highly annoyed by noise exposure. ISO also recommended a change to the adjustment range used when comparing aircraft noise to road noise. The previous edition suggested +3 to +6 dB for aircraft noise relative to road noise while the latest editions recommends an adjustment range of +5 to +8 dB. This adjustment range allows DNL to be correlated to consistent annoyance rates when originating from different noise sources (i.e., road traffic, aircraft, or railroad). This change to the adjustment range would increase the calculated percent highly annoyed at the 65-dBA DNL by approximately 2 to 5 percent greater than the previous ISO definition. **Figure B-9** depicts the estimated percentage of people highly annoyed for a given DNL using both the ISO 1996-1 estimation and the older FICON 1992 method. The results suggest that the percentage of people highly annoyed may be greater than previous thought and reliance solely on DNL for impact analysis may be insufficient if utilizing the FICON 1992 method.

The US Federal Aviation Administration (FAA) is currently conducting a major airport community noise survey at approximately 20 US airports in order to update the relationship between aircraft noise and annoyance. Results from this study are expected to be released in 2018.

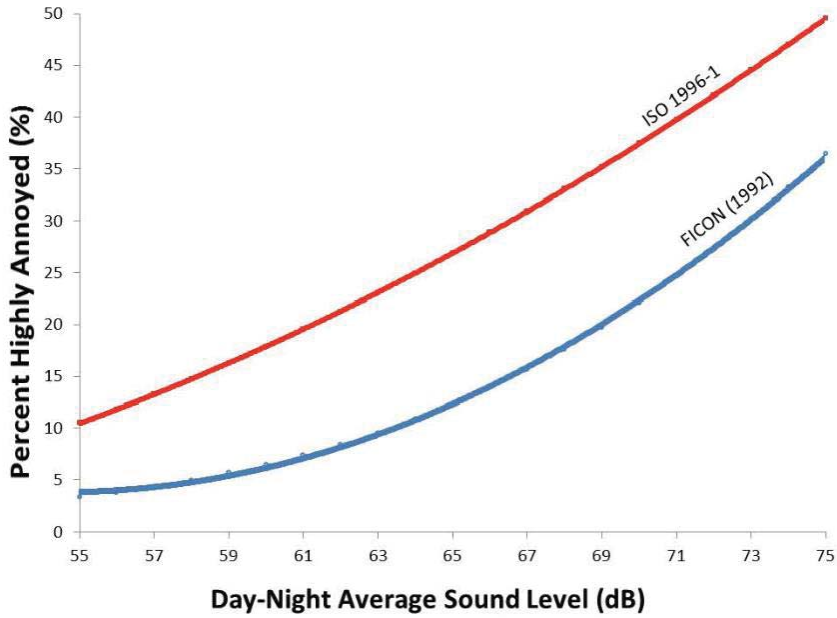


Figure B-9. Percent Highly Annoyed Comparison of ISO 1996-1 to FICON (1992).

B.1.4.2 Speech Interference

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

There are two measures of speech comprehension:

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

United States Federal Criteria for Interior Noise

In 1974, the USEPA identified a goal of an indoor $L_{eq}(24)$ of 45 dB to minimize speech interference based on sentence intelligibility and the presence of steady noise (USEPA, 1974). **Figure B-10** shows the effect of steady indoor background sound levels on sentence intelligibility. For an average adult with normal hearing and fluency in the language, steady background indoor sound levels of less than the 45-dB L_{eq} are expected to allow 100 percent sentence intelligibility.

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

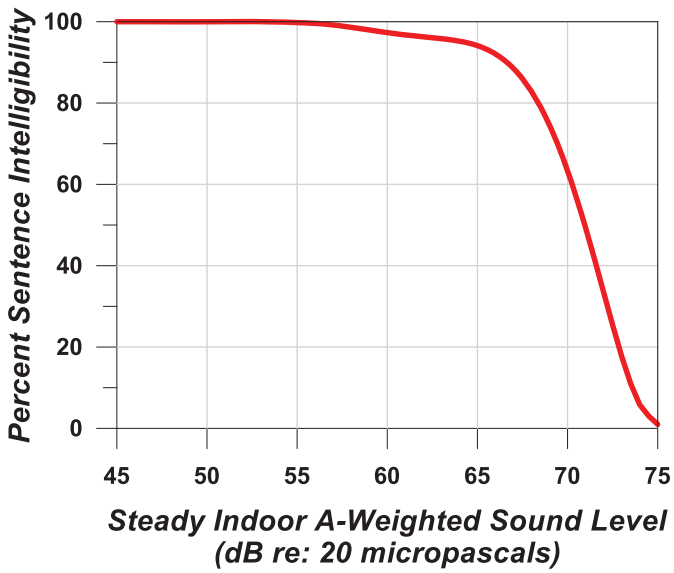


Figure B-10. Speech Intelligibility Curve (digitized from USEPA, 1974).

Classroom Criteria

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

Lazarus (1990) found that for listeners with normal hearing and fluency in the language, complete sentence intelligibility can be achieved when the signal-to-noise ratio (i.e., a comparison of the level of the sound to the level of background noise) is in the range of 15 to 18 dB. The initial ANSI (2002) classroom noise standard and American Speech-Language-Hearing Association (2005) guidelines concur, recommending at least a 15-dB signal-to-noise ratio in classrooms. If the teacher's voice level is at least 50 dB, the background noise level must not exceed an average of 35 dB. The National Research Council of Canada (Bradley, 1993) and WHO (1999) agree with this criterion for background noise.

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

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

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

Lind et al. (1998) also concluded that an L_{max} criterion of 50 dB would result in 90 percent word intelligibility. Bradley (1985) recommends SEL as a better indicator. His work indicates that 95 percent word intelligibility

would be achieved when indoor SEL did not exceed 60 dB. For typical flyover noise, this corresponds to an L_{max} of 50 dB. While WHO (1999) only specifies a background L_{max} criterion, they also note the SIL frequencies and that interference can begin at around 50 dB.

The United Kingdom Department for Education and Skills (UKDfES) established in its classroom acoustics guide a 30-minute time-averaged metric of L_{eq}(30min) for background levels and the metric of LA1,30min for intermittent noises, at thresholds of 30 to 35 dB and 55 dB, respectively. LA1,30min represents the A-weighted sound level that is exceeded 1 percent of the time (in this case, during a 30-minute teaching session) and is generally equivalent to the L_{max} metric (UKDfES, 2003).

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

Table B-3
Indoor Noise Level Criteria Based on Speech Intelligibility

Source	Metric/Level (dB)	Effects and Notes
Federal Aviation Administration (1985)	$L_{eq(during\ school\ hours)}$ = 45 dB	Federal assistance criteria for school sound insulation; supplemental single-event criteria may be used.
Lind et al. (1998), Sharp and Plotkin (1984), Wesler (1986)	L_{max} = 50 dB / Speech Interference Level 45	Single event level permissible in the classroom.
World Health Organization (1999)	L_{eq} = 35 dB L_{max} = 50 dB	Assumes average speech level of 50 dB and recommends signal to noise ratio of 15 dB.
American National Standards Institute (2010)	L_{eq} = 35 dB, based on Room Volume (e.g., cubic feet)	Acceptable background level for continuous and intermittent noise.
United Kingdom Department for Education and Skills (2003)	$L_{eq(30min)}$ = 30-35 dB L_{max} = 55 dB	Minimum acceptable in classroom and most other learning environs.

Notes:
dB = decibel(s); L_{eq} = Equivalent Sound Level; L_{max} = Maximum Sound Level

B.1.4.3 Sleep Disturbance

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

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

Initial Studies

The relation between noise and sleep disturbance is complex and not fully understood. The disturbance depends not only on the depth of sleep and the noise level but also on the nonacoustic factors cited for annoyance. The easiest effect to measure is the number of arousals or awakenings from noise events.

Much of the literature has therefore focused on predicting the percentage of the population that will be awakened at various noise levels.

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

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

Recent Sleep Disturbance Research – Field and Laboratory Studies

It was noted that early sleep laboratory studies did not account for some important factors. These included habituation to the laboratory, previous exposure to noise, and awakenings from noise other than aircraft. In the early 1990s, field studies in people's homes were conducted to validate the earlier laboratory work conducted in the 1960s and 1970s. The field studies of the 1990s (e.g., Horne, 1994) found that 80 to 90 percent of sleep disturbances were not related to outdoor noise events but rather to indoor noises and nonnoise factors. The results showed that, in real life conditions, there was less of an effect of noise on sleep than had been previously reported from laboratory studies. Laboratory sleep studies tend to show more sleep disturbance than field studies because people who sleep in their own homes are used to their environment and, therefore, do not wake up as easily (FICAN, 1997).

FICAN

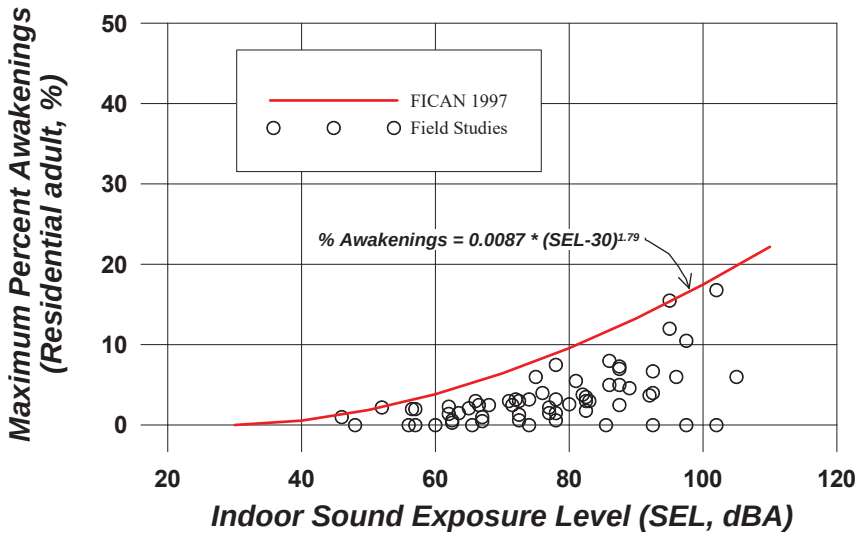
Based on this new information, in 1997 FICAN recommended a dose-response curve to use instead of the earlier 1992 FICON curve (FICAN, 1997). **Figure B-11** shows FICAN's curve, the red line, which is based on the results of three field studies shown in the figure (Ollerhead et al., 1992; Fidell et al., 1994, 1995a, 1995b), along with the data from six previous field studies.

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

Number of Events and Awakenings

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

Later studies by DLR Laboratory conducted in the laboratory comparing the probability of awakenings from different modes of transportation showed that aircraft noise lead to significantly lower awakening probabilities than either road or rail noise (Basner et al., 2011). Furthermore, it was noted that the probability of awakening, per noise event, decreased as the number of noise events increased. The authors concluded that by far the majority of awakenings from noise events merely replaced awakenings that would have occurred spontaneously anyway.



Source: FICAN 1997

Figure B-11. FICAN (1997) Recommended Sleep Disturbance Dose-Response Relationship.

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

Currently, there are no established criteria for evaluating sleep disturbance from aircraft noise although recent studies have suggested a benchmark of an outdoor SEL of 90 dB as an appropriate tentative criterion when comparing the effects of different operational alternatives. The corresponding indoor SEL would be approximately 25 dB lower (at 65 dB) with doors and windows closed, and approximately 15 dB lower (at 75 dB) with doors or windows open. According to the ANSI (2008) standard, the probability of awakening from a single aircraft event at this level is between 1 and 2 percent for people habituated to the noise sleeping in bedrooms with windows closed, and between 2 to 3 percent with windows open. The probability of the exposed population awakening at least once from multiple aircraft events at the 90-dB SEL is shown in **Table B-4**.

Table B-4
Probability of Awakening from NA90SEL

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

Source: DOD, 2009b

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

Summary

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

B.1.4.4 Noise Effects on Children

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

Effects on Learning and Cognitive Abilities

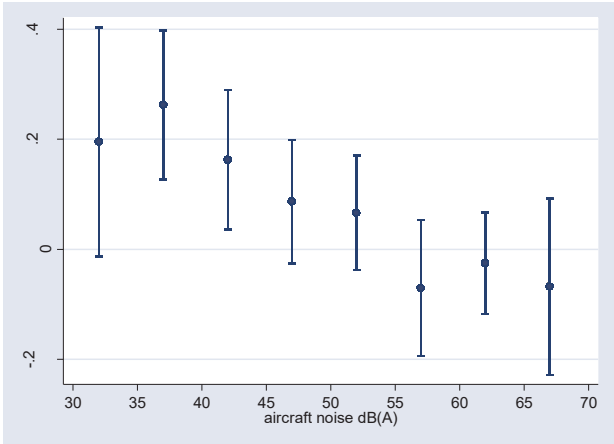
Early studies in several countries (Cohen et al., 1973, 1980, 1981; Bronzaft and McCarthy, 1975; Green et al., 1982; Evans et al., 1998; Haines et al., 2002; Lercher et al., 2003) showed lower reading scores for children living or attending school in noisy areas than for children away from those areas.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

A longitudinal study reported by Evans et al. (1998), conducted prior to relocation of the old Munich airport in 1992, reported that high noise exposure was associated with deficits in long-term memory and reading comprehension in children with a mean age of 10.8 years. Two years after the closure of the airport, these deficits disappeared, indicating that noise effects on cognition may be reversible if exposure to the noise ceases. Most convincing was the finding that deficits in memory and reading comprehension developed over the 2-year follow-up for children who became newly noise exposed near the new airport; deficits were also observed in speech perception for the newly noise-exposed children.

More recently, the Road Traffic and Aircraft Noise Exposure and Children's Cognition and Health (RANCH) study (Stansfeld et al., 2005; Clark et al., 2005) compared the effect of aircraft and road traffic noise on over 2,000 children in three countries. This was the first study to derive exposure-effect associations for a range of cognitive and health effects and was the first to compare effects across countries.

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

Figure B-12 shows RANCH's result relating noise to reading comprehension. It shows that reading falls below average (a z-score of 0) at Leq greater than 55 dB. Because the relationship is linear, reducing exposure at any level should lead to improvements in reading comprehension.



Sources: Stansfeld et al. 2005; Clark et al. 2006

Figure B-12. RANCH Study Reading Scores Varying with L_{eq}.

An observation of the RANCH study was that children may be exposed to aircraft noise for many of their childhood years and the consequences of long-term noise exposure were unknown. A follow-up study of the children in the RANCH project is being analyzed to examine the long-term effects on children's reading comprehension (Clark et al., 2009). Preliminary analysis indicated a trend for reading comprehension to be poorer at 15 to 16 years of age for children who attended noise-exposed primary schools. An additional study utilizing the same data set (Clark et al., 2012) investigated the effects of traffic-related air pollution and found little evidence that air pollution moderated the association of noise exposure on children's cognition.

There was also a trend for reading comprehension to be poorer in aircraft noise exposed secondary schools. Significant differences in reading scores were found between primary school children in the two different classrooms at the same school (Bronzaft and McCarthy, 1975). One classroom was exposed to high levels of railway noise while the other classroom was quiet. The mean reading age of the noise-exposed children was 3 to 4 months behind that of the control children. Studies suggest that the evidence of the effects of noise on children's cognition has grown stronger over recent years (Stansfeld and Clark, 2015), but further analysis adjusting for confounding factors is ongoing and needed to confirm these initial conclusions.

Studies identified a range of linguistic and cognitive factors to be responsible for children´s unique difficulties with speech perception in noise. Children have lower stored phonological knowledge to reconstruct degraded speech reducing the probability of successfully matching incomplete speech input when compared with adults. Additionally, young children are less able than older children and adults to make use of contextual cues to reconstruct noise-masked words presented in sentential context (Klatte et al., 2013).

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

The FICAN study found a significant association between noise reduction and a decrease in failure rates for high school students but not middle or elementary school students. There were some weaker associations between noise reduction and an increase in failure rates for middle and elementary schools. Overall, the study found that the associations observed were similar for children with or without learning

difficulties, and between verbal and math/science tests. As a pilot study, it was not expected to obtain final answers but provided useful indications (FICAN, 2007).

A recent study of the effect of aircraft noise on student learning (Sharp et al., 2013) examined student test scores at a total of 6,198 US elementary schools, 917 of which were exposed to aircraft noise at 46 airports with noise exposures exceeding the 55-dBA DNL. The study found small but statistically significant associations between airport noise and student mathematics and reading test scores, after taking demographic and school factors into account. Associations were also observed for ambient noise and total noise on student mathematics and reading test scores, suggesting that noise levels per se, as well as from aircraft, might play a role in student achievement.

As part of the Noise-Related Annoyance, Cognition and Health study conducted at Frankfurt airport, reading tests were conducted on 1,209 school children at 29 primary schools. It was found that there was a small decrease in reading performance that corresponded to a 1-month reading delay; however, a recent study observing children at 11 schools surrounding Los Angeles International Airport found that the majority of distractions to elementary age students were other students followed by themselves, which includes playing with various items and daydreaming. Less than 1 percent of distractions were caused by traffic noise.

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

B.1.4.5 Noise Effects on Animals and Wildlife

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

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

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

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

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

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

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

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

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

Domestic Animals

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

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

Wildlife

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

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

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

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

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

Animal responses to aircraft noise appear to be somewhat dependent on, or influenced by, the size, shape, speed, proximity (vertical and horizontal), engine noise, color, and flight profile of planes. Helicopters also appear to induce greater intensities and durations of disturbance behavior as compared to fixed-wing aircraft. Some studies showed that animals that had been previously exposed to jet aircraft noise exhibited greater degrees of alarm and disturbance to other objects creating noise, such as boats, people, and objects blowing across the landscape. Other factors influencing response to jet aircraft noise may include wind direction, speed, and local air turbulence; landscape structures (i.e., amount and type of vegetative cover); and, in the case of bird species, whether the animals are in the incubation/nesting phase.

B.1.5 References

American Speech-Language-Hearing Association. 2005. *Guidelines for Addressing Acoustics in Educational Settings, ASHA Working Group on Classroom Acoustics*.

ANSI. 1985. *Specification for Sound Level Meters, ANSI S1.4A-1985 Amendment to ANSI S1.4-1983*.

ANSI. 1988. *Quantities and Procedures for Description and Measurement of Environmental Sound: Part 1, ANSI S12.9-1988*.

ANSI. 1996. *Quantities and Procedures for Description and Measurement of Environmental Sound: Part 4, ANSI S12.9-1996*.

ANSI. 2002. *Acoustical Performance Criteria, Design Requirements, and Guidelines for Schools, ANSI S12.60-2002*.

ANSI. 2008. *Methods for Estimation of Awakenings with Outdoor Noise Events Heard in Homes, ANSI S12.9-2008/Part6*.

Austin, Jr., O.L., W.B. Robertson, Jr., and G.E. Wolfenden. 1970. *Mass Hatching Failure in Dry Tortugas Sooty Terns (Sterna fuscata)*. Proceedings of the XVth International Arnithological Congress, The Hague, The Netherlands, August 30 through September 5.

Basner, M., W. Babisch, A. Davis, M. Brink, C. Clark, S. Janssess, et al. 2014. *Auditory and non-auditory effects of noise on health*. The Lancet 383, Issue 9925, 1325 - 1332

Basner, M., H. Buess, U. Miller, G. Platt, and A. Samuel. 2004. *Aircraft Noise Effects on Sleep: Final Results of DLR Laboratory and Field Studies of 2240 Polysomnographically Recorded Subject Nights*. Internoise 2004, The 33rd International Congress and Exposition on Noise Control Engineering, August 22-25.

Basner M, U. Muller, and E.M. Elmenhorst. 2011. *Single and combined effects of air, road, and rail traffic noise on sleep and recuperation*. Sleep 2011; 34: 11–23.

Berglund, B., and T. Lindvall, eds. 1995. *Community Noise*. Jannes Snabbtryck, Stockholm, Sweden.

Bowles, A.E. 1995. *Responses of Wildlife to Noise*, In *Wildlife and Recreationists: Coexistence through Management and Research*, R.L. Knight and K.J. Gutzwiller, eds. Island Press, Covelo, California, pp. 109-156.

Bradley J.S. 1985. *Uniform Derivation of Optimum Conditions for Speech in Rooms*. National Research Council, Building Research Note, BRN 239, Ottawa, Canada.

Bradley, J.S. 1993. *NRC-CNRC NEF Validation Study: Review of Aircraft Noise and its Effects*. National Research Council Canada and Transport Canada, Contract Report A-1505.5.

Bronzaft, A.L., and D.P. McCarthy. 1975. *The effects of elevated train noise on reading ability*. J. Environment and Behavior 7, 517-527.

Clark, C., Crombie, R., Head, J., van Kamp, I., van Kempen, E., and Stansfeld, S. A. 2012. *Does Traffic-related Air Pollution Explain Associations of Aircraft and Road Traffic Noise Exposure on Children's Health and Cognition? A Secondary Analysis of the United Kingdom Sample from the RANCH Project*. American Journal of Epidemiology 176(4), 327–337

Clark, C., R. Martin, E. van Kempen, T. Alfred, J. Head, H.W. Davies, M.M. Haines, I.L. Barrio, M. Matheson, and S.A. Stansfeld. 2005. *Exposure-effect relations between aircraft and road traffic noise exposure at school and reading comprehension: the RANCH project*. American Journal of Epidemiology 163, 27-37.

Clark, C., S.A. Stansfeld, and J. Head. 2009. *The long-term effects of aircraft noise exposure on children's cognition: findings from the UK RANCH follow-up study*. In Proceedings of the Euronoise Conference. Edinburgh, Scotland, October.

Cohen, S., D.C. Glass, and J.E. Singer. 1973. *Apartment noise, auditory discrimination, and reading ability in children*. Journal of Experimental Social Psychology 9, 407-422.

Cohen, S., G.W. Evans, D.S. Krantz, et al. 1980. *Physiological, Motivational, and Cognitive Effects of Aircraft Noise on Children: Moving from Laboratory to Field*. American Psychologist 35, pp. 231-243.

Cohen, S., G.W. Evans, D.S. Krantz, et al. 1981. *Aircraft noise and children: longitudinal and cross-sectional evidence on adaptation to noise and the effectiveness of noise abatement.* Journal of Personality and Social Psychology 40, 331-345.

Cottereau, P. 1978. *The Effect of Sonic Boom from Aircraft on Wildlife and Animal Husbandry*, In *Effects of Noise on Wildlife*, Academic Press, New York, New York, pp. 63-79.

DOD. 1978. *Environmental Protection Planning in the Noise Environment*. AFM 19-10, TM 5-803-2, NAVFAC P-970. Departments of the Air Force, the Army, and the Navy. 15 June.

DOD. 2009a. *Improving Aviation Noise Planning, Analysis, and Public Communication with Supplemental Metrics*. Defense Noise Working Group Technical Bulletin, December.

DOD. 2009b. *Sleep Disturbance from Aviation Noise*. Defense Noise Working Group Technical Bulletin, November

Eagan, M.E., G. Anderson, B. Nicholas, R. Horonjeff, and T. Tivnan. 2004. *Relation Between Aircraft Noise Reduction in Schools and Standardized Test Scores*. Washington, DC, FICAN.

Evans, G.W., M. Bullinger, and S. Hygge. 1998. *Chronic Noise Exposure and Physiological Response: A Prospective Study of Children Living under Environmental Stress*. Psychological Science 9, pp. 75-77.

FAA. 1985. *Airport Improvement Program (AIP) Handbook*. Order No. 100.38.

FICAN. 1997. *Effects of Aviation Noise on Awakenings from Sleep*. June.

FICAN. 2007. *Findings of the FICAN Pilot Study on the Relationship Between Aircraft Noise Reduction and Changes in Standardised Test Scores*. Washington, DC, FICAN.

FICAN. 2008. *FICAN Recommendation for use of ANSI Standard to Predict Awakenings from Aircraft Noise*. December.

