

CHAPTER 4 ENVIRONMENTAL CONSEQUENCES

GENERAL METHODOLOGY FOR ESTABLISHING IMPACT THRESHOLDS AND MEASURING EFFECTS BY RESOURCE

General Analysis Method

Impact analyses and conclusions are based on data from existing literature, information, and insights provided by NPS, FAA, other agency experts, and NPS's professional judgment. A very large amount of data was produced and examined for this analysis, using a wide variety of metrics related to sound, noise, and other subjects. All available data and other relevant factors (context, duration, timing) were carefully considered in making impact determinations in this EIS.

Items Specific to Meeting NPS Criteria for NEPA Analysis

When developing impact criteria and thresholds for NEPA documents, the NPS follows NPS Director's Order 12, Conservation Planning, Environmental Impact Analysis and Decision Making, to develop park (and/or project) specific impact criteria and thresholds, taking into consideration the type of proposed action and context, intensity, duration, and timing of potential impacts. Because impact analyses must consider all of these factors, a given action may have a variety of impacts (for example, major adverse localized impacts in some areas, and moderate beneficial impacts in others). Thresholds and other criteria for each impact topic evaluated in this EIS were developed to determine relative differences in impacts among Alternatives solely for this project. They represent a means to evaluate impacts of this project as required by NEPA, and as such, they are not necessarily applicable to all GCNP projects or to similar projects in other parks. Figure 4.1 outlines the NPS impact analysis process.

Effects of Alternatives were analyzed by evaluating existing impacts of Alternative A (No Action/Current Conditions), then comparing anticipated impacts of Action Alternatives (E, F, and NPS Preferred) to Alternative A's existing impacts. Impacts are presented and compared to Alternative A for Base Year and Ten-Year Forecast Peak and Off-Peak Seasons (see below for definitions).

METHODOLOGY

For each impact topic described in Chapter 3, the following impact assessment methodology was followed for each Alternative

1. Define Issues of Concern

Issues were developed based on public and internal scoping and tribal consultation described in Chapters 1 and 5.

2. Identify Area of Potential Effect

Unless otherwise specified for an individual impact topic, Area of Potential Effect for this EIS is generally the Special Flight Rules Area for direct effects, and the entire study area³³ for cumulative effects. However, for substantial restoration of natural quiet, the Area of Potential Effect is Grand Canyon National Park, not the entire SFRA or study area, and only up to 17,999 feet MSL (73 Federal Register 55130).

Direct effects of Alternatives primarily include impacts of air-tour and air-tour-related aircraft, which vary by Alternative below 18,000 feet MSL in the SFRA. Effects of other aircraft below 18,000 feet within the SFRA do not vary by Alternative and are included in the analysis. Effects of other noise sources, including all ground-based noise sources and aircraft above and outside the SFRA are included only in Cumulative Effects analysis (see below).

3. Identify Mitigation Measures

Action Alternative mitigation measures to manage aircraft impacts are described in Chapter 2. Impact analysis considers mitigation measures reasonably implemented before assessing impacts

³³ As described in Chapter 1's Scope of Analysis and shown on Map 1.2, the rectangular study area encompasses the park, the Special Flight Rules Area, and lands beyond

4. Identify Environmental Consequences

Environmental Consequences (Impacts or Effects) are described using the following bulleted items.

- **Timeframe**

Evaluation considered a change in air-tour noise impacts over time resulting from actions proposed in the Alternatives such as changes in air-tour routes, air-tour operations, and/or implementation of quiet-technology incentives or requirements. For each Alternative, analysis includes impact assessment during Base Year and Ten-Year Forecast. In addition, in the Action Alternatives, analysis considers seasonal changes in air-tour routes or route use. Therefore, impacts were considered during an Alternative's Peak and Off-Peak Season. Peak and Off-Peak Season vary by Alternative, as shown below, with the exception of Alternative A, No Action/Current Conditions, which does not have Peak and Off-Peak Seasons

Under Alternative A, all routes are open and can be used year-round. Historically fewer operations occur in winter, but some winter high-use days approach Peak Day.³⁴ Because there are no seasonal differences in management of air-tours under Alternative A, only Peak Day was included in Alternative A's impact analysis (Peak Day could theoretically occur any time of year because, in Alternative A, no management constraints limit or prevent use)

- **Base Year** 2005 is the Base Year used for noise modeling in this EIS. The best available data as of the end of 2005 is used as the base for noise modeling for the Alternatives. Since 2005, the 2005 database has been checked against data from subsequent years, and although there are some differences, given all factors contributing to those differences, the 2005 database has proven consistent enough to continue as a reasonable base for evaluating impacts of Alternatives in this EIS