FICON. 1992. *Federal Agency Review of Selected Airport Noise Analysis Issues*. August.

Fidell, S., and L. Silvati. 2004. *Parsimonious alternatives to regression analysis for characterizing prevalence rates of aircraft noise annoyance*. Noise Control Eng. J. 52, 56–68.

Fidell, S., K. Pearsons, R. Howe, B. Tabachnick, L. Silvati, and D.S. Barber. 1994. *Noise-Induced Sleep Disturbance in Residential Settings*. AL/OE-TR-1994-0131, Wright Patterson AFB, OH, Armstrong Laboratory, Occupational and Environmental Health Division.

Fidell, S., K. Pearsons, B. Tabachnick, R. Howe, L. Silvati, and D.S. Barber. 1995a. *Field study of noise-induced sleep disturbance*. Journal of the Acoustical Society of America 98, No. 2, pp. 1025-1033.

Fidell, S., R. Howe, B. Tabachnick, K. Pearsons, and M. Sneddon. 1995b. *Noise-induced Sleep Disturbance in Residences near Two Civil Airports*. NASA Contractor Report 198252.

Finegold, L.S., C.S. Harris, and H.E. von Gierke. 1994. *Community annoyance and sleep disturbance: updated criteria for assessing the impact of general transportation noise on people*. Noise Control Engineering Journal 42, No. 1, pp. 25-30.

Green, K.B., B.S. Pasternack, and R.E. Shore. 1982. *Effects of Aircraft Noise on Reading Ability of School-Age Children.* Archives of Environmental Health 37, No. 1, pp. 24-31.

Griefahn, B. 1978. *Research on Noise Disturbed Sleep Since 1973*. Proceedings of Third Int. Cong. On Noise as a Public Health Problem, pp. 377-390 (as appears in NRC-CNRC NEF Validation Study: (2) Review of Aircraft Noise and Its Effects, A-1505.1, p. 31).

Haines, M.M., S.A. Stansfeld, J. Head, and R.F.S. Job. 2002. *Multilevel modelling of aircraft noise on performance tests in schools around Heathrow Airport London*. Journal of Epidemiology and Community Health 56, 139-144.

Horne, J.A., F.L. Pankhurst, L.A. Reyner, K. Hume, and I.D. Diamond. *A Field Study of Sleep Disturbance: Effects of Aircraft Noise and Other Factors on 5,742 Nights of Actimetrically Monitored Sleep in a Large Subject Sample*. American Sleep Disorders Association and Sleep Research Society: Sleep 17, No. 2, 1994, pp. 146–195.

Klatte M., K. Bergström, T. Lachmann. 2013. *Does noise affect learning? A short review on noise effects on cognitive performance in children*. Frontiers in Psychology 4:578.

Lazarus H. 1990. *New Methods for Describing and Assessing Direct Speech Communication Under Disturbing Conditions*. Environment International 16: 373-392.

Lercher, P., G.W. Evans, and M. Meis. 2003. *Ambient noise and cognitive processes among primary school children*. J. Environment and Behavior 35, 725-735.

Lind S.J., K. Pearsons, and S. Fidell. 1998. *Sound Insulation Requirements for Mitigation of Aircraft Noise Impact on Highline School District Facilities*. Volume I, BBN Systems and Technologies, BBN Report No. 8240.

Lukas, J.S. 1978. *Noise and Sleep: A Literature Review and a Proposed Criterion for Assessing Effect*, In Daryl N. May, ed., *Handbook of Noise Assessment*, Van Nostrand Reinhold Company: New York, pp. 313-334.

Manci, K.M., D.N. Gladwin, R. Villella, and M.G Cavendish. 1988. *Effects of Aircraft Noise and Sonic Booms on Domestic Animals and Wildlife: A Literature Synthesis*. US Fish and Wildlife Service National Ecology Research Center, Ft. Collins, CO, NERC-88/29. 88 pp.

Márki, Ferenc. 2013. *Outcomes of EU COSMA (Community Oriented Solutions to Minimise Aircraft Noise Annoyance) Project.* Budapest University of Technology and Economics, London, May.

Miedema, H M, and C G Oudshoorn. 2001. *Annoyance from Transportation Noise: Relationships with Exposure Metrics DNL and DENL and Their Confidence Intervals*." Environmental Health Perspectives 109.4: 409–416.

Miedema, H.M., and H. Vos. 1998. *Exposure-response relationships for transportation noise*. J. Acoust. Soc. Am 104(6): 3432–3445, December.

National Park Service. 1994. *Report to Congress: Report on Effects of Aircraft Overflights on the National Park System*. Prepared Pursuant to Public Law 100-91, The National Parks Overflights Act of 1987. 12 September.

NATO. 2000. *The Effects of Noise from Weapons and Sonic Booms, and the Impact on Humans, Wildlife, Domestic Animals and Structures*. Final Report of the Working Group Study Follow-up Program to the Pilot Study on Aircraft Noise, Report No. 241, June.

Newman, J.S., and K.R. Beattie. 1985. *Aviation Noise Effects*. US Department of Transportation, Federal Aviation Administration Report No. FAA-EE-85-2.

Ollerhead, J.B., C.J. Jones, R.E. Cadoux, A. Woodley, B.J. Atkinson, J.A. Horne, F. Pankhurst, L. Reyner, K.I. Hume, F. Van, A. Watson, I.D. Diamond, P. Egger, D. Holmes, and J. McKean. 1992. *Report of a Field Study of Aircraft Noise and Sleep Disturbance*. Commissioned by the UK Department of Transport for the 36 UK Department of Safety, Environment and Engineering, London, England: Civil Aviation Authority, December.

Pearsons, K.S., D.S. Barber, and B.G. Tabachnick. 1989. *Analyses of the Predictability of Noise-Induced Sleep Disturbance*. US Air Force Report HSD-TR-89-029, October.

Plotkin, K.J., B.H. Sharp, T. Connor, R. Bassarab, I. Flindell, and D. Schreckenberg. 2011. *Updating and Supplementing the Day-Night Average Sound Level (DNL)*. Wyle Report 11-04, DOT/FAA/AEE/2011-03, June.

Rosenblith, W.A., K.N. Stevens, and Staff of Bolt, Beranek, and Newman. 1953. *Handbook of Acoustic Noise Control, Vol. 2, Noise and Man*. US Air Force Report WADC TR-52-204.

Schreckenberg, D. and R. Schuemer. 2010. The Impact of Acoustical, Operational and Non-Auditory Factors on Short-Term Annoyance Due to Aircraft Noise. Inter Noise 2010; Noise and Sustainability. 13 - 16 June 2010, Lisbon, Portugal.

Schultz, T.J. 1978. *Synthesis of social surveys on noise annoyance*. J. Acoust. Soc. Am. 64, No. 2, pp. 377-405, August.

Sharp, B., T. Connor, D. McLaughlin, C. Clark, S. Stansfeld and J. Hervey. 2013. *Assessing Aircraft Noise Conditions Affecting Student Learning*, ACRP Web Document 16, http://www.trb.org/Aviation1/Blurbs/170328.aspx Airport Cooperative Research Program, Transportation Research Board, Washington, DC.

Sharp, B.H., and K.J. Plotkin. 1984. *Selection of Noise Criteria for School Classrooms*. Wyle Research Technical Note TN 84-2 for the Port Authority of New York and New Jersey, October.

Smith, D.G., D.H. Ellis, and T.H. Johnston. 1988. Raptors and Aircraft, In R.L Glinski, B. Gron-Pendelton, M.B. Moss, M.N. LeFranc, Jr., B.A. Millsap, and S.W. Hoffman, eds., Proceedings of the Southwest Raptor Management Symposium, National Wildlife Federation, Washington, D.C., pp. 360-367.

Stansfeld, S.A., B. Berglund, and C. Clark, I. Lopez-Barrio, P. Fischer, E. Öhrström, M.M. Haines, J. Head, S. Hygge, and I. van Kamp, B.F. Berry, on behalf of the RANCH study team. 2005. *Aircraft and road traffic noise and children's cognition and health: a cross-national study*. Lancet 365, 1942-1949.

Stansfeld, S.A. and C. Clark. 2015. *Health Effects of Noise Exposure in Children*. Current Environmental Health Reports 2(2): 171-178.

Stevens, K.N., W.A. Rosenblith, and R.H. Bolt. 1953. *Neighborhood Reaction to Noise: A Survey and Correlation of Case Histories (A).* J. Acoust. Soc. Am. 25, 833.

Stusnick, E., K.A. Bradley, J.A. Molino, and G. DeMiranda. 1992. *The Effect of Onset Rate on Aircraft Noise Annoyance, Volume 2: Rented Home Experiment*. Wyle Laboratories Research Report WR 92-3, March.

UKDfES. 2003. *Building Bulletin 93, Acoustic Design of Schools - A Design Guide*. London: The Stationary Office.

USEPA. 1974. *Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety*. USEPA Report 550/9-74-004, March.

USEPA. 1978. *Protective Noise Levels*. Office of Noise Abatement and Control, Washington, DC. USEPA Report 550/9-79-100, November.

Wesler, J.E. 1986. *Priority Selection of Schools for Soundproofing*. Wyle Research Technical Note TN 96-8 for the Port Authority of New York and New Jersey, October.

WHO. 1999. *Guidelines for Community Noise*. Berglund, B., T. Lindvall, and D. Schwela, eds.

Wyle Laboratories. 1970. *Supporting Information for the Adopted Noise Regulations for California Airports*. Wyle Report WCR 70-3(R).

This page intentionally left blank

Appendix B-2

Noise Modeling

This page intentionally left blank

B.2 NOISE MODELING

The following sections describe input data used in the noise modeling process. This data were developed in coordination with the Air Force Air Combat Command (ACC), Air Force Civil Engineer Center, and Kingsley Field Air National Guard Base (ANGB) personnel.

B.2.1 Airfield Operations

The first step in estimating the effects of the contract adversary air (ADAIR) contracting action was to determine the baseline operations at Kingsley Field ANGB. This was done using information from field personnel to scale the 2007 operations to match the operation counts recorded by the tower for 2017. The tower counted 49,000 operations in 2017 with a military to civilian ratio of 38 percent military to 62 percent civilian. **Table B-5** contains the operations that match the tower count. The next step in the process was to use the baseline operations estimated for the 114th and 550th Fighter Squadrons and scale the 2017 data accordingly. The baseline for the 114th and 550th Fighter Squadrons is 4,556 sorties. The contract ADAIR operations are meant to follow the operations of the 114th and 550th Fighter Squadrons with allowance for proficiency and maintenance flights. The closed pattern operations are not the same percentage of the sorties done by the training squadron. The contract ADAIR operation count of 2,000 includes 48 sorties for maintenance and flight proficiency for the contract ADAIR pilots. This entails the contract ADAIR aircraft being flown to the contractor's maintenance facility.

Table B-6 contains the operations to be modeled for the baseline as well as the additional contract ADAIR aircraft operations. The 114th and 550th Fighter Squadrons train together and fly the Based F-15 C/D aircraft.

A SORTIE IS A SINGLE FLIGHT, BY ONE AIRCRAFT, FROM TAKEOFF TO LANDING WHILE A SORTIE-OPERATION IS THE USE OF ONE AIRSPACE UNIT (E.G., MILITARY OPERATIONS AREA) BY ONE AIRCRAFT. THE NUMBER OF SORTIE-OPERATIONS IS USED TO QUANTIFY THE NUMBER OF USES BY AIRCRAFT AND TO ACCURATELY MEASURE POTENTIAL IMPACTS (E.G., NOISE, AIR QUALITY, AND SAFETY IMPACTS). A SORTIE-OPERATION IS NOT A MEASURE OF HOW LONG AN AIRCRAFT USES AN AIRSPACE UNIT, NOR DOES IT INDICATE THE NUMBER OF AIRCRAFT IN AN AIRSPACE UNIT DURING A GIVEN PERIOD; IT IS A MEASUREMENT FOR THE NUMBER OF TIMES A SINGLE AIRCRAFT USES A PARTICULAR AIRSPACE UNIT.

This page intentionally left blank

Table B-5
Baseline Operations at Kingsley Airfield for 2017

	Aircraft Category	Aircraft Type	AB Departure			Standard / Mil Departure			Overhead Break Arrivals			TAC 90			Straight In Arrivals			Closed Pattern			Total Annual Operations		
			Day (0700-2200)	Night (2200-0700)	Total	Day (0700-2200)	Night (2200-0700)	Total	Day (0700-2200)	Night (2200-0700)	Total	Day (0700-2200)	Night (2200-0700)	Total	Day (0700-2200)	Night (2200-0700)	Total	Day (0700-2200)	Night (2200-0700)	Total	Day (0700-2200)	Night (2200-0700)	Total
Based	Military	F-15	1282	-	1282	2990	-	2990	1038	30	1068	2076	60	2136	1038	30	1068	8658	120	8778	17082	240	17322
	Gen Aviation	GS200	-	-	-	256	-	256	-	-	-	-	-	-	256	-	256	-	-	-	512	-	512
		ASTRA	-	-	-	256	-	256	-	-	-	-	-	-	256	-	256	-	-	-	512	-	512
		DHC-8	-	-	-	818	204	1022	-	-	-	-	-	-	818	204	1022	-	-	-	1636	408	2044
		GASEPF	-	-	-	4946	-	4946	-	-	-	-	-	-	4946	-	4946	3491	-	3491	13383	-	13383
		GASPV	-	-	-	4946	-	4946	-	-	-	-	-	-	4946	-	4946	3491	-	3491	13383	-	13383
	Based Totals		**1282**	**-**	**1282**	**14212**	**204**	**14416**	**1038**	**30**	**1068**	**2076**	**60**	**2136**	**12260**	**234**	**12494**	**15640**	**120**	**15760**	**46508**	**648**	**47156**
Transient	Sentry Eagle Exercises	KC-135	-	-	-	26	-	26	-	-	-	-	-	-	26	-	26	-	-	-	52	-	52
		F-15	79	-	79	79	-	79	-	-	-	-	-	-	158	-	158	2	-	2	318	-	318
		F-16	79	-	79	79	-	79	-	-	-	-	-	-	158	-	158	2	-	2	318	-	318
		F-35	7	-	7	7	-	7	-	-	-	-	-	-	14	-	14	2	-	2	30	-	30
		F-18	79	-	79	79	-	79	-	-	-	-	-	-	158	-	158	2	-	2	318	-	318
	FBO	A-10	-	-	-	2	-	2	-	-	-	-	-	-	2	-	2	-	-	-	4	-	4
		C-12	-	-	-	6	-	6	-	-	-	-	-	-	6	-	6	-	-	-	12	-	12
		C-130	-	-	-	4	-	4	-	-	-	-	-	-	4	-	4	-	-	-	8	-	8
		F-15	-	-	-	3	-	3	-	-	-	-	-	-	3	-	3	-	-	-	6	-	6
		F-16	-	-	-	2	-	2	-	-	-	-	-	-	2	-	2	-	-	-	4	-	4
		F-18	-	-	-	23	-	23	-	-	-	-	-	-	23	-	23	-	-	-	46	-	46
		T-38	-	-	-	5	-	5	-	-	-	-	-	-	5	-	5	-	-	-	10	-	10
		T-6	-	-	-	2	-	2	-	-	-	-	-	-	2	-	2	-	-	-	4	-	4
		Helos	-	-	-	84	-	84	-	-	-	-	-	-	84	-	84	-	-	-	168	-	168
	USFS	Tankers	-	-	-	273	-	273	-	-	-	-	-	-	273	-	273	-	-	-	546	-	546
	Transient Totals		**244**	**-**	**244**	**674**	**-**	**674**	**-**	**-**	**-**	**-**	**-**	**-**	**918**	**-**	**918**	**8**	**-**	**8**	**1844**	**-**	**1844**
Military Totals			1526	-	1526	3391	-	3391	1038	30	1068	2076	60	2136	1683	30	1713	8666	120	8786	18380	240	18620
Civilian Totals			-	-	-	11495	204	11699	-	-	-	-	-	-	11495	204	11699	6982	-	6982	29972	408	30380
Grand Totals			**1526**	**0**	**1526**	**14886**	**204**	**15090**	**1038**	**30**	**1068**	**2076**	**60**	**2136**	**13178**	**234**	**13412**	**15648**	**120**	**15768**	**48352**	**648**	**49000**

(1) Tower count of 49,000 operations for CY2017 - 38% military and 62% civilian.

(2) As flown F-15 based sorties was 4272 for CY2017.

(3) Patterns by large aircraft no longer occur; as a result, transient traffic has declined.

(4) Fuel records from Fixed Based Operator, Century Aviation, used to identify all transient military aircraft. Modeled as fuel up and go because that is what they are reported to do.

(5) Sentry Eagle Exercises modeled as 42 aircraft coming to Kingsley Field for a week of exercises. Fleet mix from 2017 used. P-3 and C-130s had been used in the past, but not in 2017.

(6) AB takeoffs are 30% of the time. All use noise abatement procedure of turning off AB at end of runway.

Table B-6
Baseline Training Operations at Kingsley Field Plus Contract Adversary Air Operations

	Aircraft Category	Aircraft Type	Modeled Aircraft Type (if different)	AB Departure			Standard / MIL Departure			Overhead Break Arrivals			TAC 90			Straight In Arrivals			Closed Pattern			Total Annual Operations		
				Day (0700-2200)	Night (2200-0700)	Total	Day (0700-2200)	Night (2200-0700)	Total	Day (0700-2200)	Night (2200-0700)	Total	Day (0700-2200)	Night (2200-0700)	Total	Day (0700-2200)	Night (2200-0700)	Total	Day (0700-2200)	Night (2200-0700)	Total	Day (0700-2200)	Night (2200-0700)	Total
Based	Military	F-15C&D	F-15E	1367	-	1367	3189	-	3189	1107	32	1139	2214	64	2278	1107	32	1139	9096	265	9361	18080	393	18473
	ADAIR	CAT C	See note (2)	2000	-	2000	-	-	-	337	-	337	1013	-	1013	590	60	650	540	-	540	4480	60	4540
	Gen Aviation	GS200	COMPOS BUS JET	-	-	-	256	-	256	-	-	-	-	-	-	256	-	256	-	-	-	512	-	512
		ASTRA		-	-	-	256	-	256	-	-	-	-	-	-	256	-	256	-	-	-	512	-	512
		DHC-8		-	-	-	818	204	1022	-	-	-	-	-	-	818	204	1022	-	-	-	1636	408	2044
		GASEPF		-	-	-	4946	-	4946	-	-	-	-	-	-	4946	-	4946	3491	-	3491	13383	-	13383
		GASPV		-	-	-	4946	-	4946	-	-	-	-	-	-	4946	-	4946	3491	-	3491	13383	-	13383
	Based Totals			**3367**	**-**	**3367**	**14411**	**204**	**14615**	**1444**	**32**	**1476**	**3227**	**64**	**3291**	**12919**	**296**	**13215**	**16618**	**265**	**16883**	**51986**	**861**	**52847**
Transient	Sentry Eagle Exercises	KC-135R		-	-	-	26	-	26	-	-	-	-	-	-	26	-	26	-	-	-	52	-	52
		F-15	F-15E	79	-	79	79	-	79	-	-	-	-	-	-	158	-	158	2	-	2	318	-	318
		F-16	F-16C	79	-	79	79	-	79	-	-	-	-	-	-	158	-	158	2	-	2	318	-	318
		F-35		7	-	7	7	-	7	-	-	-	-	-	-	14	-	14	2	-	2	30	-	30
		F-18	F-18E/F	79	-	79	79	-	79	-	-	-	-	-	-	158	-	158	2	-	2	318	-	318
	FBO	A-10		-	-	-	2	-	2	-	-	-	-	-	-	2	-	2	-	-	-	4	-	4
		C-12		-	-	-	6	-	6	-	-	-	-	-	-	6	-	6	-	-	-	12	-	12
		C-130J		-	-	-	4	-	4	-	-	-	-	-	-	4	-	4	-	-	-	8	-	8
		F-15	F-15E	-	-	-	3	-	3	-	-	-	-	-	-	3	-	3	-	-	-	6	-	6
		F-16	F-16C	-	-	-	2	-	2	-	-	-	-	-	-	2	-	2	-	-	-	4	-	4
		F-18	F-18E/F	-	-	-	23	-	23	-	-	-	-	-	-	23	-	23	-	-	-	46	-	46
		T-38	T-38C	-	-	-	5	-	5	-	-	-	-	-	-	5	-	5	-	-	-	10	-	10
		T-6		-	-	-	2	-	2	-	-	-	-	-	-	2	-	2	-	-	-	4	-	4
		Helos	CH-47	-	-	-	84	-	84	-	-	-	-	-	-	84	-	84	-	-	-	168	-	168
	USFS	Tankers	MD-83	-	-	-	166	-	166	-	-	-	-	-	-	166	-	166	-	-	-	332	-	332
	Transient Totals			**244**	**-**	**244**	**567**	**-**	**567**	**-**	**-**	**-**	**-**	**-**	**-**	**811**	**-**	**811**	**8**	**-**	**8**	**1630**	**-**	**1630**
Military Totals				3611	-	3611	3590	-	3590	1444	32	1476	3227	64	3291	2342	92	2434	9644	265	9909	23858	453	24311
Civilian Totals				-	-	-	11388	204	11592	-	-	-	-	-	-	11388	204	11592	6982	-	6982	29758	408	30166
Grand Totals				**3611**	**-**	**3611**	**14978**	**204**	**15182**	**1444**	**32**	**1476**	**3227**	**64**	**3291**	**13730**	**296**	**14026**	**16626**	**265**	**16891**	**53616**	**861**	**54477**

Notes:
(0) This table represents operations at the airfield. Every operation is an aircraft leaving (wheels up) or departing (wheels down). 2 closed pattern operations = 1 circuit (1 wheels down + 1 wheels up). 1 sortie = 1 departure + 1 arrival.
(1) F-15 departures are either with AB or MIL power.
(2) ADAIR operations apply only to the Proposed Action scenario to be modeled as F18E/F, F16C, or F16A for high, med, and low noise Type C Proposed Action scenarios, respectively;
(3) 70 % of Mil Power Departures use noise abatement profile.
(4) All AB Power departures use noise abatement profile.
(5) Modeling based on FY16 scheduled sorties: 4556
(6) ADAIR sorties w/ proficiency flights: 2000
(7) Fraction of operations at night: 0.0283
(8) Closed pattern ops to sortie ratio: 2.0547
(9) Based F-15 flights: 70% of Departures at Mil Power; 30% of Departures at AB Power
(10) Based F-15 arrivals: 25% Overhead Break; 50% TAC 90; 25% Straight In
(11) USFS is the average number of sorties for 2014 - 2017

B.2.2 Runway and Flight Track Use

This section describes the flight tracks used by the aircraft operating out of Kingsley Field as well as the runway utilization. Utilization percentages are provided for each runway in **Table B-7**. Flight track maps for all aircraft are presented on **Figure B-13** (departures), **Figure B-14** (arrivals) and **Figure B-15** (closed patterns). Closed pattern flight track represent aircraft patterns that depart and arrive on the same runway. Example flight profiles that use closed pattern flight tracks are simulated flame out and visual flight rules pattern profiles.

Table B-7
Runway Usage for Based Aircraft at Kingsley Field

Op Type	Runway				
	ID	Military		Civilian	
		Day (0700-2200)	Night (2200-0700)	Day (0700-2200)	Night (2200-0700)
Departure	14	65%	0%	79%	3%
	32	35%	0%	10%	<0.5%
	07	0%	0%	4%	0%
	25	0%	0%	4%	0%
Arrival	14	35%	0%	79%	3%
	32	62%	3%	10%	<0.5%
	07	0%	0%	4%	0%
	25	0%	0%	4%	0%
Closed Pattern	14	35%	0%	80%	0%
	32	65%	0%	20%	0%
	07	0%	0%	0%	0%
	25	0%	0%	0%	0%

Note: USFS operations expected to follow civilian runway usage ratio on Runway 14-32.

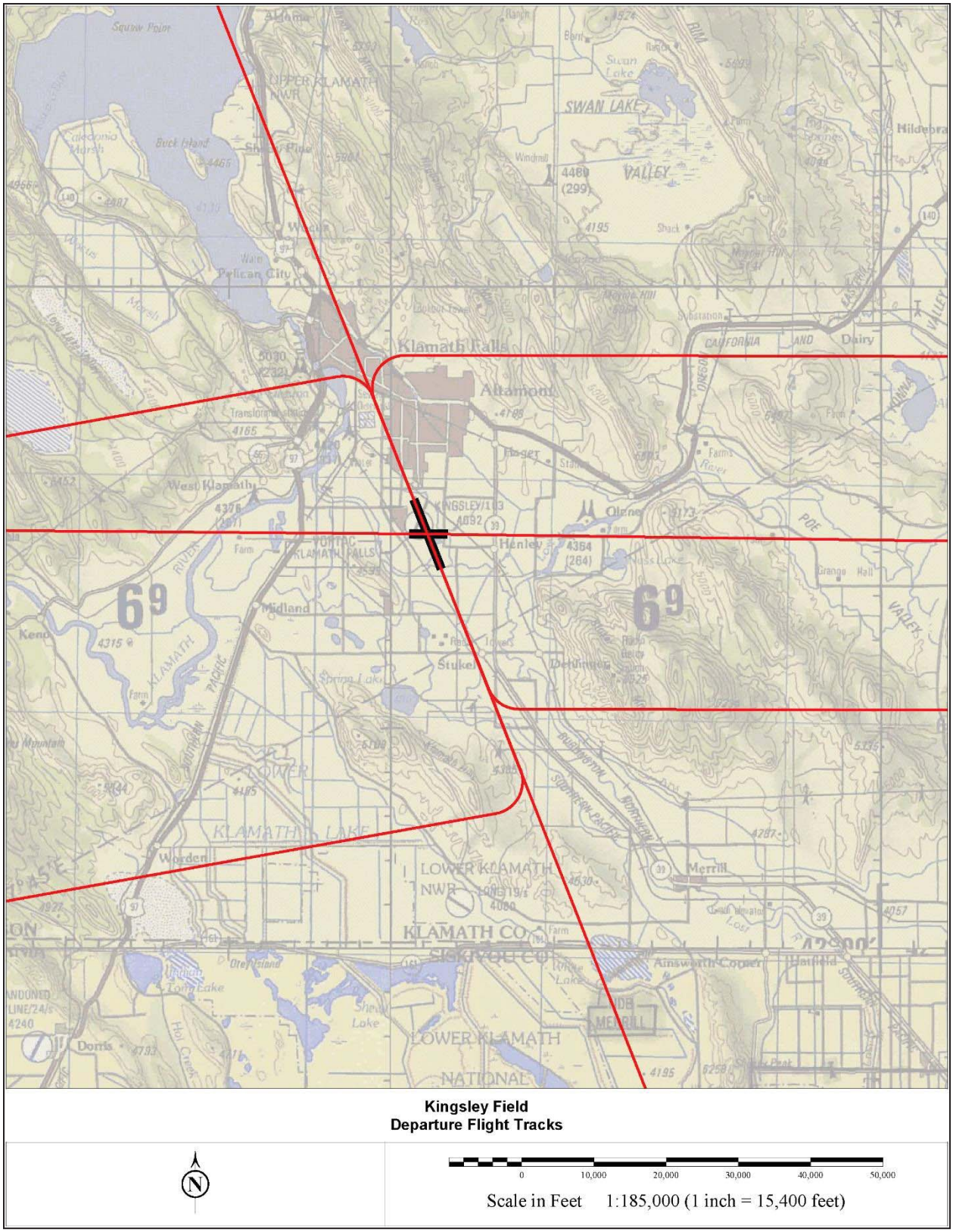


Figure B-13. Departure Flight Tracks at Kingsley Field.

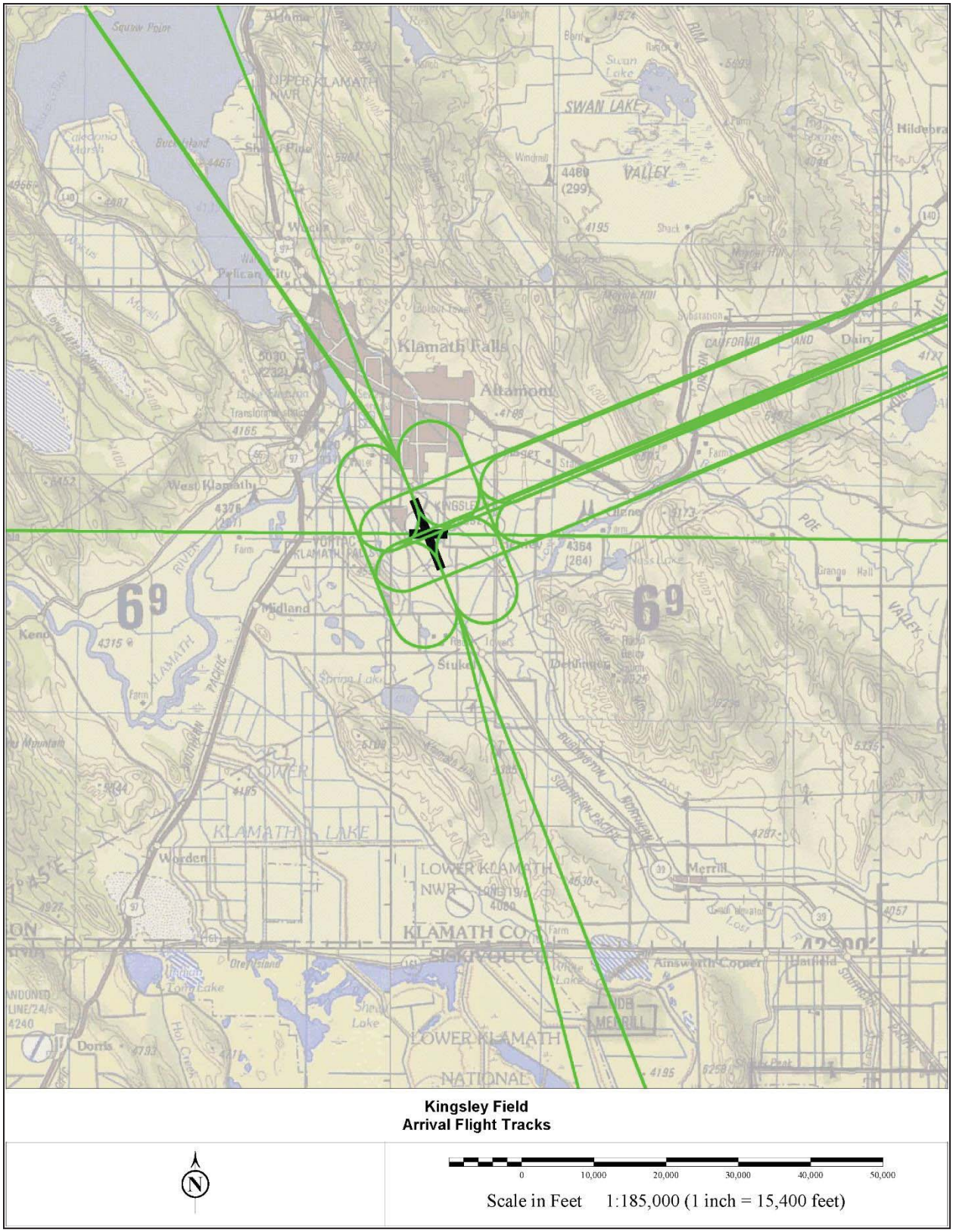


Figure B-14. Arrival Flight Tracks at Kingsley Field.

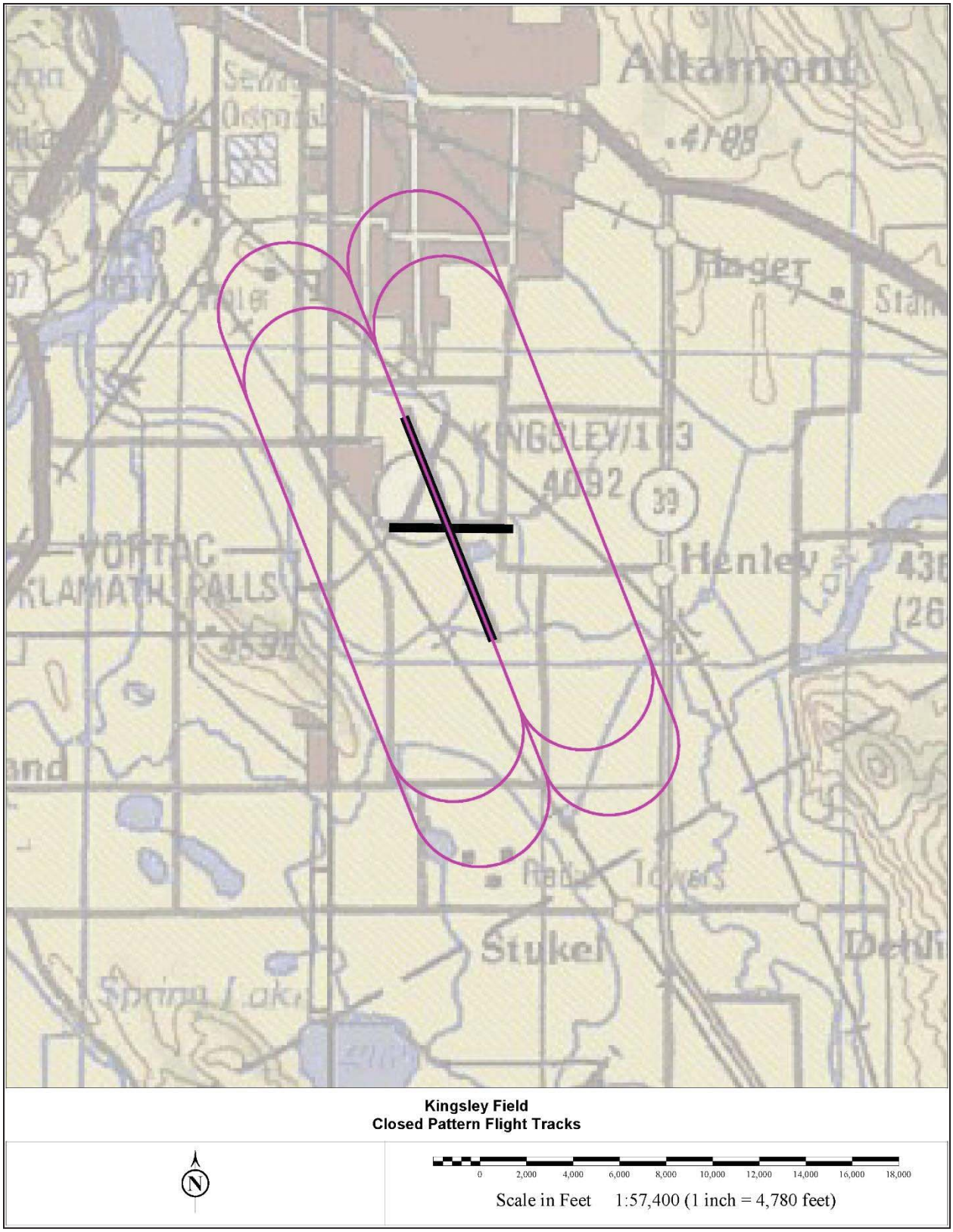


Figure B-15. Closed Pattern Flight Tracks at Kingsley Field.

B.2.3 Flight Profiles and Aircraft

The ADAIR program would locate contractor aircraft at Kingsley Field with the appropriate capabilities to respond to the needs of the fighters at the bases. The Air Force identified three categories of aircraft with differing capabilities (A, B, and C) on the contract. Kingsley Field is designated a category C location. To fulfill the requirements of a category a contractor could provide a variety of aircraft with the appropriate specifications. Because the type of aircraft for contract ADAIR are not known at this time, representative noise surrogates were selected for the lowest through highest potential noise emission scenarios for the aircraft that contractors may select to provide for each of the categories. To model a given noise scenario for a certain category, all contract ADAIR flight operations were assigned to the surrogate. All three scenarios modeled separately in the final analysis for Kingsley Field. The surrogate selected for the different categories and scenarios are presented in **Table B-8**.

Table B-8
Aircraft Scenarios

Category	High Noise Scenario	Medium Noise Scenario	Low Noise Scenario
A	A-4N (A-4C surrogate)	MiG-21 (F-104D&G surrogate)	L-59 (T-45 surrogate)
B	F-5 (F-5E surrogate)	A-4K (A-4C surrogate)	T-59 Hawk (T-45 surrogate)
C	Eurofighter Typhoon (F-18E/F surrogate)	Dassault Mirage (F-16C surrogate)	JAS 39 Gripen (F-16A surrogate)

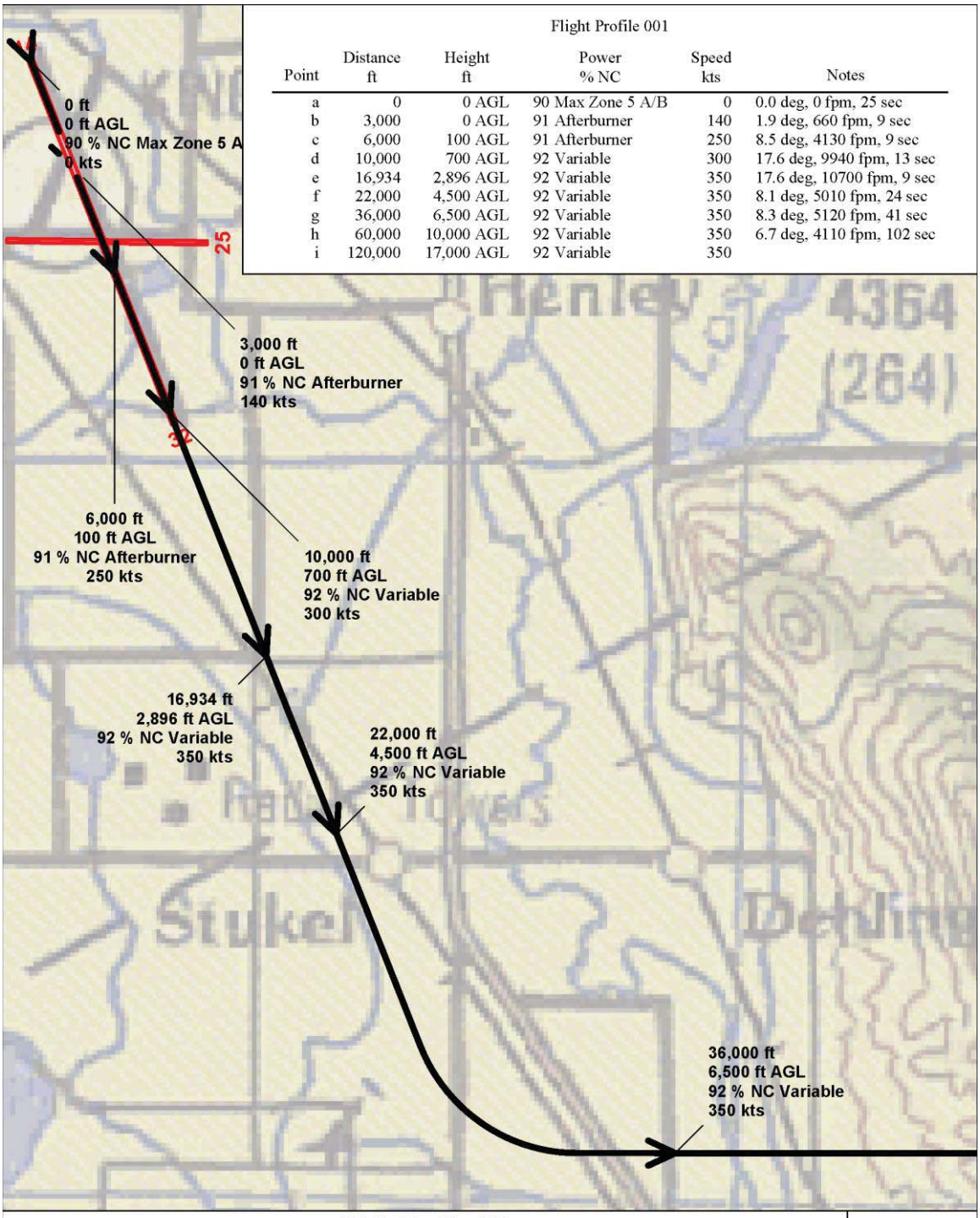
This section details the representative profiles for each aircraft that is based at Kingsley Field ANGB. This includes the F-15 aircraft of the 114th and 550th Fighter Squadrons and the proposed ADAIR aircraft for Category C. The Category C aircraft are modeled as the F-16A for the low-noise scenario, the F-16C for the medium-noise scenario, and the F-18E/F for the high-noise scenario. Because it is unknown which aircraft type or combination thereof that the contractor will bring to Kingsley Field ANGB, each scenario is modeled separately as if it were the only aircraft in the contract ADAIR inventory.

Representative profiles provide the speed and power setting of each type of aircraft as a function of distance along the flight track for the representative maneuvers. For modeling purposes, the appropriate profile is used for all flight tracks that conform to that maneuver type. For example, all overhead break arrival tracks utilize the representative profile for modeling that maneuver.

The operations tables (**Tables B-5** and **B-6**) can be used with the runway usage table (**Table B-7**) to understand the distribution of the following representative profiles that will be modeled on tracks associated with each runway. One important point to note in looking at flight profiles: the description of the power setting indicates the aircraft's configuration. For modeling noise emissions, there are two different configurations. Any description with the words Approach or Parallel indicate that the aircraft is fully configured for arrival (landing gear down, flaps set, etc.). All other descriptions in the profile indicate the aircraft is not fully configured for arrival.

B.2.3.1 Based Aircraft Representative Flight Profiles

Flight Profiles for the 114th and 550th Fighter Squadrons' F-15s



Flight Profile 001

Point	Distance ft	Height ft	Power % NC	Speed kts	Notes
a	0	0 AGL	90 Max Zone 5 A/B	0	0.0 deg, 0 fpm, 25 sec
b	3,000	0 AGL	91 Afterburner	140	1.9 deg, 660 fpm, 9 sec
c	6,000	100 AGL	91 Afterburner	250	8.5 deg, 4130 fpm, 9 sec
d	10,000	700 AGL	92 Variable	300	17.6 deg, 9940 fpm, 13 sec
e	16,934	2,896 AGL	92 Variable	350	17.6 deg, 10700 fpm, 9 sec
f	22,000	4,500 AGL	92 Variable	350	8.1 deg, 5010 fpm, 24 sec
g	36,000	6,500 AGL	92 Variable	350	8.3 deg, 5120 fpm, 41 sec
h	60,000	10,000 AGL	92 Variable	350	6.7 deg, 4110 fpm, 102 sec
i	120,000	17,000 AGL	92 Variable	350	

Flight Profile 001
F-15 DEPARTURE RUNWAY 14_1 AB SID - REPRESENTATIVE

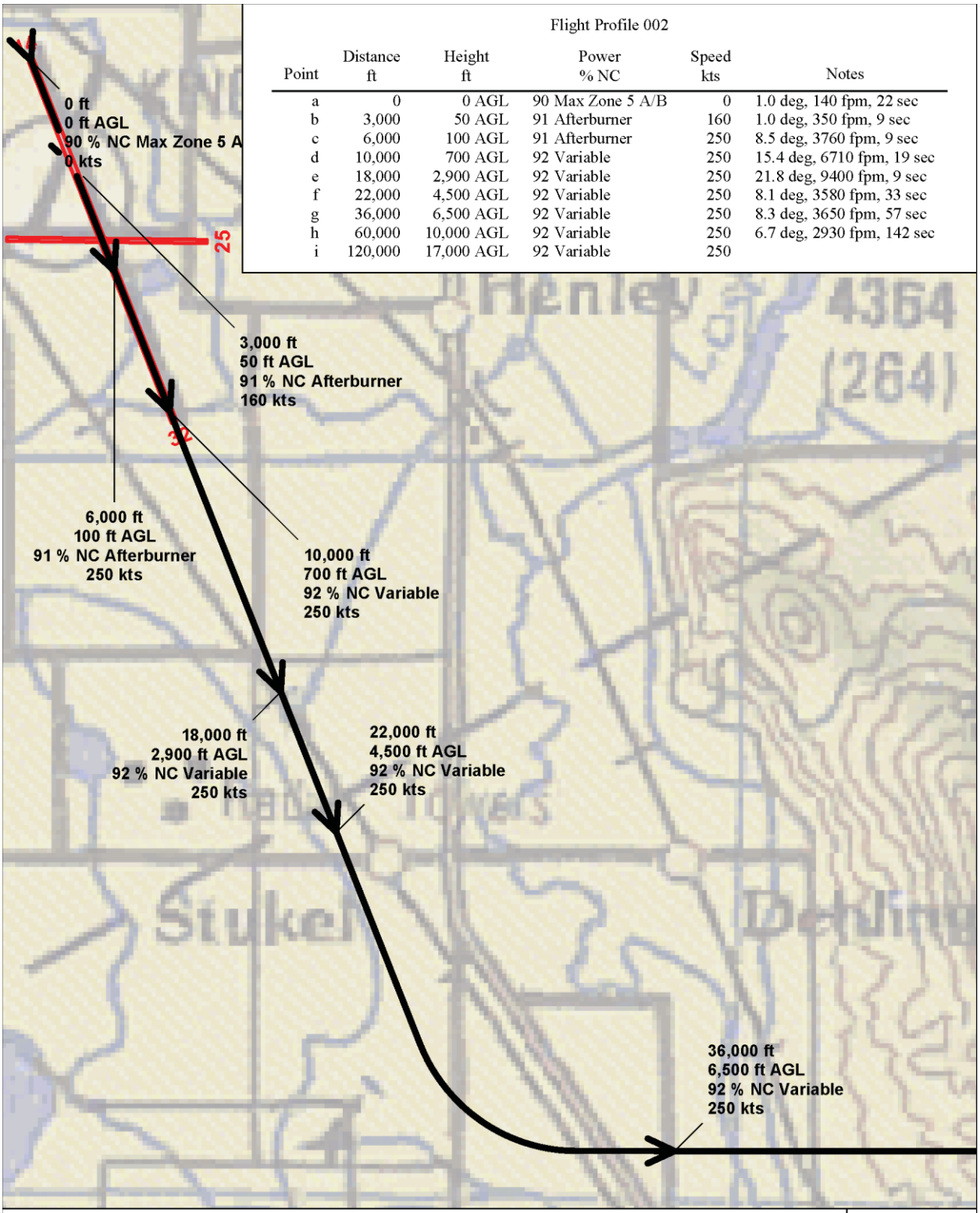
0 2,000 4,000 6,000 8,000 10,000 12,000 14,000 16,000

Scale in Feet 1:47,800 (1 inch = 3,990 feet)

N

Flight Profile 002

Point	Distance ft	Height ft	Power % NC	Speed kts	Notes
a	0	0 AGL	90 Max Zone 5 A/B	0	1.0 deg, 140 fpm, 22 sec
b	3,000	50 AGL	91 Afterburner	160	1.0 deg, 350 fpm, 9 sec
c	6,000	100 AGL	91 Afterburner	250	8.5 deg, 3760 fpm, 9 sec
d	10,000	700 AGL	92 Variable	250	15.4 deg, 6710 fpm, 19 sec
e	18,000	2,900 AGL	92 Variable	250	21.8 deg, 9400 fpm, 9 sec
f	22,000	4,500 AGL	92 Variable	250	8.1 deg, 3580 fpm, 33 sec
g	36,000	6,500 AGL	92 Variable	250	8.3 deg, 3650 fpm, 57 sec
h	60,000	10,000 AGL	92 Variable	250	6.7 deg, 2930 fpm, 142 sec
i	120,000	17,000 AGL	92 Variable	250	