- **Ten-Year Forecast** Ten-Year Forecast is the best estimate of what will occur ten years after implementing each Alternative, starting from the Base Year scenario. For the Ten-Year Forecast, growth in aircraft operations was assumed as explained in Appendix D. Also, full implementation of each Alternative's action elements is assumed to be achieved in the Ten-Year Forecast (for example, full conversion to quiet-technology aircraft if that is an Alternative element)

- **Peak Season** Because Action Alternatives (E, F, and NPS Preferred) propose different seasonal changes to routes, Alternatives are analyzed for different Peak Seasons. Alternative A (No Action/Current Conditions) does not contain, and is not analyzed for, Peak and Off-Peak Seasons

Alternative	Peak Season
E	July 1- September 15
F	February 1-November 30
NPS Preferred	May 1-October 31

- **Off-Peak Season** Because Action Alternatives (E, F, and NPS Preferred) propose different seasonal changes to routes, Alternatives are analyzed for different Off-Peak Seasons. Alternative A (No Action/Current Conditions) does not contain, and is not analyzed for, Peak and Off-Peak Seasons

Alternative	Off-Peak Season
E	September 16-June 30
F	December 1-January 31
NPS Preferred	November 1-April 30

³⁴ Peak Day Noise analysis for this EIS is based on a 12-hour time period of 7 a.m. to 7 p.m. on the Peak Day, the day with the highest total number of air-tour and air-tour-related operations. Based on a review of the best available data at the time EIS noise modeling analysis began, Peak Day occurred August 8, 2005, with a total 635 operations. This day forms the basis for Base Year analyses for the Alternatives. Data for subsequent years was checked to ensure use of 2005 Peak Day as the basis for Base Year analysis was still reasonable

1 Effects were characterized based on

- 2
- 3 • **Direct Effect** Caused by an action and occurs in the same time and place as the action
 - 4
 - 5 • **Indirect Effect** Caused by an action but occurs later in time or farther away but still reasonably
 - 6 foreseeable
 - 7
 - 8 • **Beneficial Effect** Generally a positive change in resource condition, a positive change in visitor
 - 9 experience, or a change that moves a resource or visitor experience toward a
 - 10 desired condition (consistent with the purpose and/or management objectives of
 - 11 the affected park land or other area)
 - 12
 - 13 • **Adverse Effect** Generally a change that moves the resource or visitor experience away from a
 - 14 desired condition or that detracts from visitor experience or resource condition.
 - 15 More specific descriptions of adverse and beneficial impacts may be provided
 - 16 for individual Impact Topics
 - 17
 - 18 • **Impact Intensity** Uses four intensity thresholds, **negligible**, **minor**, **moderate**, and **major**
 - 19 as defined for each impact topic and explained below in Impact Intensity
 - 20 Threshold and shown in Table 4.1
 - 21
 - 22 • **Duration** Considers length of time a resource would be affected by an event or related
 - 23 series of events. Duration (**short or long term**) varies by impact topic and is
 - 24 addressed in each
 - 25
 - 26 • **Timing** Considers sensitive time periods or seasons, sensitive time(s) of day, how often
 - 27 impact would occur, and whether impact is recurring
 - 28
 - 29 • **Area** **Marble Canyon, East End, Central, and West End** as shown on Map 3.2
 - 30
 - 31 • **Context** Generally refers to an impact's geographical extent, whether **regional** or
 - 32 **localized**, but also whether it would occur in a location sensitive to such
 - 33 impacts. Generally, regional impacts in this EIS are associated with a large part
 - 34 of the park or SFRA. Localized impacts are generally associated with specific
 - 35 sites or flight routes. If definitions vary from these, they are discussed under that
 - 36 impact topic
 - 37
 - 38 ○ **Management Zone** Park Management Zones are an important part of Context (see
 - 39 above) for some Impact Topics. Park Management Zones considered in this EIS are
 - 40 **Wilderness, Non-Wilderness, and Developed** (as described in Chapter 3). In general,
 - 41 impact analyses consider that, in the Developed Zone (about 2% of the park), more
 - 42 noise sources are present and more noise impact (from all sources, including aircraft)
 - 43 are accepted than in Wilderness and Non-Wilderness Zones, based on each
 - 44 Management Zone's objectives
 - 45
 - 46 • **Cumulative Effect** As described in CEQ's regulation 1508.7 as follows
 - 47 ○ Cumulative impacts are impacts that result from incremental impacts of the
 - 48 action when added to other past, present, and reasonably foreseeable future
 - 49 actions, regardless of what agency or person undertakes such other actions
 - 50 ○ Cumulative impacts can result from individually minor but collectively
 - 51 significant actions taking place over a period of time
 - 52
 - 53 Each cumulative impact analysis is additive, considering the overall impact of each
 - 54 Alternative when combined with effects of other past, present, and reasonably
 - 55 foreseeable future actions—in and outside the Area of Potential Effect. Thus, it was