Flight Profile 002

F-15 DEPARTURE RUNWAY 14_1 AB NOISE ABATEMENT - REPRESENTATIVE

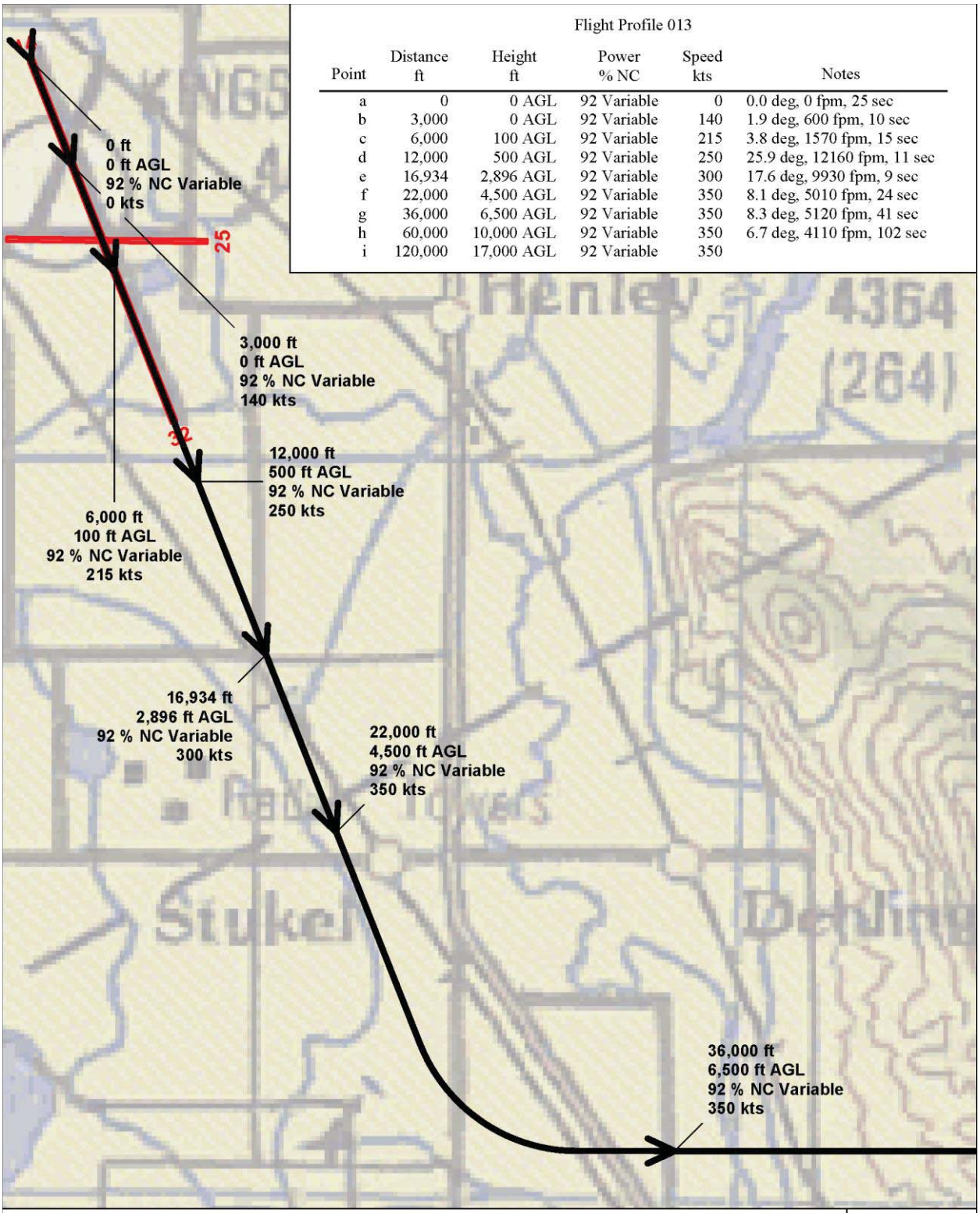
0 2,000 4,000 6,000 8,000 10,000 12,000 14,000 16,000

Scale in Feet 1:47,800 (1 inch = 3,990 feet)

N

Flight Profile 013

Point	Distance ft	Height ft	Power % NC	Speed kts	Notes
a	0	0 AGL	92 Variable	0	0.0 deg, 0 fpm, 25 sec
b	3,000	0 AGL	92 Variable	140	1.9 deg, 600 fpm, 10 sec
c	6,000	100 AGL	92 Variable	215	3.8 deg, 1570 fpm, 15 sec
d	12,000	500 AGL	92 Variable	250	25.9 deg, 12160 fpm, 11 sec
e	16,934	2,896 AGL	92 Variable	300	17.6 deg, 9930 fpm, 9 sec
f	22,000	4,500 AGL	92 Variable	350	8.1 deg, 5010 fpm, 24 sec
g	36,000	6,500 AGL	92 Variable	350	8.3 deg, 5120 fpm, 41 sec
h	60,000	10,000 AGL	92 Variable	350	6.7 deg, 4110 fpm, 102 sec
i	120,000	17,000 AGL	92 Variable	350	



Flight Profile 013

F-15 DEPARTURE RUNWAY 14_1 MILPOWER SID - REPRESENTATIVE

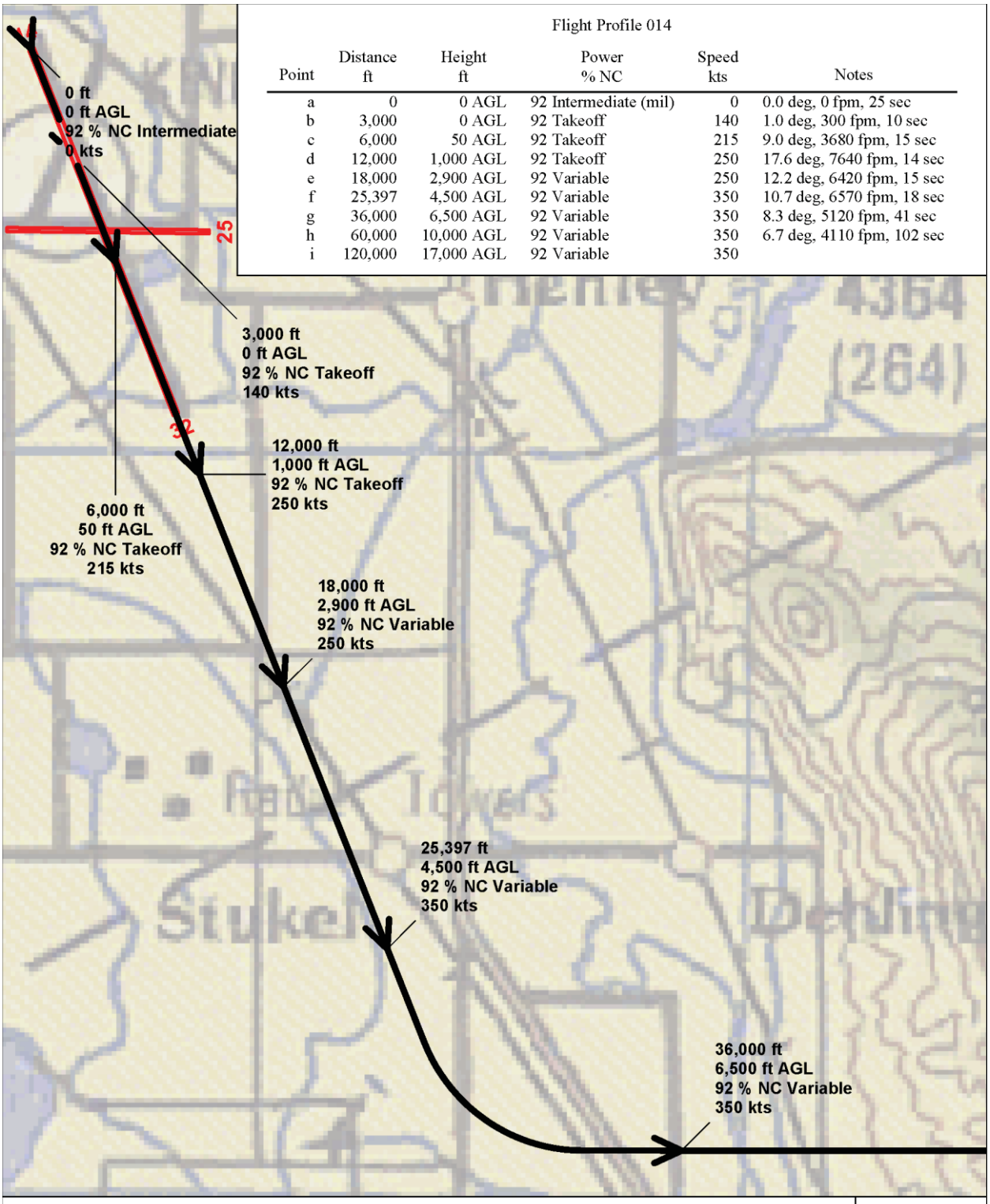
0 2,000 4,000 6,000 8,000 10,000 12,000 14,000 16,000

Scale in Feet 1:47,800 (1 inch = 3,990 feet)

N

Flight Profile 014

Point	Distance ft	Height ft	Power % NC	Speed kts	Notes
a	0	0 AGL	92 Intermediate (mil)	0	0.0 deg, 0 fpm, 25 sec
b	3,000	0 AGL	92 Takeoff	140	1.0 deg, 300 fpm, 10 sec
c	6,000	50 AGL	92 Takeoff	215	9.0 deg, 3680 fpm, 15 sec
d	12,000	1,000 AGL	92 Takeoff	250	17.6 deg, 7640 fpm, 14 sec
e	18,000	2,900 AGL	92 Variable	250	12.2 deg, 6420 fpm, 15 sec
f	25,397	4,500 AGL	92 Variable	350	10.7 deg, 6570 fpm, 18 sec
g	36,000	6,500 AGL	92 Variable	350	8.3 deg, 5120 fpm, 41 sec
h	60,000	10,000 AGL	92 Variable	350	6.7 deg, 4110 fpm, 102 sec
i	120,000	17,000 AGL	92 Variable	350	



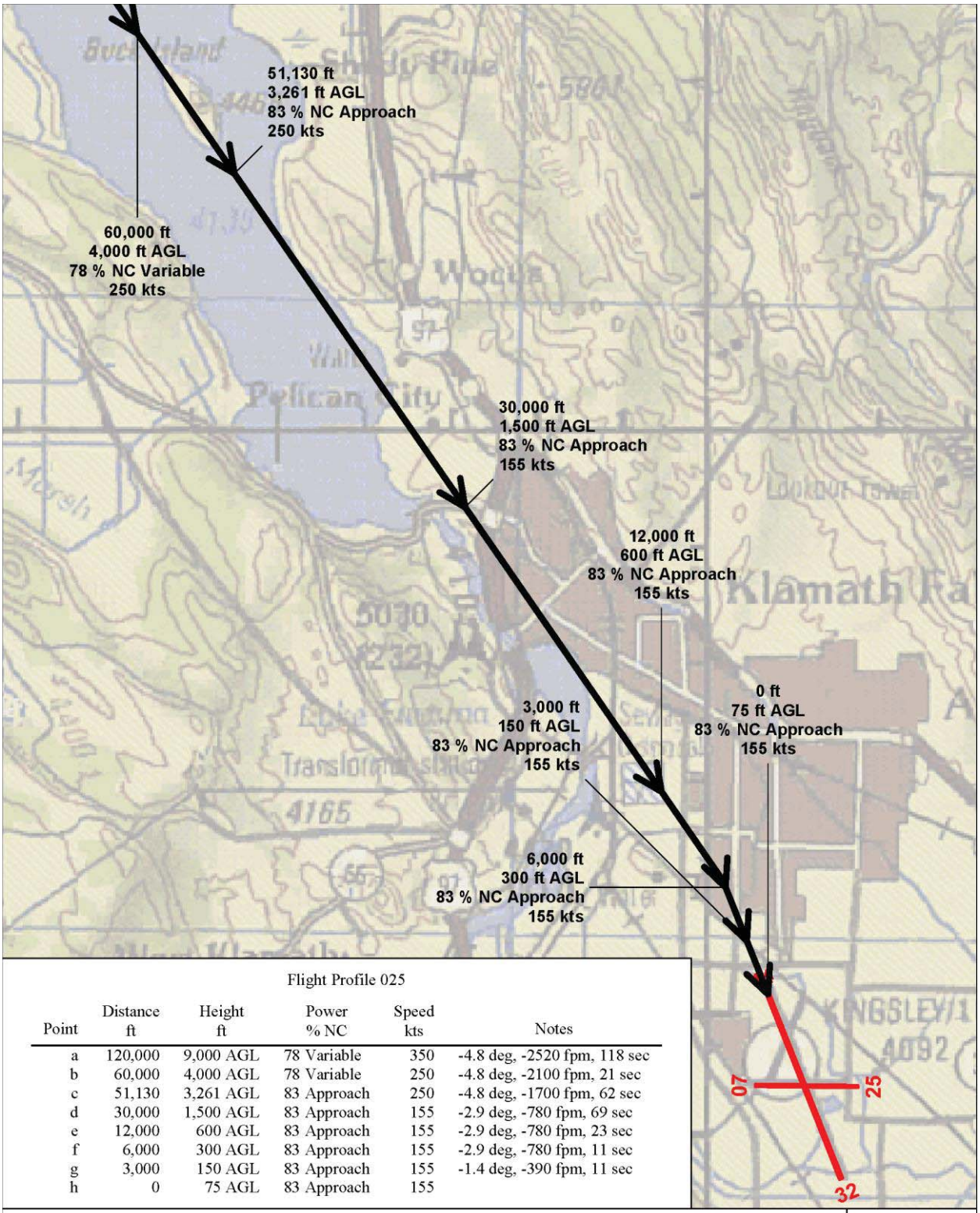
Flight Profile 014

F-15 DEPARTURE RUNWAY 14_1 MILPOWER NOISE ABATEMENT - REPRESENTATIVE

0 2,000 4,000 6,000 8,000 10,000 12,000 14,000 16,000

Scale in Feet 1:47,800 (1 inch = 3,990 feet)

N



Flight Profile 025

Point	Distance ft	Height ft	Power % NC	Speed kts	Notes
a	120,000	9,000 AGL	78 Variable	350	-4.8 deg, -2520 fpm, 118 sec
b	60,000	4,000 AGL	78 Variable	250	-4.8 deg, -2100 fpm, 21 sec
c	51,130	3,261 AGL	83 Approach	250	-4.8 deg, -1700 fpm, 62 sec
d	30,000	1,500 AGL	83 Approach	155	-2.9 deg, -780 fpm, 69 sec
e	12,000	600 AGL	83 Approach	155	-2.9 deg, -780 fpm, 23 sec
f	6,000	300 AGL	83 Approach	155	-2.9 deg, -780 fpm, 11 sec
g	3,000	150 AGL	83 Approach	155	-1.4 deg, -390 fpm, 11 sec
h	0	75 AGL	83 Approach	155	

Flight Profile 025

F-15 ARRIVAL RUNWAY 14_3 VORTAC AND STRAIGHT IN - REPRESENTATIVE

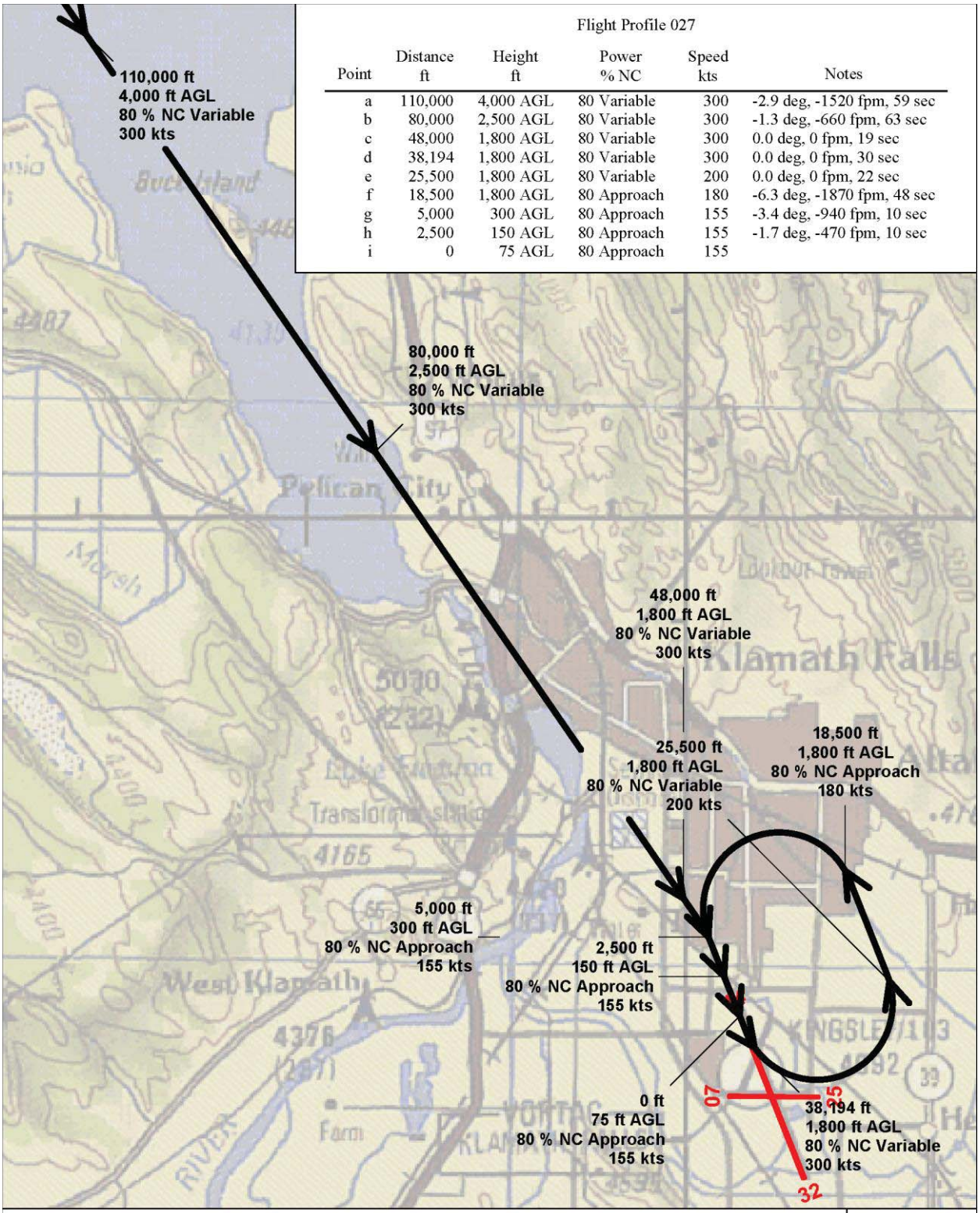
0 4,000 8,000 12,000 16,000 20,000 24,000 28,000 32,000

Scale in Feet 1:93,900 (1 inch = 7,830 feet)

N

Flight Profile 027

Point	Distance ft	Height ft	Power % NC	Speed kts	Notes
a	110,000	4,000 AGL	80 Variable	300	-2.9 deg, -1520 fpm, 59 sec
b	80,000	2,500 AGL	80 Variable	300	-1.3 deg, -660 fpm, 63 sec
c	48,000	1,800 AGL	80 Variable	300	0.0 deg, 0 fpm, 19 sec
d	38,194	1,800 AGL	80 Variable	300	0.0 deg, 0 fpm, 30 sec
e	25,500	1,800 AGL	80 Variable	200	0.0 deg, 0 fpm, 22 sec
f	18,500	1,800 AGL	80 Approach	180	-6.3 deg, -1870 fpm, 48 sec
g	5,000	300 AGL	80 Approach	155	-3.4 deg, -940 fpm, 10 sec
h	2,500	150 AGL	80 Approach	155	-1.7 deg, -470 fpm, 10 sec
i	0	75 AGL	80 Approach	155	

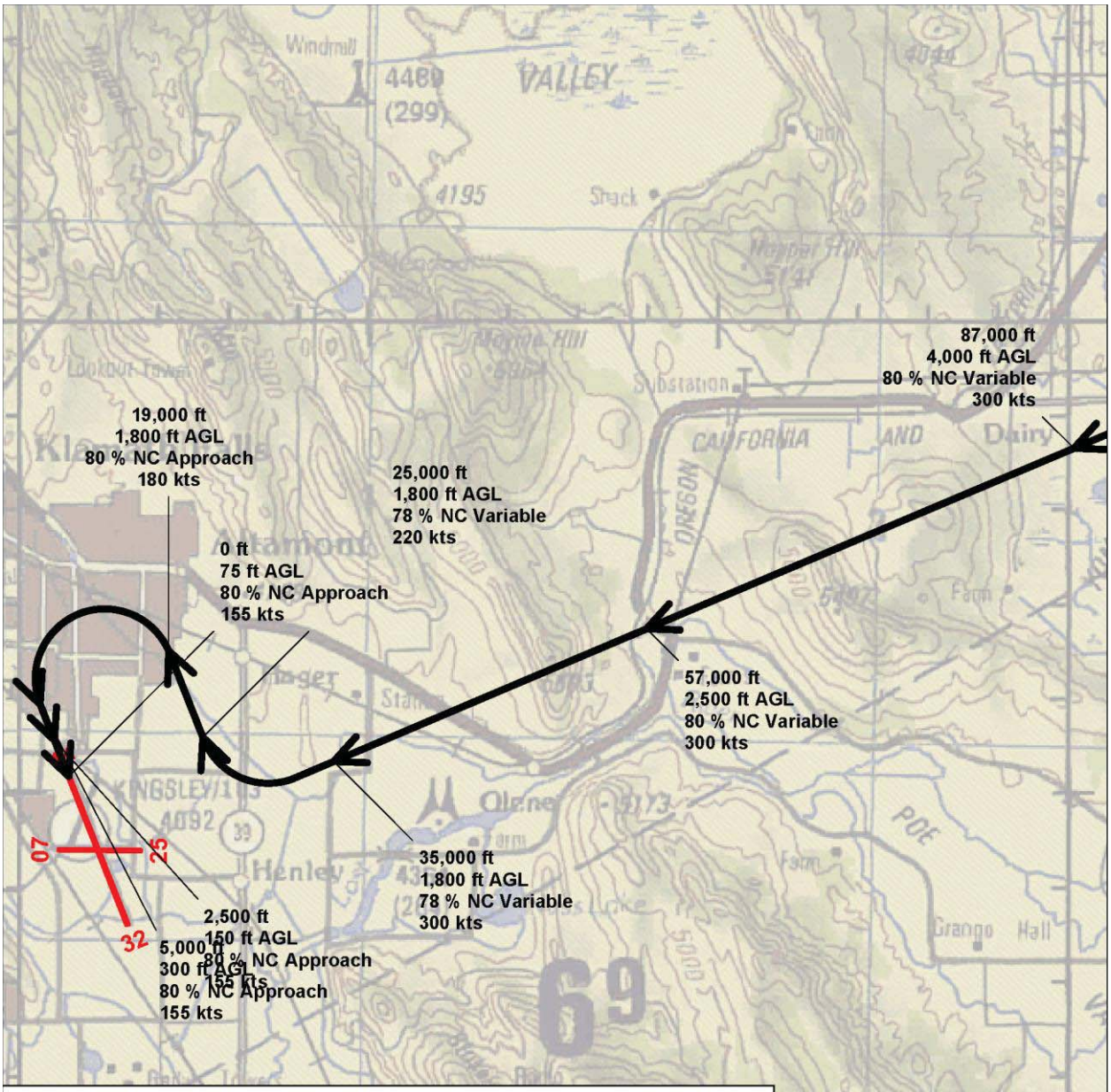


Flight Profile 027
F-15 ARRIVAL RUNWAY 14-1 OVERHEAD EAST - REPRESENTATIVE

0 4,000 8,000 12,000 16,000 20,000 24,000 28,000 32,000 36,000

Scale in Feet 1:106,000 (1 inch = 8,860 feet)

N



Flight Profile 031

Point	Distance ft	Height ft	Power % NC	Speed kts	Notes
a	87,000	4,000 AGL	80 Variable	300	-2.9 deg, -1520 fpm, 59 sec
b	57,000	2,500 AGL	80 Variable	300	-1.8 deg, -970 fpm, 43 sec
c	35,000	1,800 AGL	78 Variable	300	0.0 deg, 0 fpm, 23 sec
d	25,000	1,800 AGL	78 Variable	220	0.0 deg, 0 fpm, 18 sec
e	19,000	1,800 AGL	80 Approach	180	-6.1 deg, -1810 fpm, 50 sec
f	5,000	300 AGL	80 Approach	155	-3.4 deg, -940 fpm, 10 sec
g	2,500	150 AGL	80 Approach	155	-1.7 deg, -470 fpm, 10 sec
h	0	75 AGL	80 Approach	155	

Flight Profile 031

F-15 ARRIVAL RUNWAY 14_4 TAC 90 LEAD EAST - REPRESENTATIVE

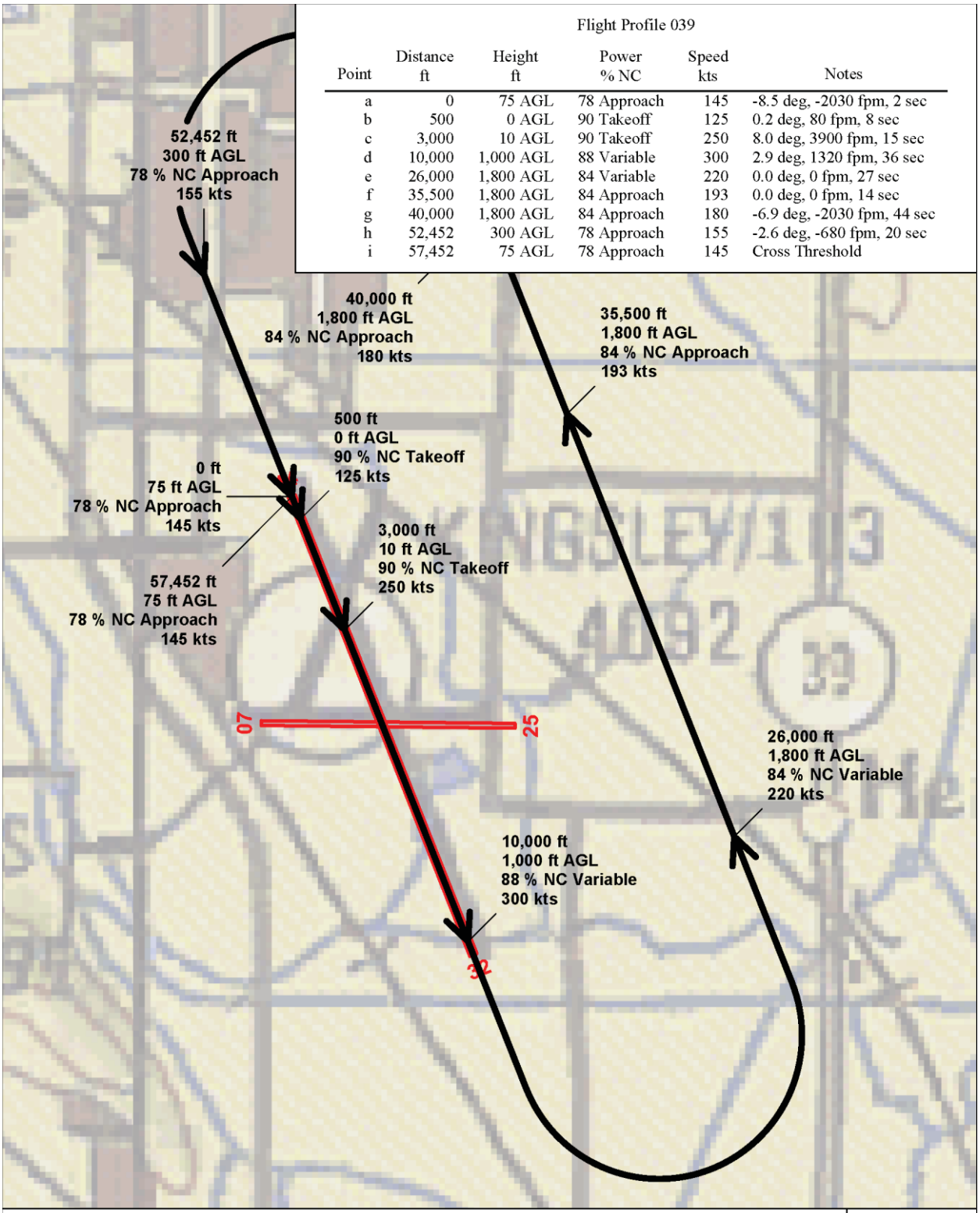
0 4,000 8,000 12,000 16,000 20,000 24,000 28,000 32,000 36,000 40,000 44,000

Scale in Feet 1:132,000 (1 inch = 11,000 feet)

N

Flight Profile 039

Point	Distance ft	Height ft	Power % NC	Speed kts	Notes
a	0	75 AGL	78 Approach	145	-8.5 deg, -2030 fpm, 2 sec
b	500	0 AGL	90 Takeoff	125	0.2 deg, 80 fpm, 8 sec
c	3,000	10 AGL	90 Takeoff	250	8.0 deg, 3900 fpm, 15 sec
d	10,000	1,000 AGL	88 Variable	300	2.9 deg, 1320 fpm, 36 sec
e	26,000	1,800 AGL	84 Variable	220	0.0 deg, 0 fpm, 27 sec
f	35,500	1,800 AGL	84 Approach	193	0.0 deg, 0 fpm, 14 sec
g	40,000	1,800 AGL	84 Approach	180	-6.9 deg, -2030 fpm, 44 sec
h	52,452	300 AGL	78 Approach	155	-2.6 deg, -680 fpm, 20 sec
i	57,452	75 AGL	78 Approach	145	Cross Threshold



Flight Profile 039
F-15 CLOSED PATTERN RUNWAY 14 EAST-REPRESENTATIVE

0 2,000 4,000 6,000 8,000 10,000 12,000

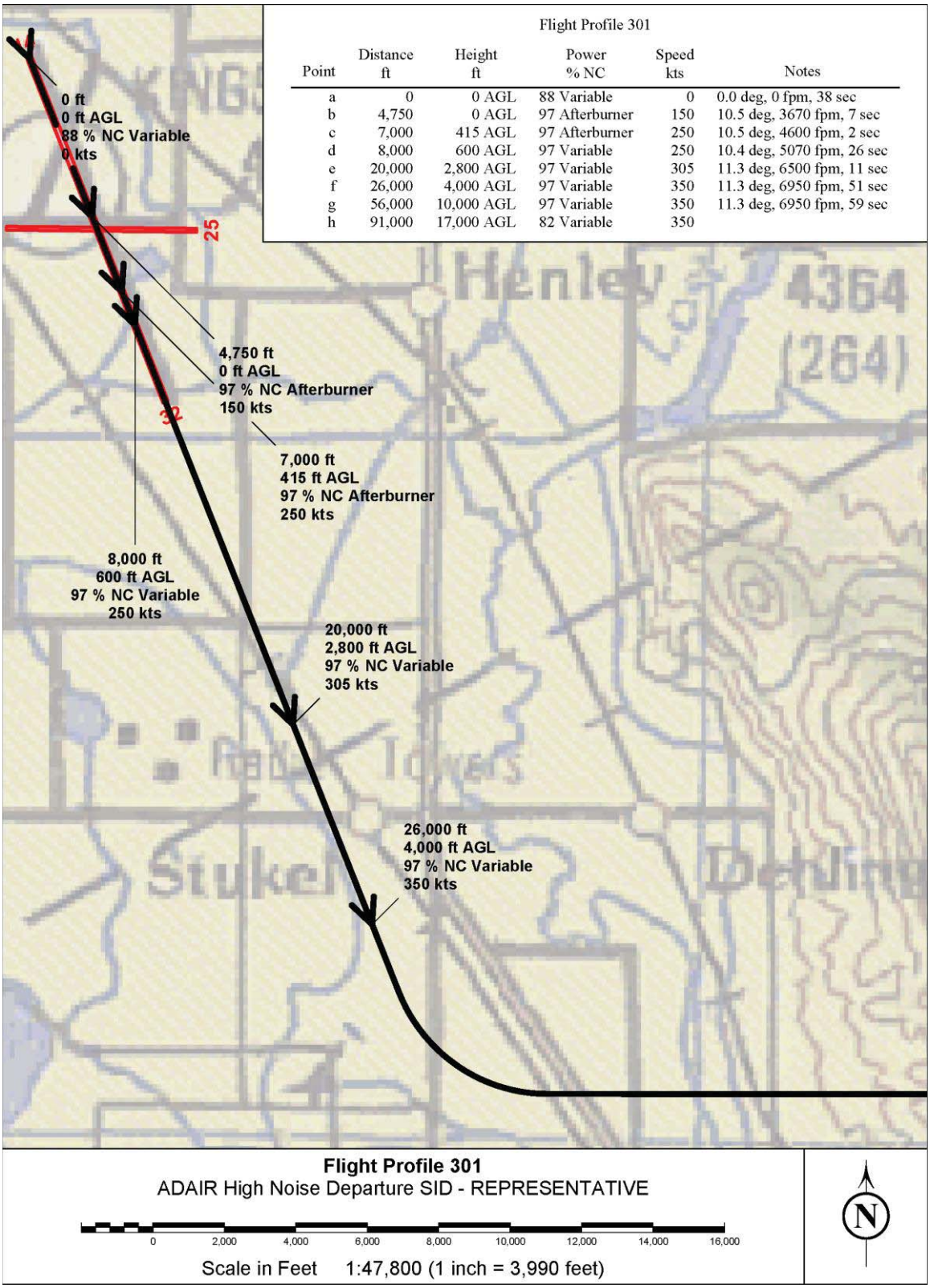
Scale in Feet 1:37,700 (1 inch = 3,140 feet)

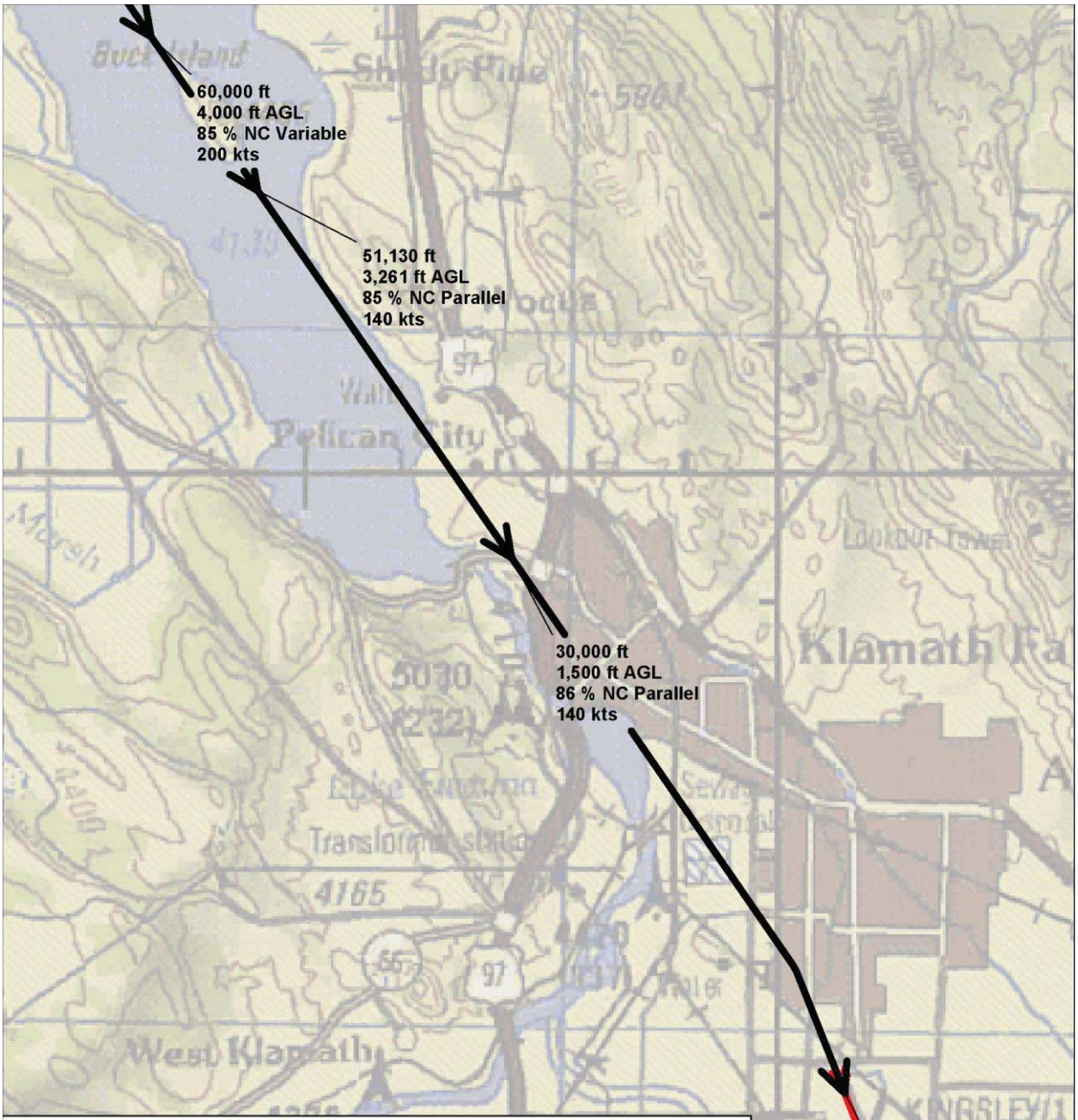
B.2.3.2 Contract ADAIR Aircraft Representative Flight Profiles

Contract ADAIR High Noise Eurofighter Typhoon (F-18E/F Surrogate)

Flight Profile 301

Point	Distance ft	Height ft	Power % NC	Speed kts	Notes
a	0	0 AGL	88 Variable	0	0.0 deg, 0 fpm, 38 sec
b	4,750	0 AGL	97 Afterburner	150	10.5 deg, 3670 fpm, 7 sec
c	7,000	415 AGL	97 Afterburner	250	10.5 deg, 4600 fpm, 2 sec
d	8,000	600 AGL	97 Variable	250	10.4 deg, 5070 fpm, 26 sec
e	20,000	2,800 AGL	97 Variable	305	11.3 deg, 6500 fpm, 11 sec
f	26,000	4,000 AGL	97 Variable	350	11.3 deg, 6950 fpm, 51 sec
g	56,000	10,000 AGL	97 Variable	350	11.3 deg, 6950 fpm, 59 sec
h	91,000	17,000 AGL	82 Variable	350	





Flight Profile 313

Point	Distance ft	Height ft	Power % NC	Speed kts	Notes
a	120,000	9,000 AGL	85 Variable	200	-4.8 deg, -1680 fpm, 178 sec
b	60,000	4,000 AGL	85 Variable	200	-4.8 deg, -1430 fpm, 31 sec
c	51,130	3,261 AGL	85 Parallel	140	-4.8 deg, -1180 fpm, 89 sec
d	30,000	1,500 AGL	86 Parallel	140	-2.7 deg, -670 fpm, 127 sec
e	0	75 AGL	86 Parallel	140	

Flight Profile 313

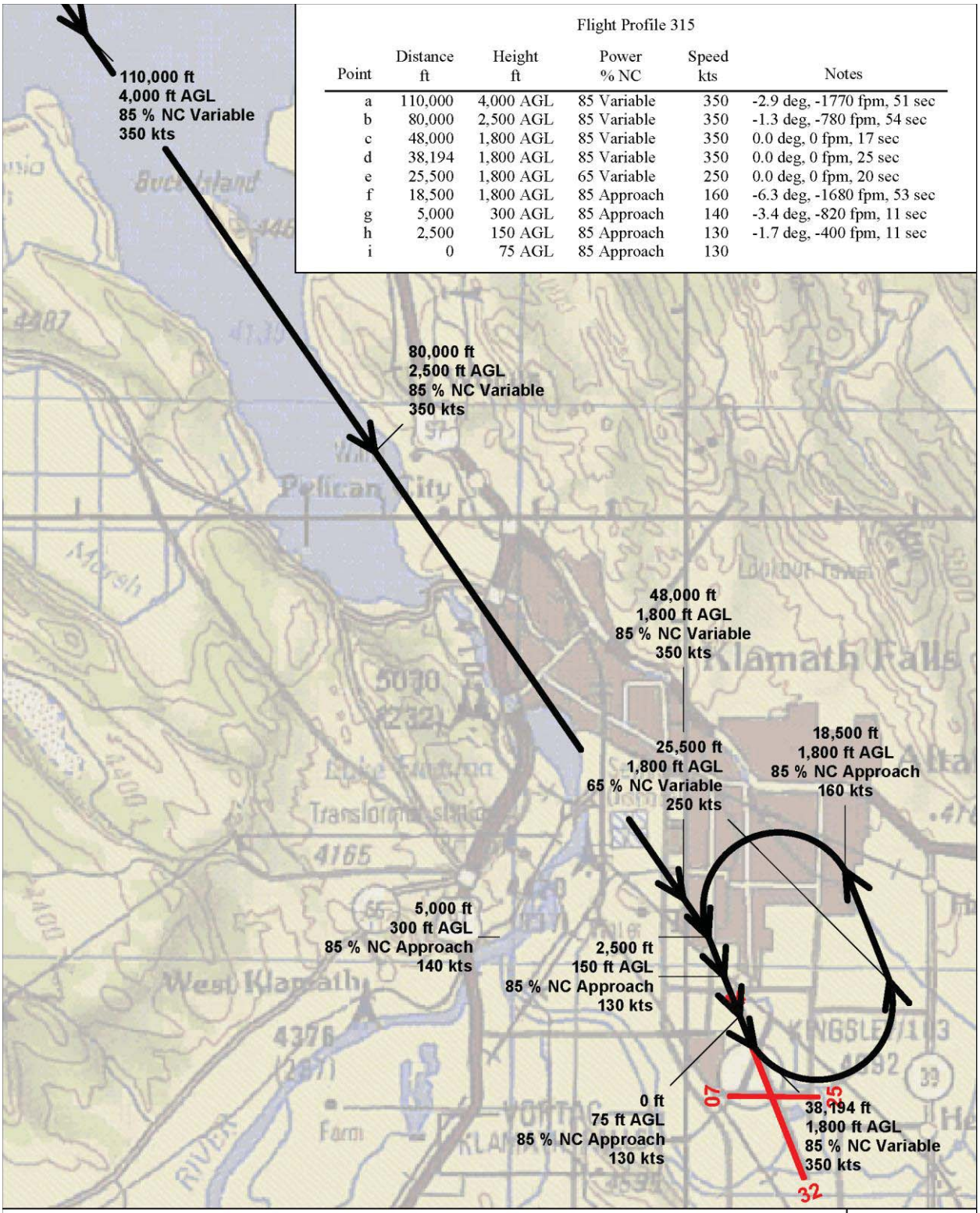
ADAIR High Noise - VORTAC Straight In Arrival - REPRESENTATIVE

0 4,000 8,000 12,000 16,000 20,000 24,000 28,000 32,000

Scale in Feet 1:93,900 (1 inch = 7,830 feet)

Flight Profile 315

Point	Distance ft	Height ft	Power % NC	Speed kts	Notes
a	110,000	4,000 AGL	85 Variable	350	-2.9 deg, -1770 fpm, 51 sec
b	80,000	2,500 AGL	85 Variable	350	-1.3 deg, -780 fpm, 54 sec
c	48,000	1,800 AGL	85 Variable	350	0.0 deg, 0 fpm, 17 sec
d	38,194	1,800 AGL	85 Variable	350	0.0 deg, 0 fpm, 25 sec
e	25,500	1,800 AGL	65 Variable	250	0.0 deg, 0 fpm, 20 sec
f	18,500	1,800 AGL	85 Approach	160	-6.3 deg, -1680 fpm, 53 sec
g	5,000	300 AGL	85 Approach	140	-3.4 deg, -820 fpm, 11 sec
h	2,500	150 AGL	85 Approach	130	-1.7 deg, -400 fpm, 11 sec
i	0	75 AGL	85 Approach	130	

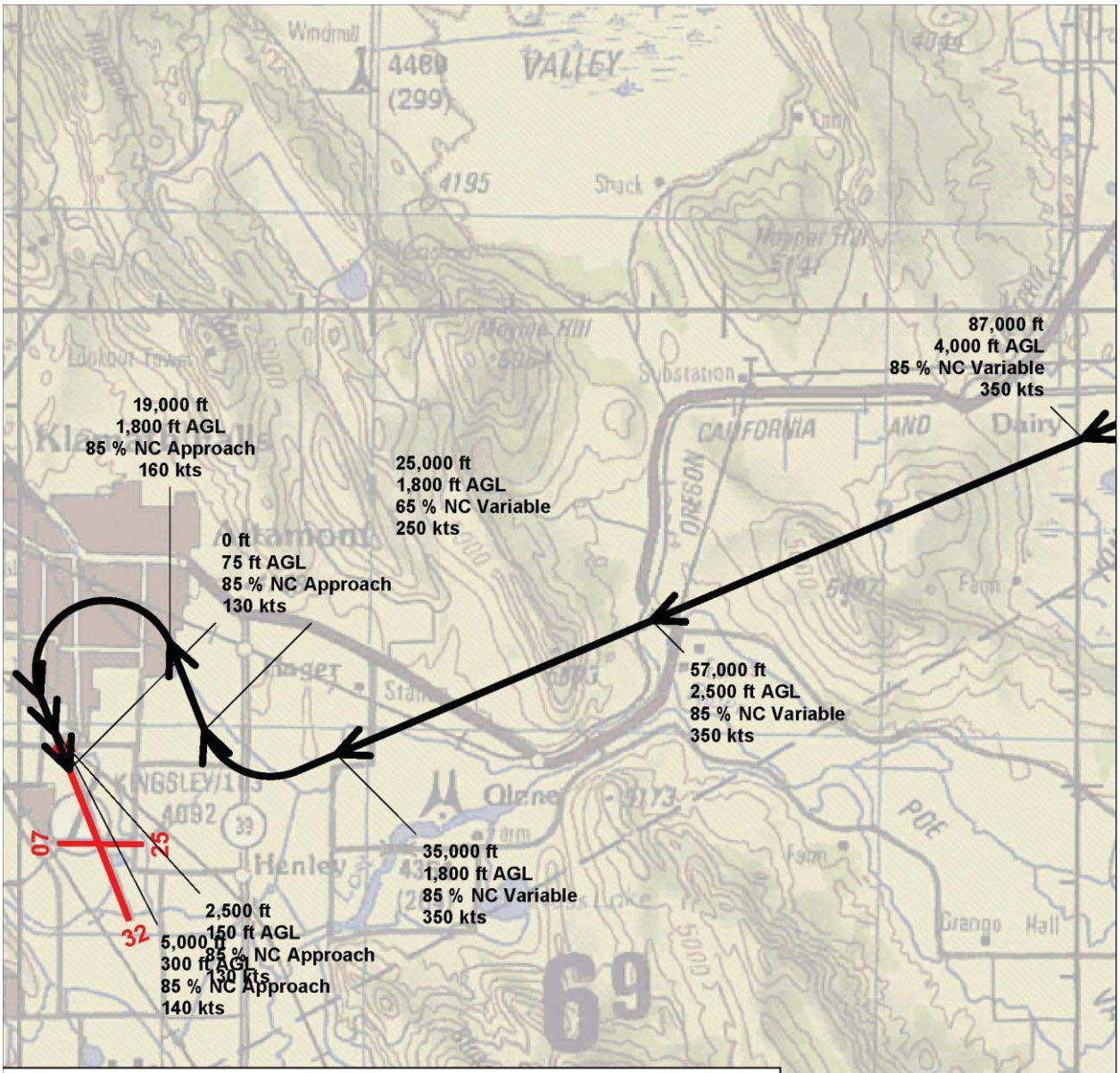


Flight Profile 315

ADAIR High Noise - OH Break - Arrival - REPRESENTATIVE

0 4,000 8,000 12,000 16,000 20,000 24,000 28,000 32,000 36,000

Scale in Feet 1:106,000 (1 inch = 8,860 feet)