necessary to identify other ongoing or reasonably foreseeable future projects at GCNP and, if applicable, the surrounding region. Because the scope of this project is relatively large, the geographic and temporal scope of the cumulative analysis is similarly large. The geographic scope for this analysis includes actions in and adjacent to park boundaries, while the temporal scope includes projects in a range of generally ten years (except Ethnographic Resources which considers a longer period). Given this, projects were identified for conducting cumulative effects analysis, and are listed in Appendix G

Cumulative effects analysis includes noise from aircraft flying 18,000 feet and above, aircraft flying below 18,000 feet but outside the SFRA, non-aircraft noise sources, and impacts of Alternatives

The park area affected by non-aircraft noise sources is localized to areas of human use, primarily Developed Zone areas (2% of the park), and a small component from vehicles on remote roads, motorboats on the Colorado River, and area mining activities. Aircraft flights above and outside the SFRA are the primary cumulative noise source impacting most of the SFRA

SOUND METRICS AND NOISE MODELING FOR ALL ALTERNATIVES

Noise was characterized based on the following metrics.

The FAA's Integrated Noise Model (INM) was used to predict effects of Alternatives regarding Soundscape and noise impacts. For additional information on metrics and modeling see Appendix D.

- **Percent Time Audible (%TA)** **Also known as Audibility.** Percent of time during the 12-hour day used in this analysis (7 a.m. to 7 p.m.) that aircraft sounds can be heard by humans and other animals with normal hearing. Percent Time Audible refers to potential for a human or animal to detect presence of sound, and provides information primarily related to duration of aircraft noise impacts

The extent to which aircraft sounds are actually heard on the ground depends on amplitude (sound pressure level) and sound structure (its frequency content and temporal pattern); hearing ability and attention of the animal or human; and other simultaneous sounds (ambient conditions). Since aircraft sound can be heard at or below ambient conditions, the Percent Time Audible metric is even sensitive to distant noise. However, because Percent Time Audible says nothing about how loud the aircraft is, Percent Time Audible is used in conjunction with Average Sound Level (L_{Aeq12}) and Percent Time Above (%TALA) metrics (both described below) to provide additional insight into the nature of the noise and its potential impacts.

Percent Time Audible was also used to assess restoration of natural quiet to GCNP's Soundscape. Substantial Restoration of Natural Quiet is defined by the NPS to mean 50% or more of the park will achieve natural quiet (no aircraft audible) 75 to 100% of the day, each and every day. All Alternatives must meet Public Law 100-91 provisions to substantially restore natural quiet in the park. However, Substantial Restoration of Natural Quiet is a determination rather than a metric value that lends itself to an impact intensity level definition, and is applicable only to GCNP, not other lands in the SFRA or study area. The amount of Substantial Restoration of Natural Quiet achieved by an Alternative is not reported in terms of negligible, minor, moderate, or major impact intensity level. In addition Percent Time Audible was only calculated within the GCNP boundary

- **Average Sound** **Also known as Equivalent Sound Level.** The logarithmic average, on an energy basis, of aircraft sound pressure levels in decibels (dBA) over the 12-hour day used in this