Flight Profile 319

Point	Distance ft	Height ft	Power % NC	Speed kts	Notes
a	87,000	4,000 AGL	85 Variable	350	-2.9 deg, -1770 fpm, 51 sec
b	57,000	2,500 AGL	85 Variable	350	-1.8 deg, -1130 fpm, 37 sec
c	35,000	1,800 AGL	85 Variable	350	0.0 deg, 0 fpm, 20 sec
d	25,000	1,800 AGL	65 Variable	250	0.0 deg, 0 fpm, 17 sec
e	19,000	1,800 AGL	85 Approach	160	-6.1 deg, -1620 fpm, 55 sec
f	5,000	300 AGL	85 Approach	140	-3.4 deg, -820 fpm, 11 sec
g	2,500	150 AGL	85 Approach	130	-1.7 deg, -400 fpm, 11 sec
h	0	75 AGL	85 Approach	130	

Flight Profile 319

ADAIR - High Noise - ARRIVAL RUNWAY 14_4 TAC 90 EAST LEAD - REPRESENTATIVE

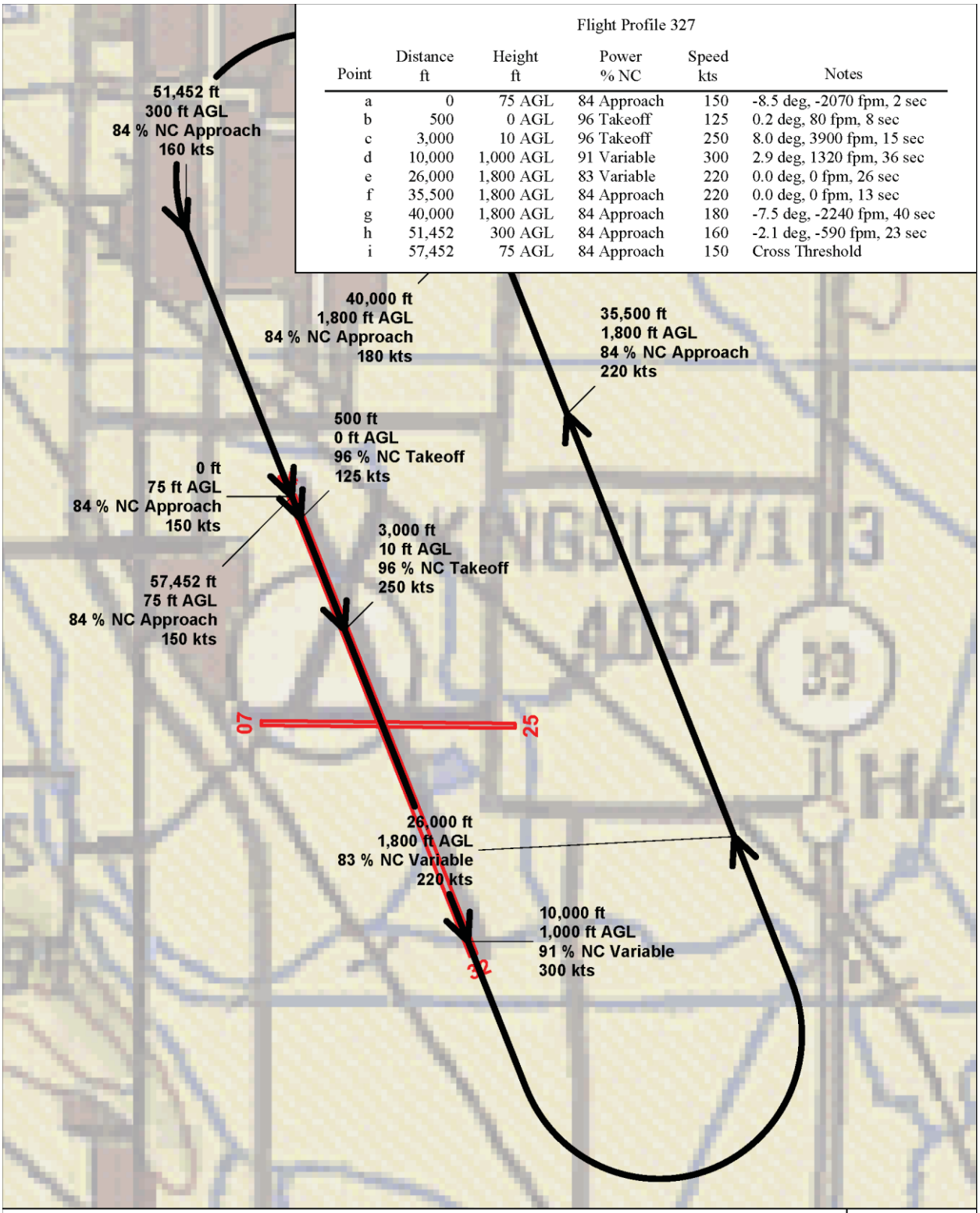
0 4,000 8,000 12,000 16,000 20,000 24,000 28,000 32,000 36,000 40,000 44,000

Scale in Feet 1:132,000 (1 inch = 11,000 feet)

N

Flight Profile 327

Point	Distance ft	Height ft	Power % NC	Speed kts	Notes
a	0	75 AGL	84 Approach	150	-8.5 deg, -2070 fpm, 2 sec
b	500	0 AGL	96 Takeoff	125	0.2 deg, 80 fpm, 8 sec
c	3,000	10 AGL	96 Takeoff	250	8.0 deg, 3900 fpm, 15 sec
d	10,000	1,000 AGL	91 Variable	300	2.9 deg, 1320 fpm, 36 sec
e	26,000	1,800 AGL	83 Variable	220	0.0 deg, 0 fpm, 26 sec
f	35,500	1,800 AGL	84 Approach	220	0.0 deg, 0 fpm, 13 sec
g	40,000	1,800 AGL	84 Approach	180	-7.5 deg, -2240 fpm, 40 sec
h	51,452	300 AGL	84 Approach	160	-2.1 deg, -590 fpm, 23 sec
i	57,452	75 AGL	84 Approach	150	Cross Threshold



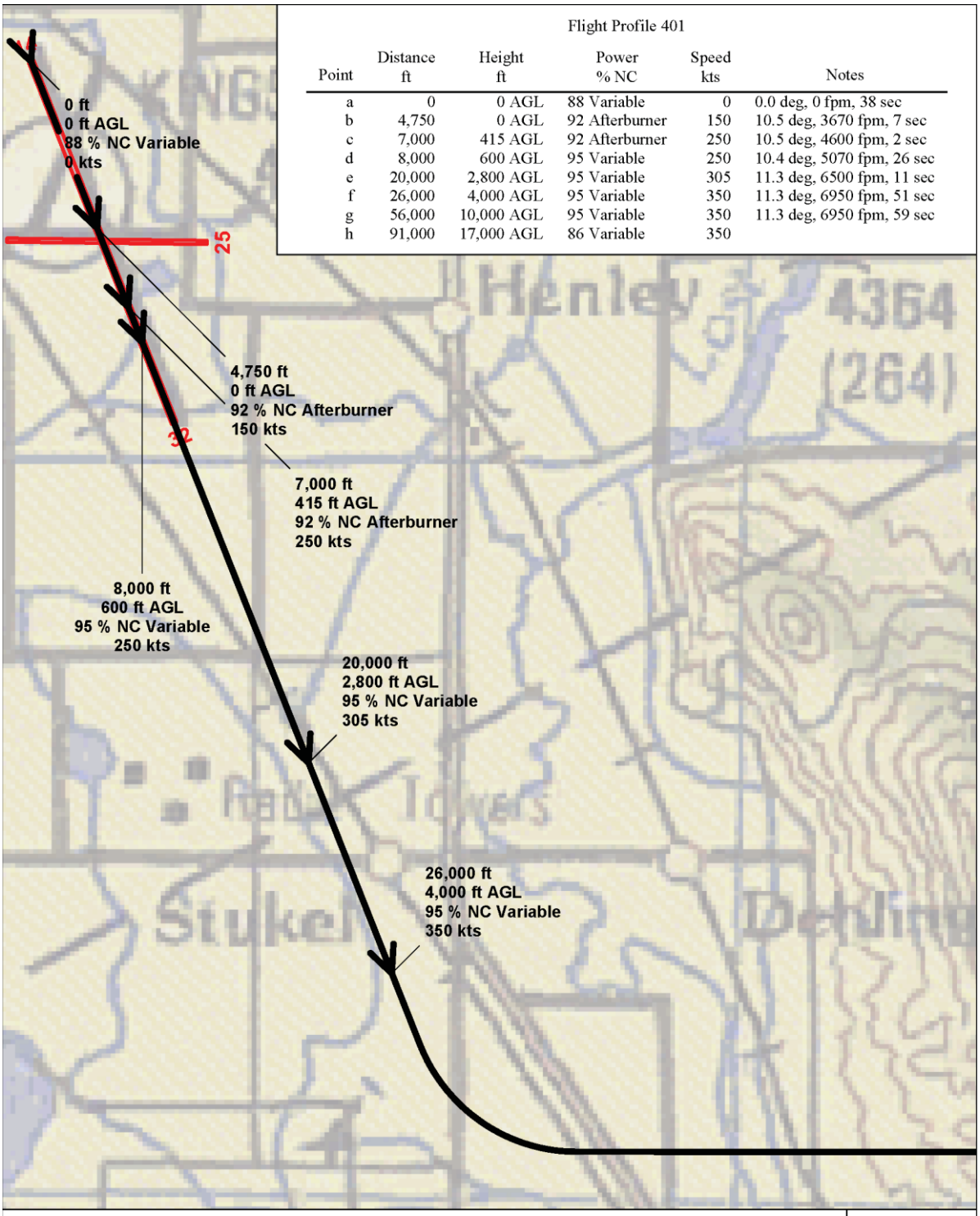
Flight Profile 327

ADAIR High Noise - CLOSED PATTERN RUNWAY 14 EAST - REPRESENTATIVE

0 2,000 4,000 6,000 8,000 10,000 12,000

Scale in Feet 1:37,700 (1 inch = 3,140 feet)

Contract ADAIR Medium Noise Dassault Mirage (F-16C F100 PW220 Surrogate)



Flight Profile 401

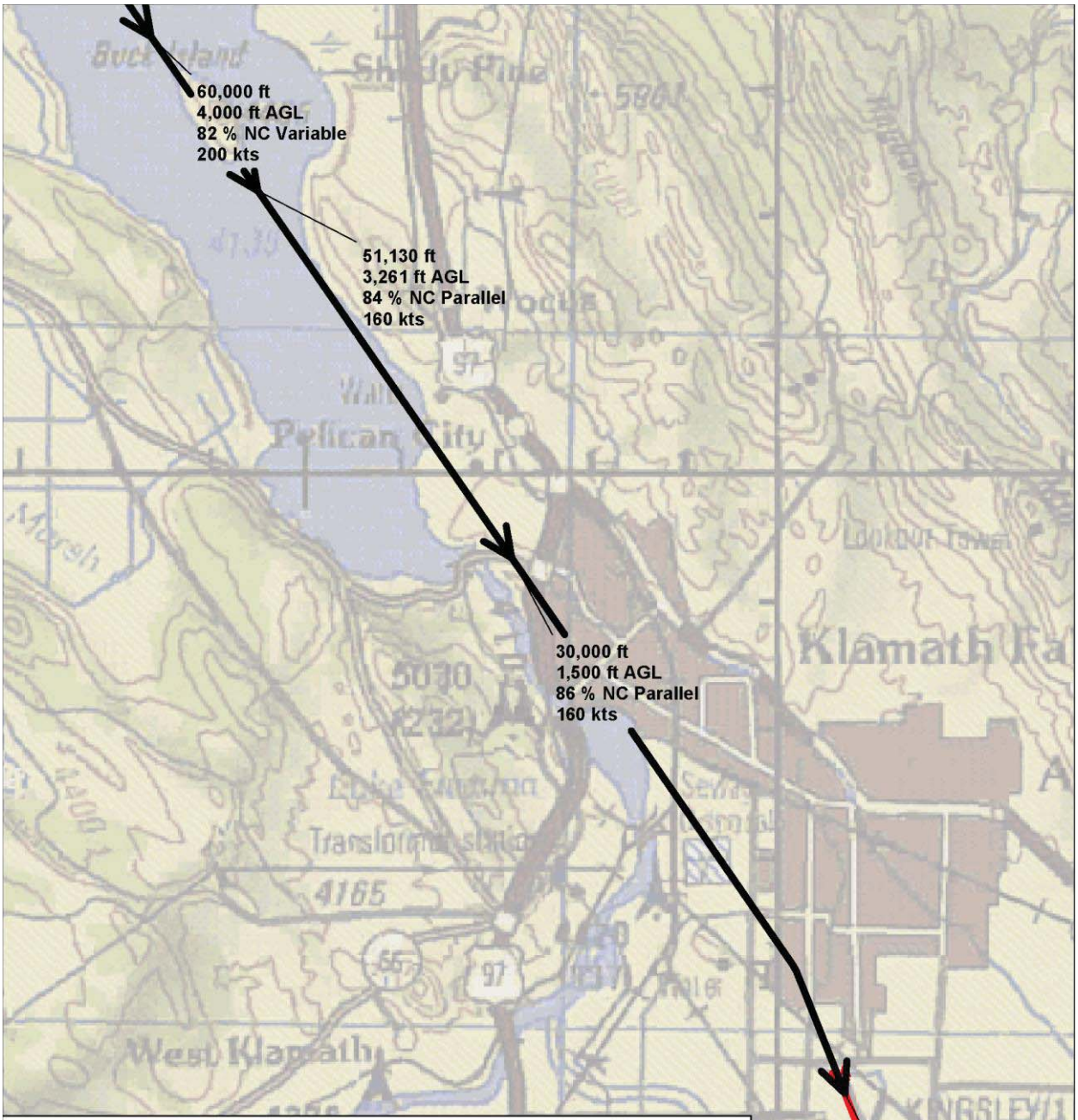
Point	Distance ft	Height ft	Power % NC	Speed kts	Notes
a	0	0 AGL	88 Variable	0	0.0 deg, 0 fpm, 38 sec
b	4,750	0 AGL	92 Afterburner	150	10.5 deg, 3670 fpm, 7 sec
c	7,000	415 AGL	92 Afterburner	250	10.5 deg, 4600 fpm, 2 sec
d	8,000	600 AGL	95 Variable	250	10.4 deg, 5070 fpm, 26 sec
e	20,000	2,800 AGL	95 Variable	305	11.3 deg, 6500 fpm, 11 sec
f	26,000	4,000 AGL	95 Variable	350	11.3 deg, 6950 fpm, 51 sec
g	56,000	10,000 AGL	95 Variable	350	11.3 deg, 6950 fpm, 59 sec
h	91,000	17,000 AGL	86 Variable	350	

Flight Profile 401
ADAIR Med Noise - Depature SID - REPRESENTATIVE

0 2,000 4,000 6,000 8,000 10,000 12,000 14,000 16,000

Scale in Feet 1:47,800 (1 inch = 3,990 feet)

N



Flight Profile 413

Point	Distance ft	Height ft	Power % NC	Speed kts	Notes
a	120,000	9,000 AGL	82 Variable	200	-4.8 deg, -1680 fpm, 178 sec
b	60,000	4,000 AGL	82 Variable	200	-4.8 deg, -1510 fpm, 29 sec
c	51,130	3,261 AGL	84 Parallel	160	-4.8 deg, -1350 fpm, 78 sec
d	30,000	1,500 AGL	86 Parallel	160	-2.7 deg, -770 fpm, 111 sec
e	0	75 AGL	86 Parallel	160	

Flight Profile 413

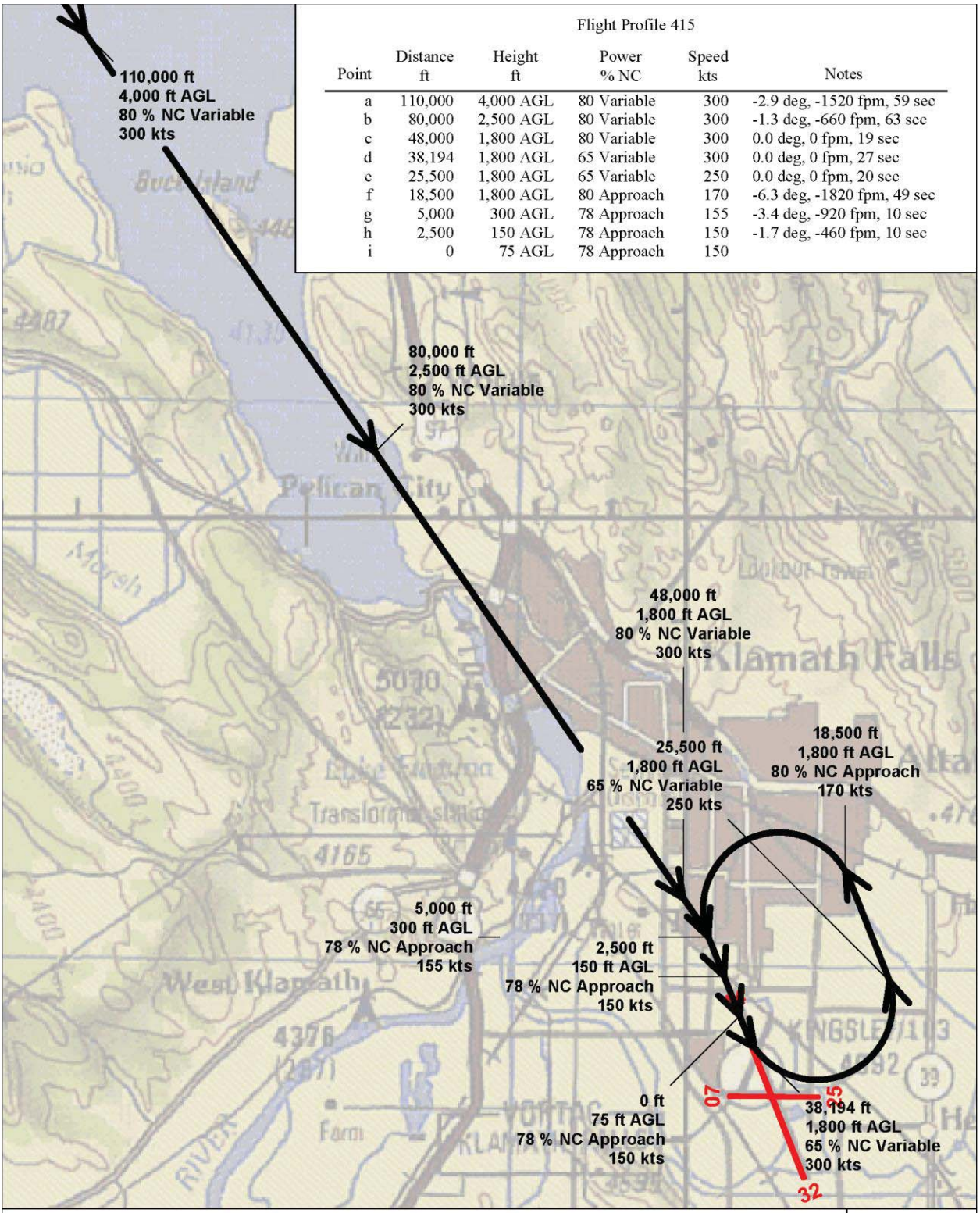
ADAIR Med Noise - VORTAC Straight In Arrival- REPRESENTATIVE

0 4,000 8,000 12,000 16,000 20,000 24,000 28,000 32,000

Scale in Feet 1:93,900 (1 inch = 7,830 feet)

Flight Profile 415

Point	Distance ft	Height ft	Power % NC	Speed kts	Notes
a	110,000	4,000 AGL	80 Variable	300	-2.9 deg, -1520 fpm, 59 sec
b	80,000	2,500 AGL	80 Variable	300	-1.3 deg, -660 fpm, 63 sec
c	48,000	1,800 AGL	80 Variable	300	0.0 deg, 0 fpm, 19 sec
d	38,194	1,800 AGL	65 Variable	300	0.0 deg, 0 fpm, 27 sec
e	25,500	1,800 AGL	65 Variable	250	0.0 deg, 0 fpm, 20 sec
f	18,500	1,800 AGL	80 Approach	170	-6.3 deg, -1820 fpm, 49 sec
g	5,000	300 AGL	78 Approach	155	-3.4 deg, -920 fpm, 10 sec
h	2,500	150 AGL	78 Approach	150	-1.7 deg, -460 fpm, 10 sec
i	0	75 AGL	78 Approach	150	



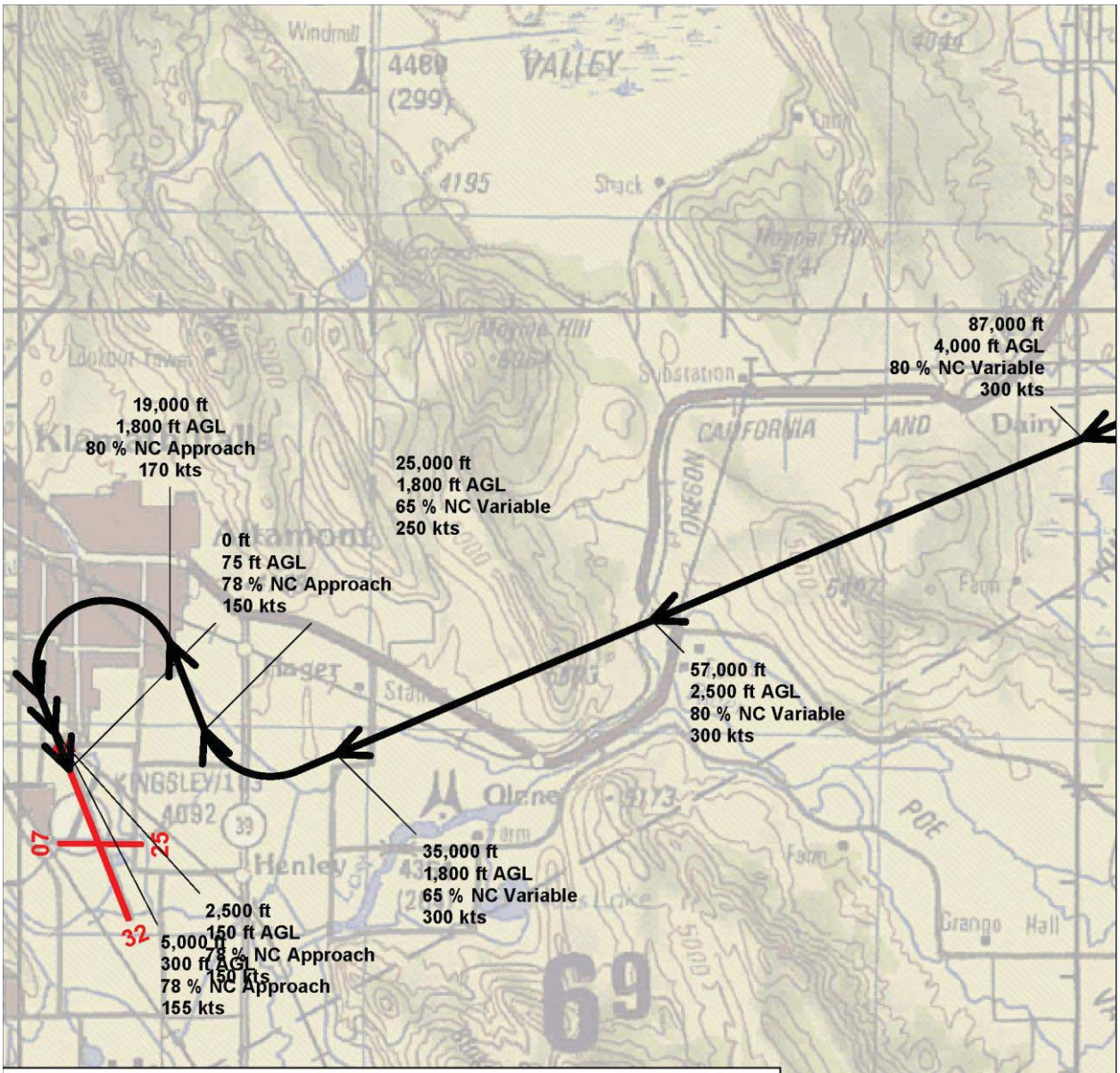
Flight Profile 415

ADAIR Med Noise - OH Break - Arrival - REPRESENTATIVE

0 4,000 8,000 12,000 16,000 20,000 24,000 28,000 32,000 36,000

Scale in Feet 1:106,000 (1 inch = 8,860 feet)