1	Level (L_{Aeq12})	analysis. Average Sound Level takes into account number of aircraft operations,
2		their time-varying sound levels, and their duration. It provides information primarily
3		related to energy intensity of aircraft noise impacts (in lay terms, loudness). However,
4		occasional loud sound levels may heavily influence (increase) Average Sound Level.
5		Long periods without aircraft sounds may also influence (decrease) Average Sound Level
6		values. The values must be used cautiously. The Average Sound Level metric does not
7		take ambient sound levels into account and only provides a measure of sound levels
8		emitted by aircraft operations by themselves. Average Sound Level is used in conjunction
9		with Percent Time Audible and Percent Time Above to gain fuller insight into the nature
10		of the noise and its potential impacts
11		
12	• Distance	Distance (also known as Slant Distance) relates primarily to proximity of aircraft to
13	in Meters	a location or point of interest on the ground, such as a visitor attraction site or wildlife
14		habitat, not to the relationship of distance and sound levels. Distance impacts include
15		visual aspects such as how big or how close an aircraft appears to visitors or wildlife
16		on the ground, with related issues of disturbance, seclusion, solitude, and privacy
17		
18		Distance measures also provide important information about opportunities for air-tour
19		visitors to view specific ground features. (Ground points of interest, known as Location
20		Points, are shown on Map 3.2). Distances shown in analysis are for Peak Season only.
21		For routes that change during Off-Peak Season, Distances for routes not in use during
22		Off-Peak Season would be greater than 2,000 meters
23		
24	• Percent Time Above	35, 45, and 55 dBA (%TALA35, %TALA45, and %TALA55, respectively)
25		Percentage of time during the 12-hour day used in this analysis that aircraft sounds
26		exceed 35, 45, and 55 dBA, respectively. The 10 dBA increments generally represent
27		a ten-fold increase in number of aircraft (assuming roughly the same amount of noise
28		for each aircraft), and a perceived doubling in loudness. Percent Time Above metrics
29		are used in conjunction with Average Sound Level and Percent Time Audible to gain
30		fuller insight into the nature of the noise and its potential impacts
31		
32		Two types of noise-modeling analyses were performed for this EIS, 1) Contour Analysis (Percent Time Audible and
33		Average Sound Level), and 2) representative Location Point Analysis (for all metrics).
34		
35	• Contour Analysis	Produced maps presenting SFRA flight tracks and key features, with data values in
36		colored contours for the entire park and and/or SFRA as shown in each map's legend;
37		data tables summarize contour data by Management Zone (Developed, Non-Wilderness,
38		and Wilderness). Contour Analysis was not performed for Marble Canyon, East End,
39		Central, and West End and SFRA (see Appendix D for further information on INM
40		modeling)
41		
42	• Location Point	NPS identified 127 individual points (shown on Map 3.2 and Table 3.2) to represent
43	Analysis	noise-sensitive areas for park resources or visitor experiences, or as part of a ten-
44		kilometer grid to ensure sufficient locations throughout the park were included in
45		noise modeling. For further information on noise modeling see Appendix D
46		
47		Both Contour and Location Point Analysis include Percent Time Audible and Average
48		Sound Level. Percent Time Above is only computed for Location Point Analysis.
49		Because ambient data outside GCNP is limited, and calculations of Percent Time Audible
50		require ambient values as inputs, Percent Time Audible is only calculated for the area
51		inside GCNP. Calculations of Average Sound Level require noise source data as inputs
52		(mostly aircraft in this EIS), so Average Sound Level is calculated for the entire SFRA.
53		

- 1 • **Dual-Zone System** Noise modeling for this EIS uses a Dual-Zone System (Audibility and Noticeability),³⁵
 2 for Percent Time Audible calculations, which generally addresses different objectives for
 3 different Management Zones. Specifically, for Noticeability Zone (approximately 66% of
 4 the park), natural ambient sound levels were used directly in computing Percent Time
 5 Audible in the noise model. For areas in the Noticeability Zone (approximately 34% of
 6 the park), 10 dB were added to natural ambient sound levels in the noise model to
 7 account for factors such as increased visitor activity and presence of non-natural sound
 8 sources. For reasons explained in the Federal Register Notice described in the footnote,
 9 when NPS and FAA agreed to use the Dual-Zone System for modeling at GCNP, most of
 10 the Developed Zone (including South and North Rim developed areas), GCNP's West
 11 End, and Marble Canyon are within the Noticeability Zone

12
 13 The Dual-Zone System was used in calculations to assess whether natural quiet has been
 14 substantially restored to GCNP. When interpreting modeling results, NPS takes into
 15 account that the overall definition of Substantial Restoration of Natural Quiet is based on
 16 audibility and natural ambient sound levels (natural Soundscape), not noticeability
 17

18 **Development of Impact Intensity Thresholds**

19
 20 To identify possible consequences of noise exposure, NPS reviewed noise standards accepted by the American
 21 National Standards Institute (ANSI) and the Environmental Protection Agency (EPA), the entire body of relevant
 22 peer-reviewed scientific literature, park management objectives and mandates (GMP, NPS Management Policies,
 23 etc.), natural ambient and other sound data measured at Grand Canyon, and public scoping comments. NPS also
 24 consulted applicable agencies, scientists, subject-matter and resource experts, and affiliated tribes.
 25

26 Consistent with CEQ regulations (40 CFR 1502.22), and NPS Director's Order 12, Conservation Planning,
 27 Environmental Impact Analysis and Decision Making (Sections 4.4 and 4.5), and considering the review described
 28 above, the NPS determined that

- 29 • The current state of scientific knowledge is incomplete or unavailable for some effects of aircraft noise on
 30 Impact Topics evaluated in this EIS. For example numerous studies document responses of visitors and wildlife
 31 to loud noise events. However chronic exposure to less obvious (less loud) noise sources is less understood.
 32 Also evidence of behavioral responses to noise is insufficient to be decisively interpreted or dismissed
- 33 • Impact analysis methodology is essential in evaluating reasonably foreseeable significant adverse impacts on
 34 the human environment
- 35 • Simple comparisons of noise metric values do not provide enough information to understand differences in
 36 impacts among Alternatives sufficient to make reasoned decisions based on best available science
 37

38 After considering the above bulleted items, and incorporating theoretical approaches and research methods generally
 39 accepted in the scientific community, NPS used professional judgment regarding consequences requiring
 40 management action to develop impact intensity threshold descriptions and select specific values for the quantitative
 41 framework shown in Table 4.1. For all Impact Topics except Socioeconomics (to which noise modeling does not
 42 apply), NPS applied noise modeling and other data to threshold descriptions to make determinations on Alternative
 43 A (No Action/Current Conditions) impact levels, then used a similar approach to evaluate changes in impacts for
 44 Action Alternatives compared to Alternative A.
 45

46 The quantitative framework in Table 4.1 is only one part of the impact intensity determination process. While this
 47 framework is integrated into impact intensity threshold descriptions as applicable for individual Impact Topics, it is
 48 impossible to develop a single framework that works equally well in all situations all the time. Therefore, final
 49 impact intensity determinations may differ from a strict adherence to the framework if, in NPS professional
 50 judgment, the preponderance of evidence from all available information in relation to context, duration, or timing

³⁵ Audibility/Noticeability zones for noise modeling are not the same as park Management Zones. The Dual-Zone System is explained in 64 Federal Register 3969, Notice Change in Noise Evaluation Methodology for Air-tour operations Over Grand Canyon National Park, and in Appendix D. A map of Dual-Zones for noise modeling is in Appendix D, Fig. 1

1 indicates a different impact level or a range of levels, such as situations where not all metrics indicate the same
2 impact intensity level.

3
4 Multiple metrics and approaches are considered as appropriate for each impact topic and situation to provide the
5 most reasonably complete description of noise and other impacts. Potential for interactive effects of metrics grouped
6 together are examined, in addition to values of individual metrics. Scientific literature most closely related to
7 individual species and specific situations was also re-evaluated to see if any adjustment to impact intensity level
8 indicated by the framework was warranted considering the particular context, duration, or timing involved.

9
10 To estimate level and length of time a resource or visitor may be affected by aircraft noise, Percent Time Audible in
11 combination with Average Sound Levels were the primary metrics evaluated. Distance was also a factor (except in
12 Soundscapes and Socioeconomics where Distance does not apply). In addition, analyses considered the qualitative
13 response a resource or visitor would likely have to the sound environment. Both the metrics and this assessment of
14 response were used to determine level of impact.

15
16 There were many cases when metrics did not all clearly indicate the same level of impact (negligible, minor,
17 moderate, or major). In such cases, a hierarchy was generally applied relating to a metric's importance level in
18 eliciting visitor or resource response, tempered by professional judgment related to metric values in specific
19 situations. Percent Time Audible was usually given more weight in determining impact level because it generally
20 better indicates amount of time a resource or visitor is exposed to conditions outside natural conditions (i.e.,
21 impacted at some level) than Average Sound Level (usually second in the hierarchy), or Distance (usually third in
22 the hierarchy). Metrics indicating Percent Time Above certain decibel levels were usually considered to help clarify
23 information provided by the other metrics.

24
25 For areas outside GCNP, but in the SFRA where Percent Time Audible was not assessed, Average Sound Level was
26 normally considered more important in determining impact intensity level than Distance.

27
28 **TABLE 4.1 NPS QUANTITATIVE IMPACT ANALYSIS FRAMEWORK**

Metric ^d	Negligible	Minor	Moderate	Major
Percent Time Audible (Aircraft) during a 12-hour Day ^{bc}	Less than or equal to 5%	Greater than 5% and less than or equal to 10%	Greater than 10% and less than or equal to 25%	Greater than 25%
Average Sound Level (L_{Aeq12}) Energy Average of Aircraft Sound Levels during a 12-hour Day ^d	Less than or equal to 15 dBA	Greater than 15 dBA and less than or equal to 25 dBA	Greater than 25 dBA and less than or equal to 35 dBA	Greater than 35 dBA
Distance between Points of Interest on the Ground and Aircraft Routes	Greater than or equal to 2,000 meters	Less than 2,000 meters and greater than or equal to 1,000 meters	Less than 1,000 meters and greater than or equal to 500 meters	Less than 500 meters

^aSee text above for definitions of these metrics

^bPercent Time Audible and Average Sound Level consider a 12-hour time period (7 a.m. to 7 p.m.)