N



Flight Profile 419

Point	Distance ft	Height ft	Power % NC	Speed kts	Notes
a	87,000	4,000 AGL	80 Variable	300	-2.9 deg, -1520 fpm, 59 sec
b	57,000	2,500 AGL	80 Variable	300	-1.8 deg, -970 fpm, 43 sec
c	35,000	1,800 AGL	65 Variable	300	0.0 deg, 0 fpm, 22 sec
d	25,000	1,800 AGL	65 Variable	250	0.0 deg, 0 fpm, 17 sec
e	19,000	1,800 AGL	80 Approach	170	-6.1 deg, -1750 fpm, 51 sec
f	5,000	300 AGL	78 Approach	155	-3.4 deg, -920 fpm, 10 sec
g	2,500	150 AGL	78 Approach	150	-1.7 deg, -460 fpm, 10 sec
h	0	75 AGL	78 Approach	150	

Flight Profile 419

ADAIR - Med Noise - ARRIVAL RUNWAY 14_4 TAC 90 EAST LEAD - REPRESENTATIVE

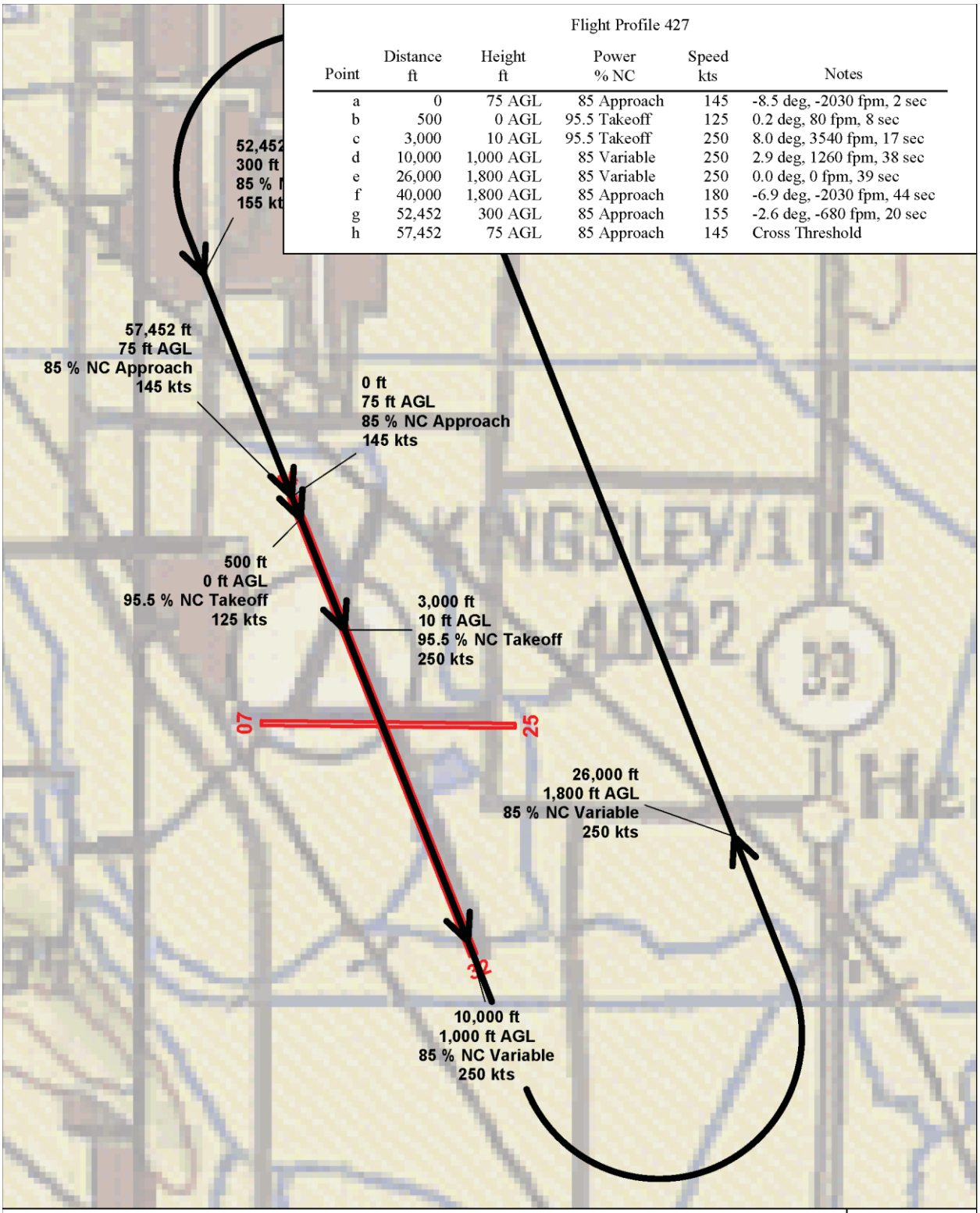
0 4,000 8,000 12,000 16,000 20,000 24,000 28,000 32,000 36,000 40,000 44,000

Scale in Feet 1:132,000 (1 inch = 11,000 feet)

N

Flight Profile 427

Point	Distance ft	Height ft	Power % NC	Speed kts	Notes
a	0	75 AGL	85 Approach	145	-8.5 deg, -2030 fpm, 2 sec
b	500	0 AGL	95.5 Takeoff	125	0.2 deg, 80 fpm, 8 sec
c	3,000	10 AGL	95.5 Takeoff	250	8.0 deg, 3540 fpm, 17 sec
d	10,000	1,000 AGL	85 Variable	250	2.9 deg, 1260 fpm, 38 sec
e	26,000	1,800 AGL	85 Variable	250	0.0 deg, 0 fpm, 39 sec
f	40,000	1,800 AGL	85 Approach	180	-6.9 deg, -2030 fpm, 44 sec
g	52,452	300 AGL	85 Approach	155	-2.6 deg, -680 fpm, 20 sec
h	57,452	75 AGL	85 Approach	145	Cross Threshold



Flight Profile 427
ADAIR Med Noise - VFR Inside DW - REPRESENTATIVE

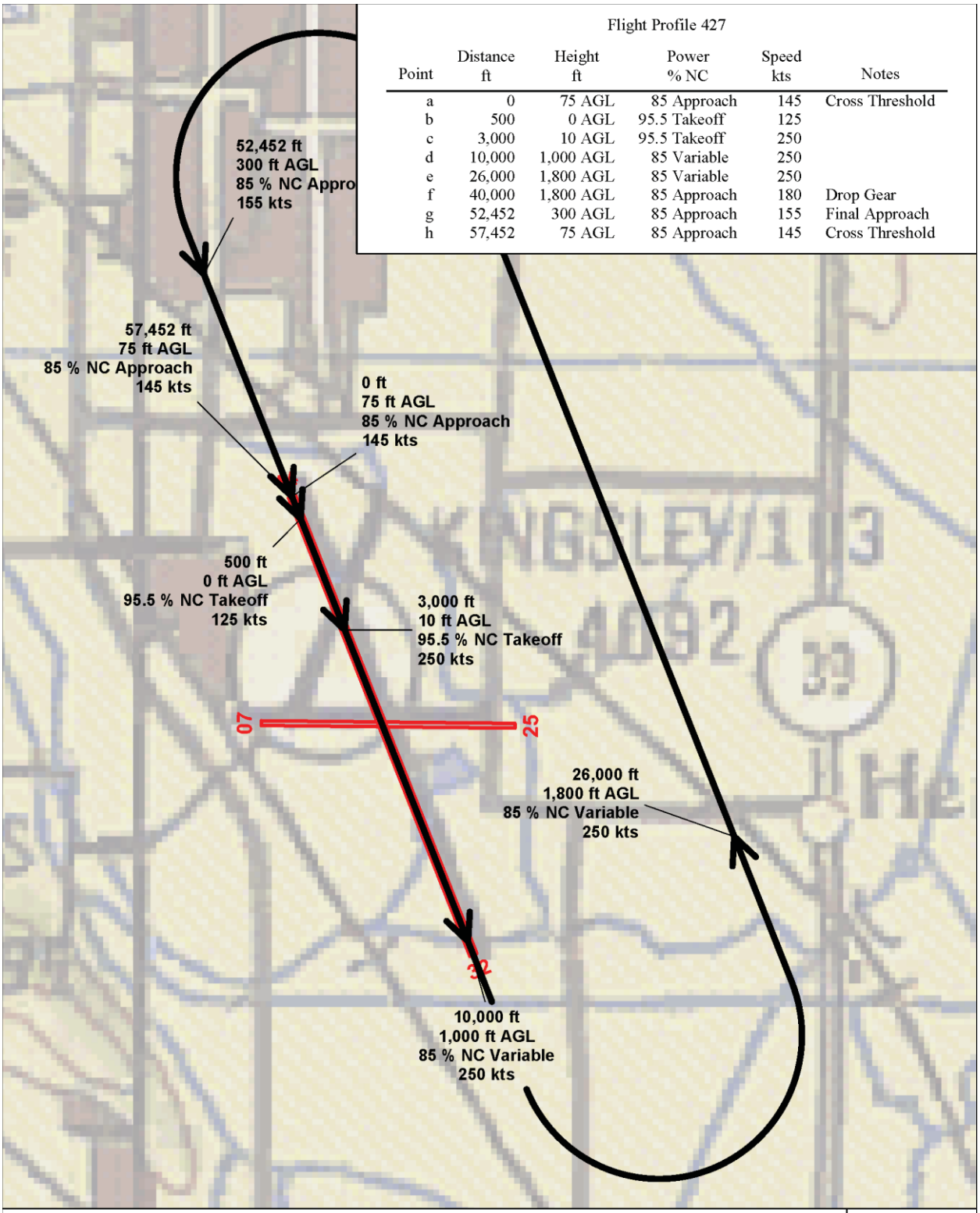
0 2,000 4,000 6,000 8,000 10,000 12,000

Scale in Feet 1:37,700 (1 inch = 3,140 feet)

N

Flight Profile 427

Point	Distance ft	Height ft	Power % NC	Speed kts	Notes
a	0	75 AGL	85 Approach	145	Cross Threshold
b	500	0 AGL	95.5 Takeoff	125	
c	3,000	10 AGL	95.5 Takeoff	250	
d	10,000	1,000 AGL	85 Variable	250	
e	26,000	1,800 AGL	85 Variable	250	
f	40,000	1,800 AGL	85 Approach	180	Drop Gear
g	52,452	300 AGL	85 Approach	155	Final Approach
h	57,452	75 AGL	85 Approach	145	Cross Threshold



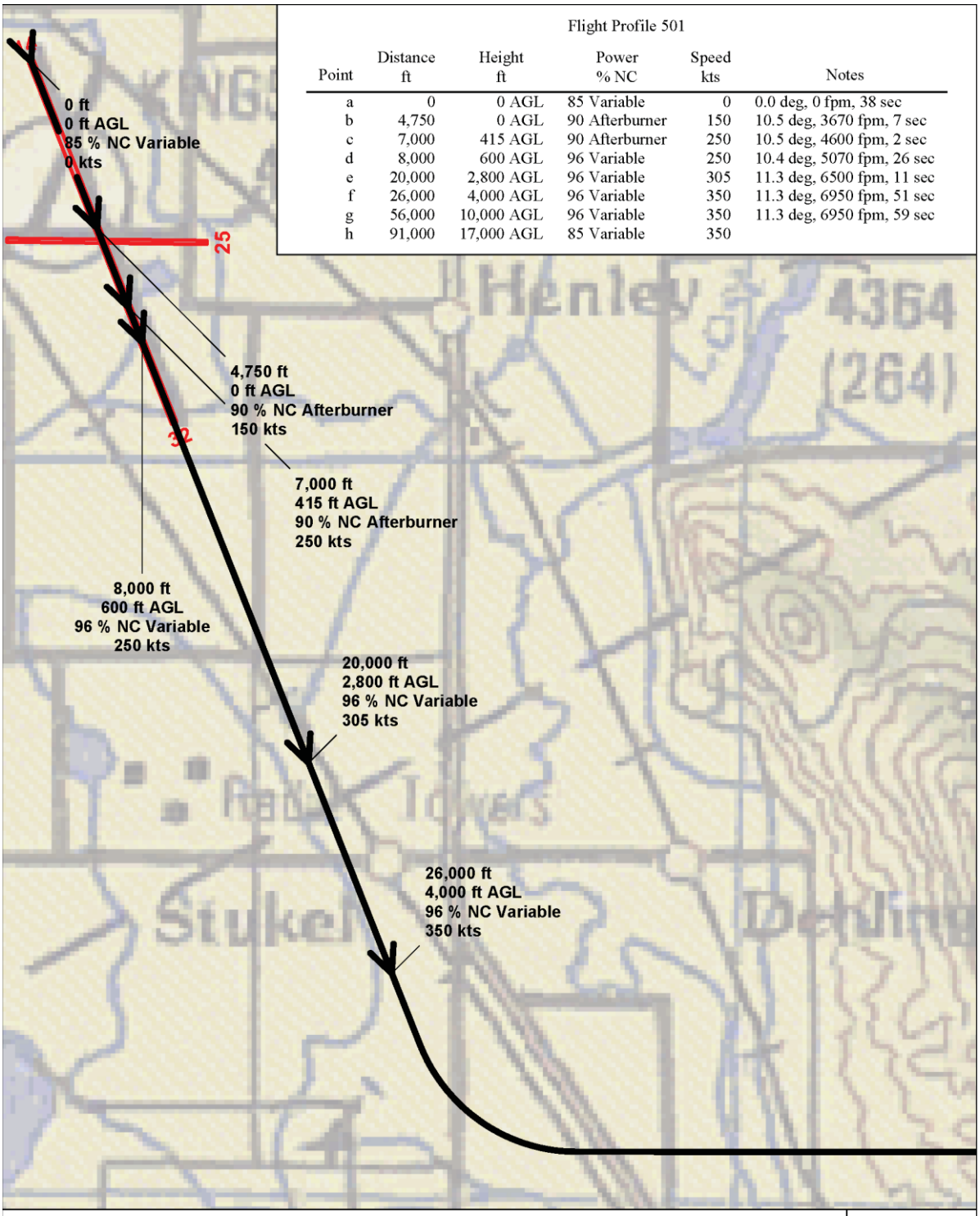
Flight Profile 427
ADAIR Med Noise - VFR Inside DW - REPRESENTATIVE

0 2,000 4,000 6,000 8,000 10,000 12,000

Scale in Feet 1:37,700 (1 inch = 3,140 feet)

N

Contract ADAIR Low Noise FAS 39 Gripen (F-16A Surrogate)



Flight Profile 501

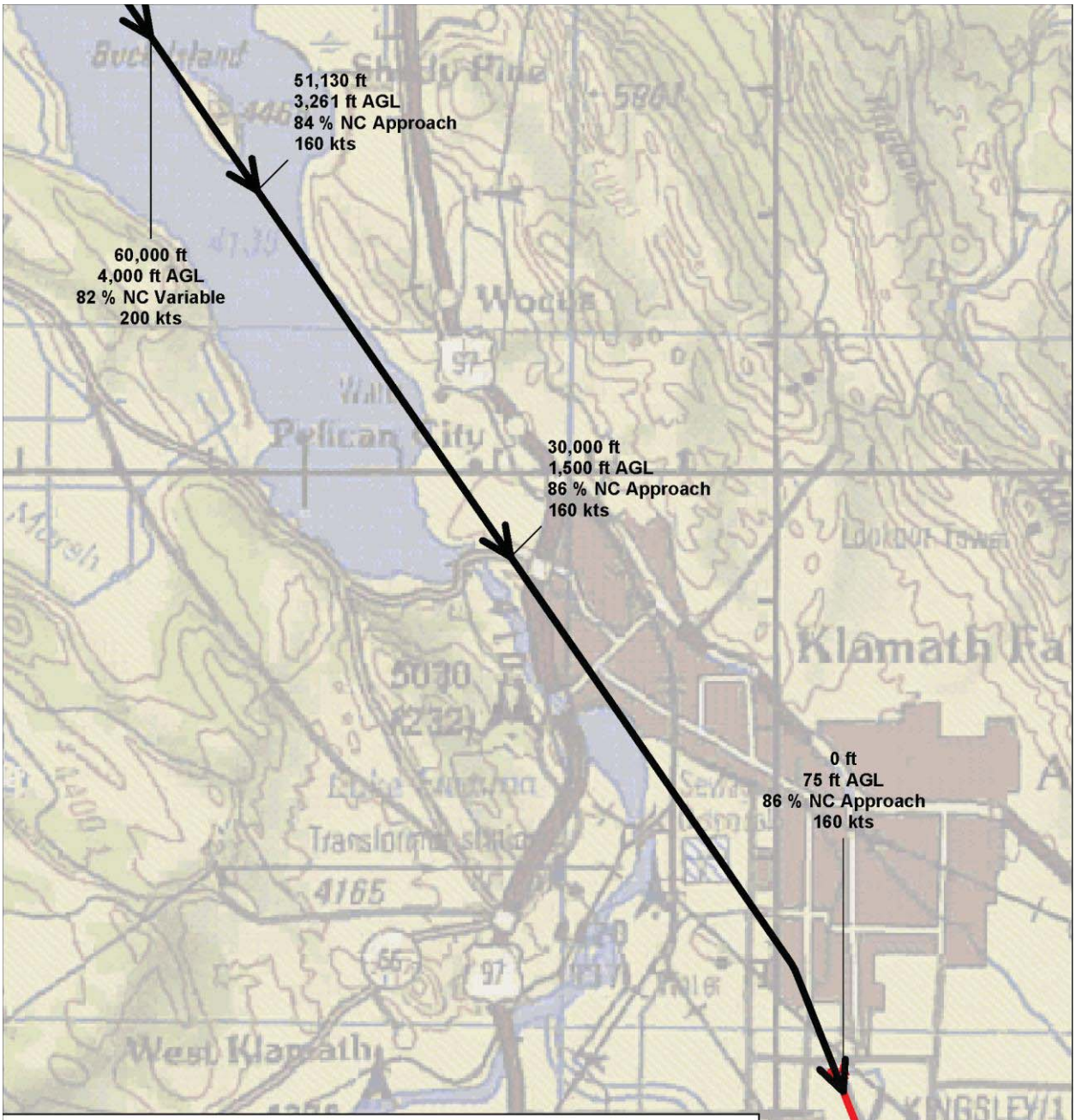
Point	Distance ft	Height ft	Power % NC	Speed kts	Notes
a	0	0 AGL	85 Variable	0	0.0 deg, 0 fpm, 38 sec
b	4,750	0 AGL	90 Afterburner	150	10.5 deg, 3670 fpm, 7 sec
c	7,000	415 AGL	90 Afterburner	250	10.5 deg, 4600 fpm, 2 sec
d	8,000	600 AGL	96 Variable	250	10.4 deg, 5070 fpm, 26 sec
e	20,000	2,800 AGL	96 Variable	305	11.3 deg, 6500 fpm, 11 sec
f	26,000	4,000 AGL	96 Variable	350	11.3 deg, 6950 fpm, 51 sec
g	56,000	10,000 AGL	96 Variable	350	11.3 deg, 6950 fpm, 59 sec
h	91,000	17,000 AGL	85 Variable	350	

Flight Profile 501
ADAIR Low Noise - Departure SID - REPRESENTATIVE

0 2,000 4,000 6,000 8,000 10,000 12,000 14,000 16,000

Scale in Feet 1:47,800 (1 inch = 3,990 feet)

N



Flight Profile 513

Point	Distance ft	Height ft	Power % NC	Speed kts	Notes
a	120,000	9,000 AGL	82 Variable	200	-4.8 deg, -1680 fpm, 178 sec
b	60,000	4,000 AGL	82 Variable	200	-4.8 deg, -1510 fpm, 29 sec
c	51,130	3,261 AGL	84 Approach	160	-4.8 deg, -1350 fpm, 78 sec
d	30,000	1,500 AGL	86 Approach	160	-2.7 deg, -770 fpm, 111 sec
e	0	75 AGL	86 Approach	160	

Flight Profile 513

ADAIR Low Noise - VORTAC Straight In Arrival - REPRESENTATIVE

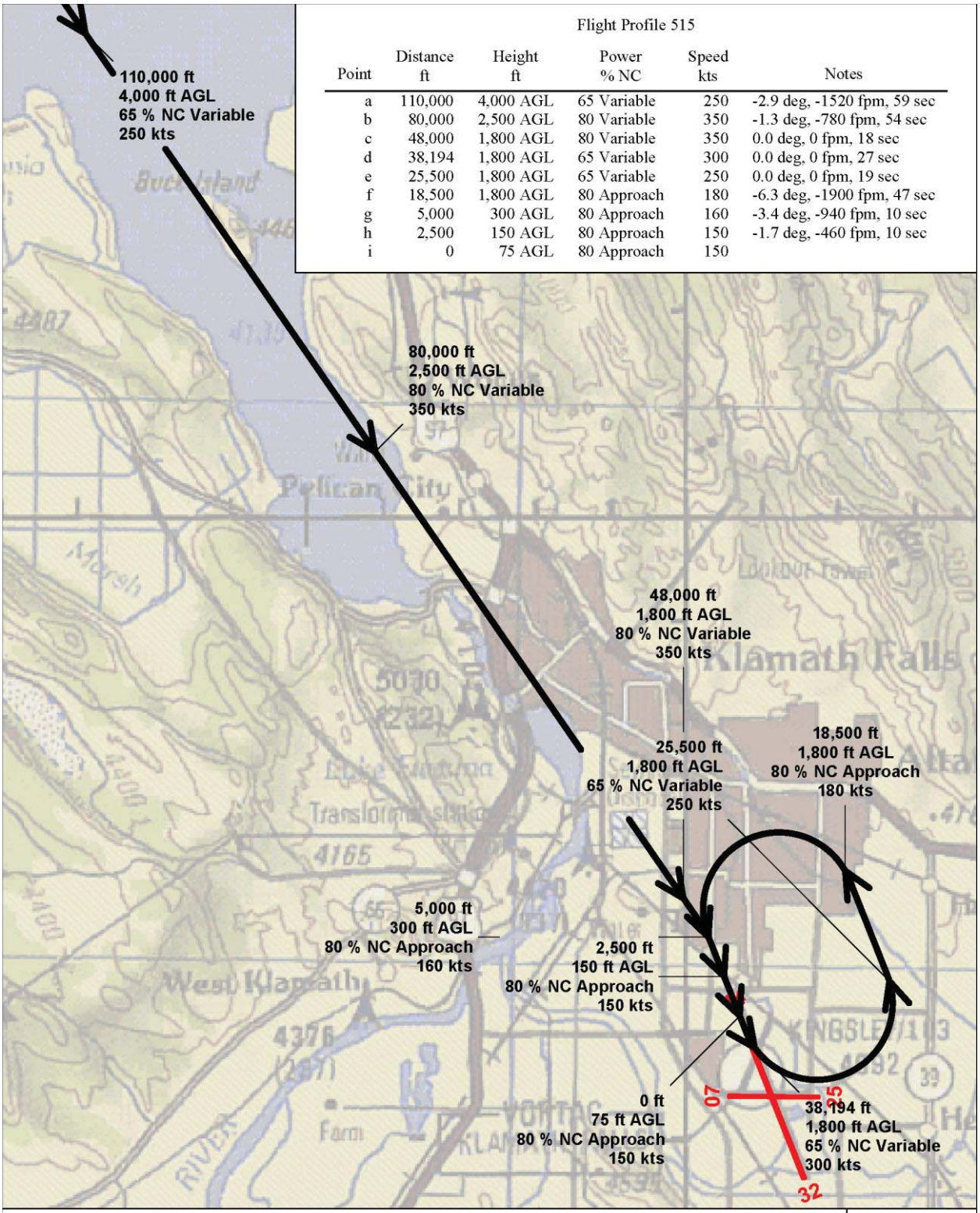
0 4,000 8,000 12,000 16,000 20,000 24,000 28,000 32,000