^cThe framework for negligible, minor, moderate, and major in terms of Percent Time Audible was selected for reasons which include 1) Substantial Restoration of Natural Quiet at GCNP depends on park percent in which aircraft are audible less than or equal to 25% of a 12-hour day (the breakpoint between moderate and major impact levels); 2) 5% Percent Time Audible translates to an average of one flight per hour for the entire 12-hour day using an average of three minutes audibility per flight (the breakpoint between Negligible and Minor impact levels); and 3) 10% Percent Time Audible is a reasonable minor/moderate breakpoint considering the other two breakpoints and all above information sources

^dSpecific Average Sound Levels values were selected in the framework for reasons which include 1) accepted EPA and ANSI standards (Acoustical Society of America 2002, Crocker1997) recommend levels at and below 35 dBA (breakpoint between moderate and major impact levels) for numerous indoor settings where there is a reasonable expectation for quiet (classrooms, theaters), and for outdoor rural settings; 2) increments of 10 dBA in Average Sound Level are consistent with a ten-fold increase in number of aircraft (assuming roughly the same amount of noise for each aircraft), and a perceived doubling of loudness

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30
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Summary

Impacts are presented in the most reasonably accurate manner available. As appropriate, different impact intensity descriptions are presented for different locations, contexts, or time periods. Impacts are not averaged over large areas or long periods unless specifically stated. For example, moderate to major adverse impacts might occur beneath flight routes at the same time moderate to major beneficial impacts occur in portions of Flight-Free Zones, and impacts may be quite different during different time periods.

The NPS equates the term *major impacts* (or effects) to the term *significant* as used in NEPA and its implementing regulations. The NPS thus distinguishes between proposed actions and associated effects requiring EIS preparation versus those that require only an Environmental Assessment.

All available data were comprehensively examined to make impact determinations for each impact topic using standard NPS impact analysis methods outlined in Figure 4.1 to Figure 4.5. Criteria or conditions considered in determining magnitude of impact were developed based on guidance from the NPS Intermountain Regional Office Environmental Quality Division, the NPS Natural Resource Program Center’s Natural Sounds Program, and park planning and resource staffs’ best professional judgment. Likewise, intensity determined for each impact topic was based on all available data.

FIGURE 4.1 GENERAL NPS METHODOLOGY FOR IMPACT ANALYSIS



AND

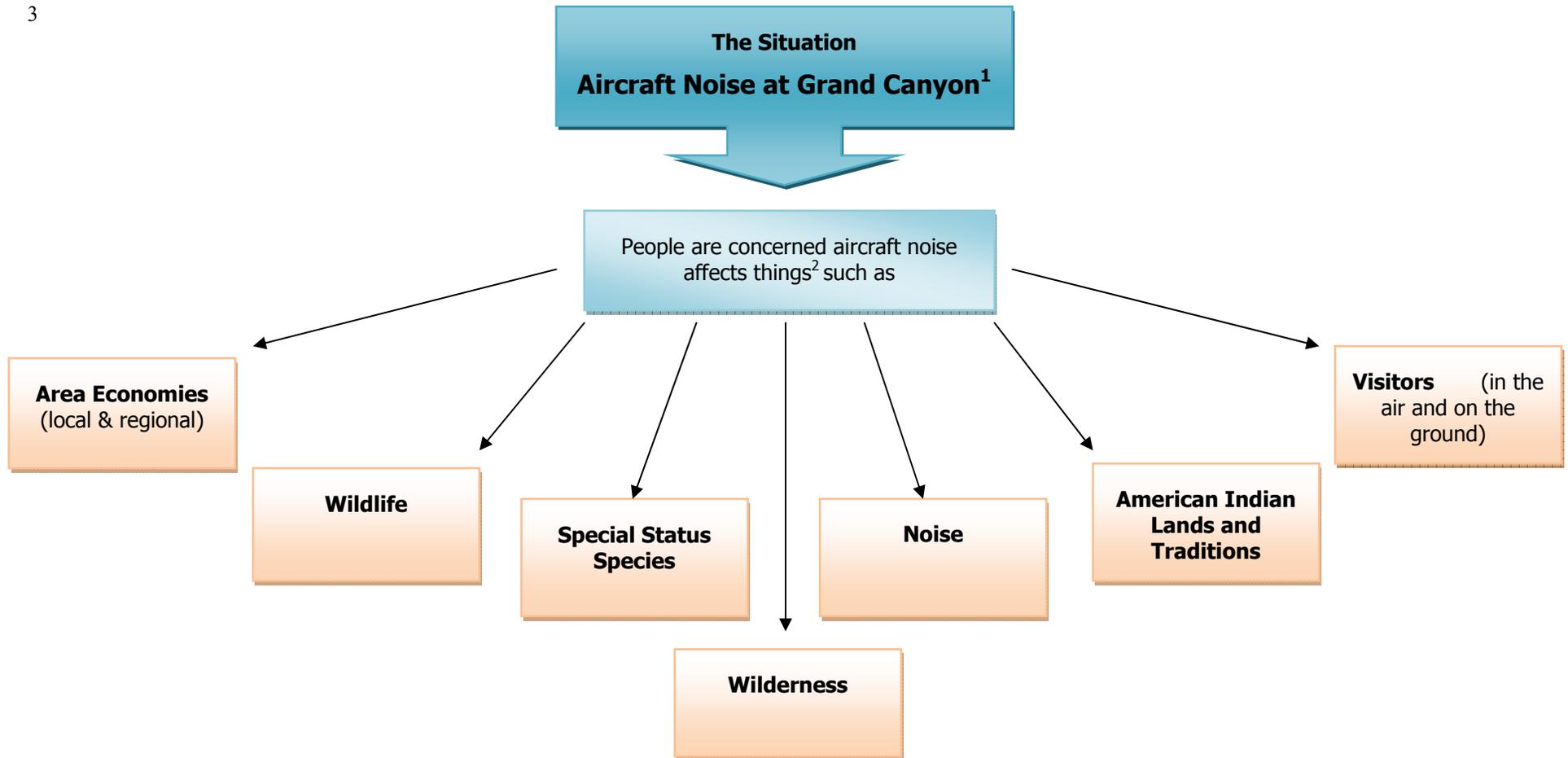
Intensity	<i>and</i>	Context	<i>and</i>	Duration	<i>and</i>	Timing	<i>leads to</i>	Impact of Alternative
Negligible Minor Moderate Major		Local or Regional and/or NPS Mgmt. Zone (as applicable)		Short term or Long term		Sensitive Times and/or Frequency of Impact		26 27 28 29 30 31 32 33