Scale in Feet 1:93,900 (1 inch = 7,830 feet)

N

Flight Profile 515

Point	Distance ft	Height ft	Power % NC	Speed kts	Notes
a	110,000	4,000 AGL	65 Variable	250	-2.9 deg, -1520 fpm, 59 sec
b	80,000	2,500 AGL	80 Variable	350	-1.3 deg, -780 fpm, 54 sec
c	48,000	1,800 AGL	80 Variable	350	0.0 deg, 0 fpm, 18 sec
d	38,194	1,800 AGL	65 Variable	300	0.0 deg, 0 fpm, 27 sec
e	25,500	1,800 AGL	65 Variable	250	0.0 deg, 0 fpm, 19 sec
f	18,500	1,800 AGL	80 Approach	180	-6.3 deg, -1900 fpm, 47 sec
g	5,000	300 AGL	80 Approach	160	-3.4 deg, -940 fpm, 10 sec
h	2,500	150 AGL	80 Approach	150	-1.7 deg, -460 fpm, 10 sec
i	0	75 AGL	80 Approach	150	

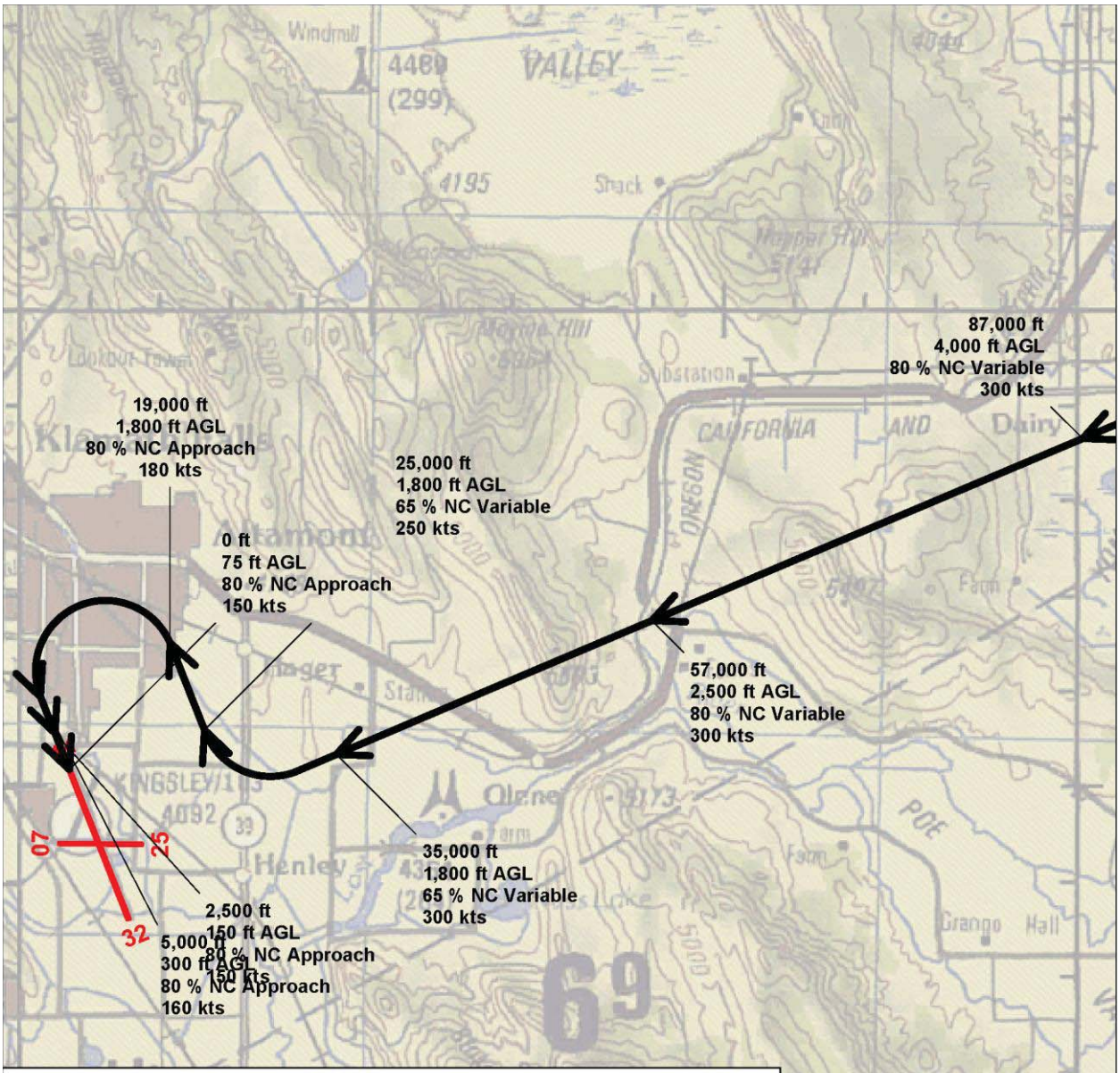


Flight Profile 515

ADAIR Low Noise - OH Break - Arrival - REPRESENTATIVE

0 4,000 8,000 12,000 16,000 20,000 24,000 28,000 32,000 36,000

Scale in Feet 1:106,000 (1 inch = 8,860 feet)



Flight Profile 519

Point	Distance ft	Height ft	Power % NC	Speed kts	Notes
a	87,000	4,000 AGL	80 Variable	300	-2.9 deg, -1520 fpm, 59 sec
b	57,000	2,500 AGL	80 Variable	300	-1.8 deg, -970 fpm, 43 sec
c	35,000	1,800 AGL	65 Variable	300	0.0 deg, 0 fpm, 22 sec
d	25,000	1,800 AGL	65 Variable	250	0.0 deg, 0 fpm, 17 sec
e	19,000	1,800 AGL	80 Approach	180	-6.1 deg, -1830 fpm, 49 sec
f	5,000	300 AGL	80 Approach	160	-3.4 deg, -940 fpm, 10 sec
g	2,500	150 AGL	80 Approach	150	-1.7 deg, -460 fpm, 10 sec
h	0	75 AGL	80 Approach	150	

Flight Profile 519

ADAIR - Low Noise - ARRIVAL RUNWAY 14_4 TAC 90 EAST LEAD - REPRESENTATIVE

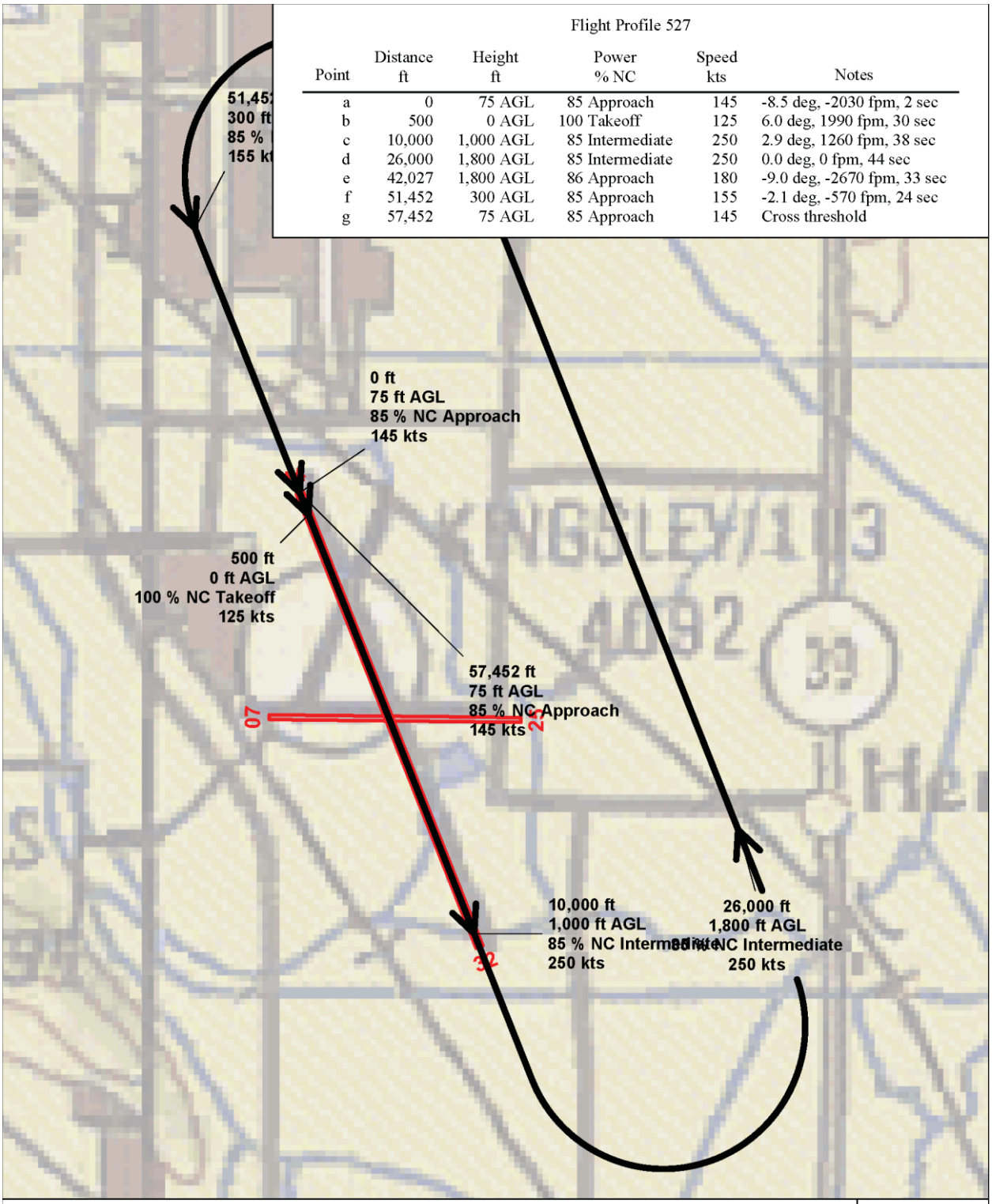
0 4,000 8,000 12,000 16,000 20,000 24,000 28,000 32,000 36,000 40,000 44,000

Scale in Feet 1:132,000 (1 inch = 11,000 feet)

N

Flight Profile 527

Point	Distance ft	Height ft	Power % NC	Speed kts	Notes
a	0	75 AGL	85 Approach	145	-8.5 deg, -2030 fpm, 2 sec
b	500	0 AGL	100 Takeoff	125	6.0 deg, 1990 fpm, 30 sec
c	10,000	1,000 AGL	85 Intermediate	250	2.9 deg, 1260 fpm, 38 sec
d	26,000	1,800 AGL	85 Intermediate	250	0.0 deg, 0 fpm, 44 sec
e	42,027	1,800 AGL	86 Approach	180	-9.0 deg, -2670 fpm, 33 sec
f	51,452	300 AGL	85 Approach	155	-2.1 deg, -570 fpm, 24 sec
g	57,452	75 AGL	85 Approach	145	Cross threshold



Flight Profile 527

ADAIR Low Noise - VFR Inside DW Closed Pattern Runway 14 EAST - REPRESENTATIVE

0 2,000 4,000 6,000 8,000 10,000 12,000

Scale in Feet 1:38,500 (1 inch = 3,210 feet)

B.2.4 Ground/Maintenance Run-ups

This section details the number, type, and duration of the ground and maintenance engine run-up operations at the airfield. Contract ADAIR aircraft maintenance would include routine inspections and minor unscheduled repairs on the flightline. Aircraft requiring major scheduled (depot level maintenance) or unscheduled maintenance would be expected to be flown back to the contractor's home base for repairs. The only ground operations expected to increase with the addition of contract ADAIR aircraft would be the preflight run-up checks, postflight idling, and trim tests. **Figure B-16** shows the location of the hush house towards the south end of the field and the location that trim operations are done. **Figure B-17** shows the location on the apron where aircraft maintenance operations occur. Some maintenance operations occur 0.5 miles north of the apron at Building 400. **Figure B-18** shows the area at and around Building 400. **Figure B-19** shows two proposed parking locations for ADAIR aircraft. Bravo row parking location is coincident with the Apron A parking location shown in **Figure B-17**. **Table B-9** details the number, type, and duration of the on-field maintenance operations.

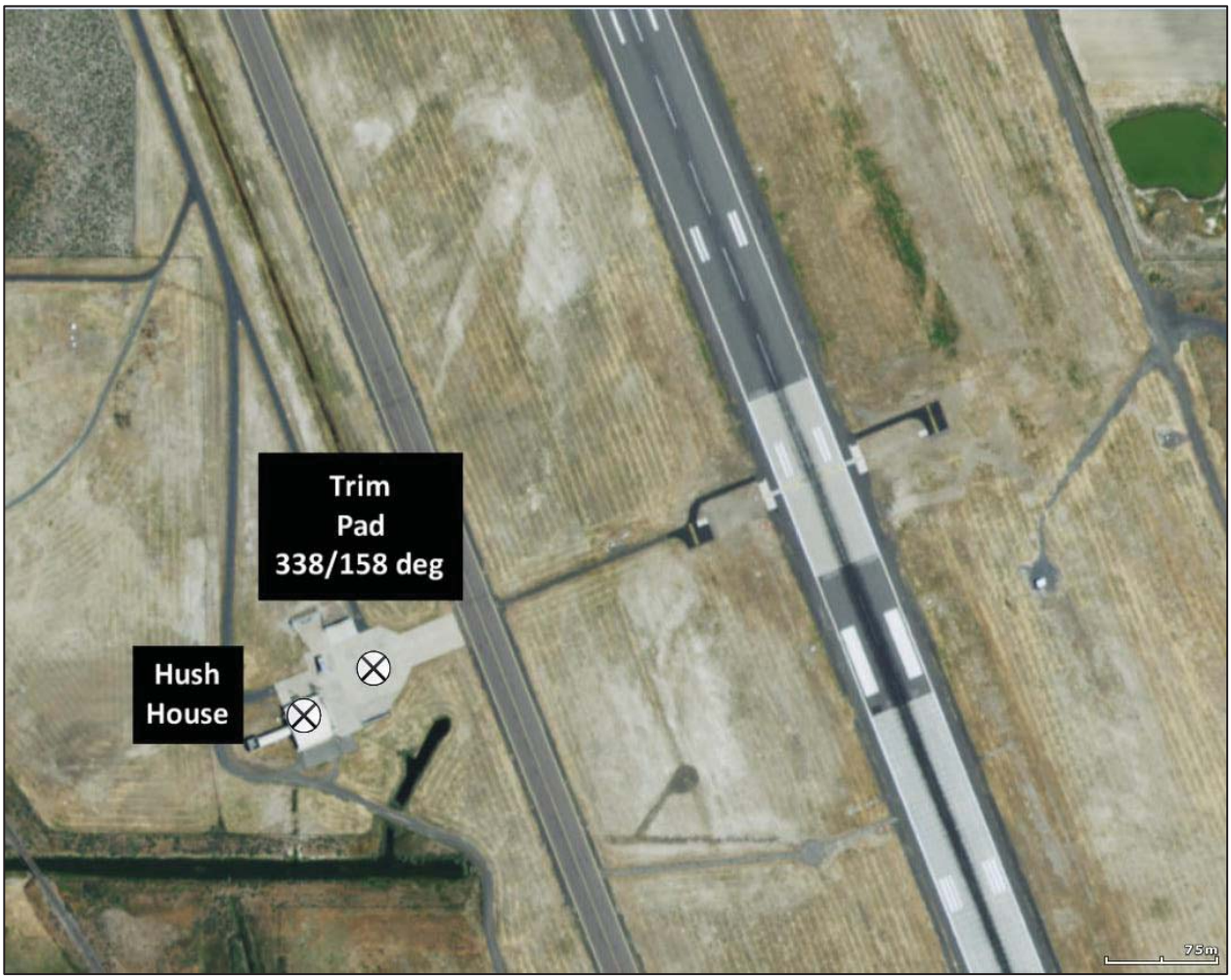


Figure B-16. Maintenance Locations at Kingsley Field for Trim and Hush House Operations.

Figure B-17. Run-up Locations on the Apron at Kingsley Field.

Figure B-18. Run-up Location at Building 400.

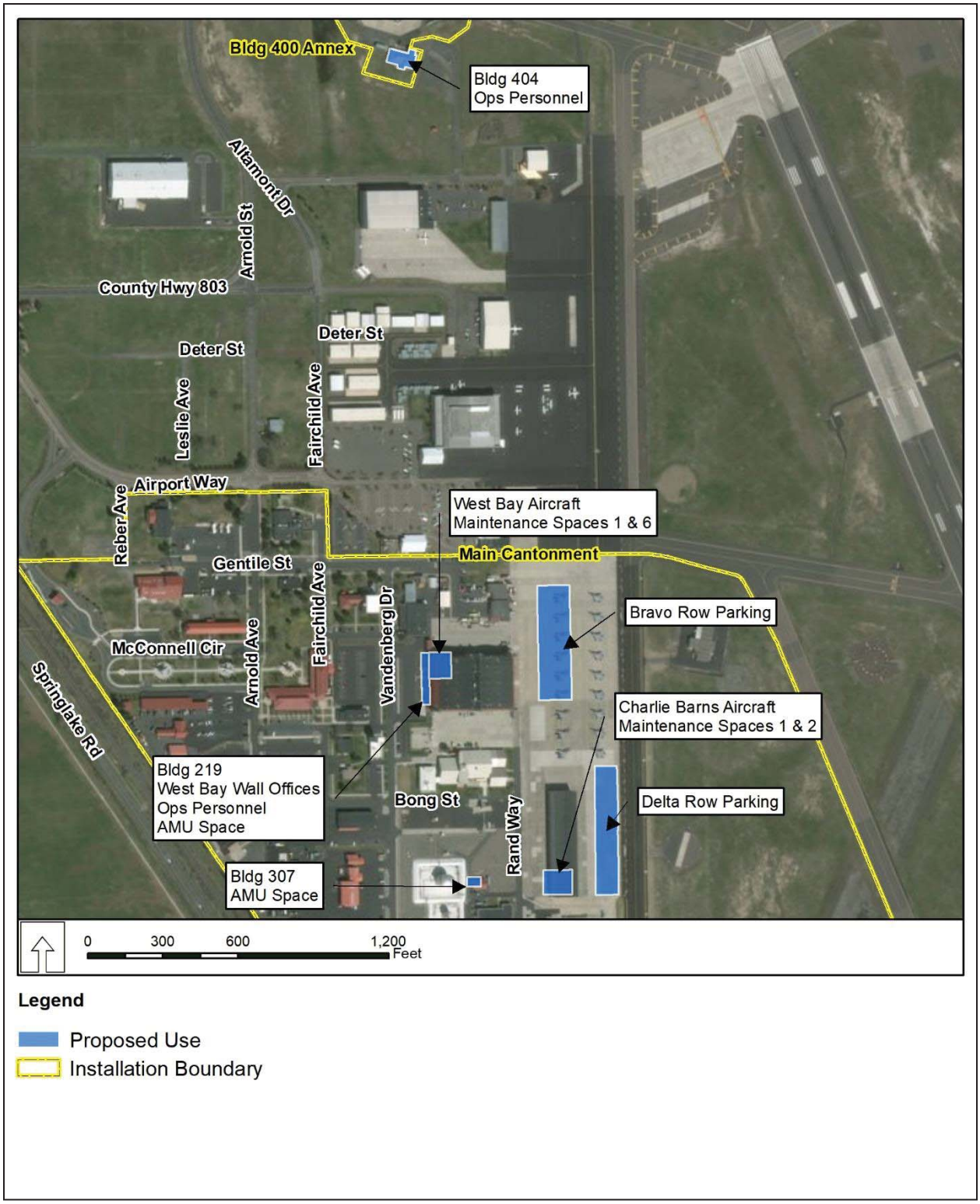


Figure B-19. Proposed Locations for Contract Adversary Air Operation and Maintenance Facilities.

Table B-9
Location, Type, and Duration of Ground/Maintenance Run-Up Operations at Kingsley Field

Aircraft Type	Engine Type	Run-up Type	Baseline Annual Events	ADAIR Events	Percent Day (0700-2200)	Percent Night (2200-0700)	Run-up Pad ID	Percent Pad used	Magnetic Heading (degrees)	Engine Power Setting	Duration Per Event (Minutes)	# of Engines Running Per Event
F-15C/D	F100-PW-220	Hush House Engine Runs	25	0	100%	0	Hush House	100%	62	63%-Idle	113	1
										80%	30	
										90%	40	
										Max A/B	8	
		2 Engine Check	34	0	70%	30%	Building 400	100%	107.5	63%-Idle	30	2
										80%	1	
		2 Engine Check	72	0	100%	0	Apron A/ Apron B	50/50%	45/315	63%-Idle	9	2
										80%	1	
		1 Engine Check	524	0	100%	0	Apron A/ Apron B	50/50%	45/315	63%-Idle	23	1
										80%	2	
		Pre-Flight 2 Engine Run	1/sortie	0	100%	0	Apron A/ Apron B	50/50%	45/315	63%-Idle	30	2
		Trim	9	0	100%	0	Trim Pad facing N/S	50/50%	338/158	63%-Idle	25	1
										80%	8	
										90%	17	
										Max A/B	6	
ADAIR Category C		Pre/Post-Flight 2 Engine Run	0	1/sortie	100%	0	Bravo Row (Apron A)	100%	45	Idle	20	All
		Pre/Post-Flight 2 Engine Run	0	1/sortie	100%	0	Delta Row	100%	315	Idle	20	All
		Trim	0	144	100%	0	Trim Pad facing N/S	50/50%	338/158	Idle	12	1
										Approach	27	
										Intermediate	9	
										Military	9	
										Afterburner	3	

(1) Base provided maintenance records for 6300 sorties over 18 months.
(2) Using 4,556 baseline sorties and the Mx records for 6300 sorties.
(3) Expect ADAIR aircraft to be maintained elsewhere except for preflight runups and Trim Tests. Based on 2000 sorties. Actual aircraft to be modeled will be from Category C.
(4) For the 6,300 sorties , Apron A/B had 100 2-Engine Checks and 725 1-Engine Checks; Building 400 had 47 2-Engine Checks.
(5) There were 25 engine runs in the hush house and 12 trim checks for the 6300 sorties.
(6) ADAIR trim testing based on ACAM model with 24 test/year/aircraft expecting 6 ADAIR aircraft.
(7) Orange rows represent alternative locations for ADAIR aircraft parking. Only one option will be used.

B.2.5 Monitoring

If the Air Force selected the High Noise Scenario, a Mitigation and Monitoring Plan will be developed. The plan would describe the monitoring approach, method of execution, and timing for implementation. In addition, the plan would establish a process for identifying and making changes, as appropriate, to the action or the mitigations to result in beneficial outcomes that avoid or reduce adverse outcomes.