34

AND



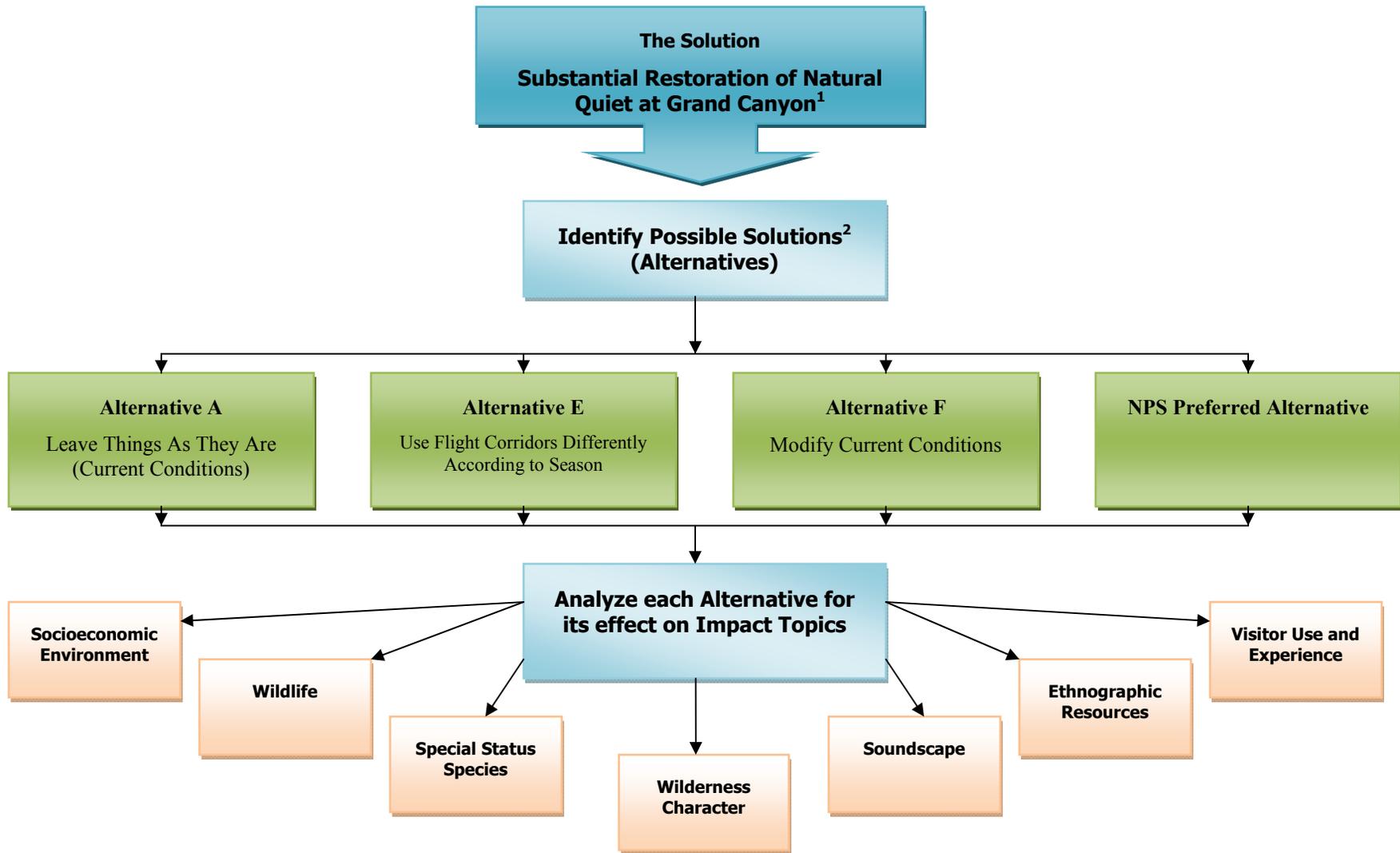
1 **FIGURE 4.2 THE EIS PROCESS STEP ONE**
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¹ In an EIS the affected location is called the *Area of Potential Effect* or the *Study Area*. In this EIS, the Study Area is larger than Grand Canyon National Park. See Map 1.2

² Things potentially affected by the situation are called *Impact Topics* listed in the next Figure, and are determined as described in Chapter 1

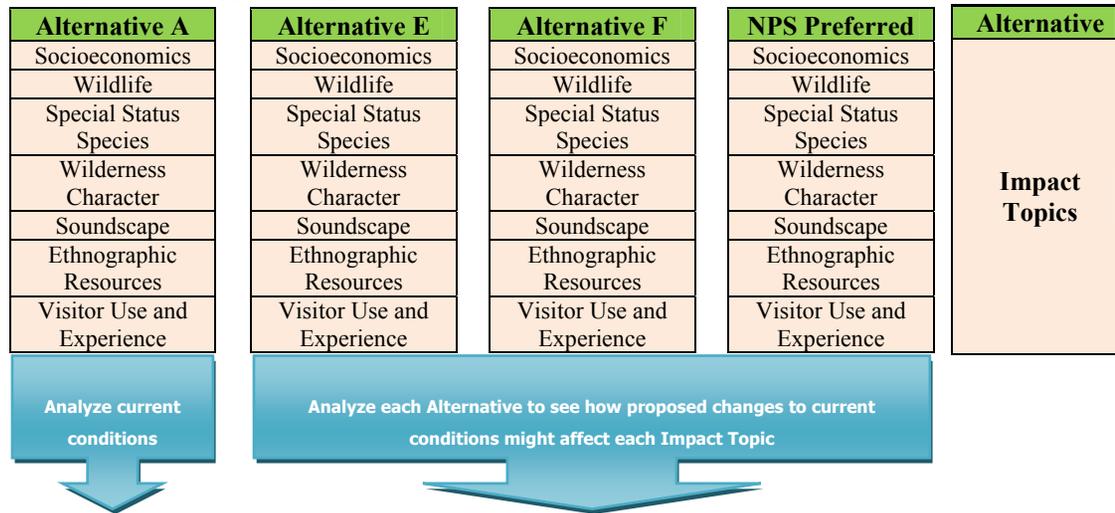
1 **FIGURE 4.3 THE EIS PROCESS STEP TWO**
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¹As directed by law and policy; see Chapter 1 and Appendix A

²Alternatives are derived from public scoping, consultation, and subject-matter experts as described in Chapters 2 and 5

1 **FIGURE 4.4 THE EIS PROCESS STEP THREE**

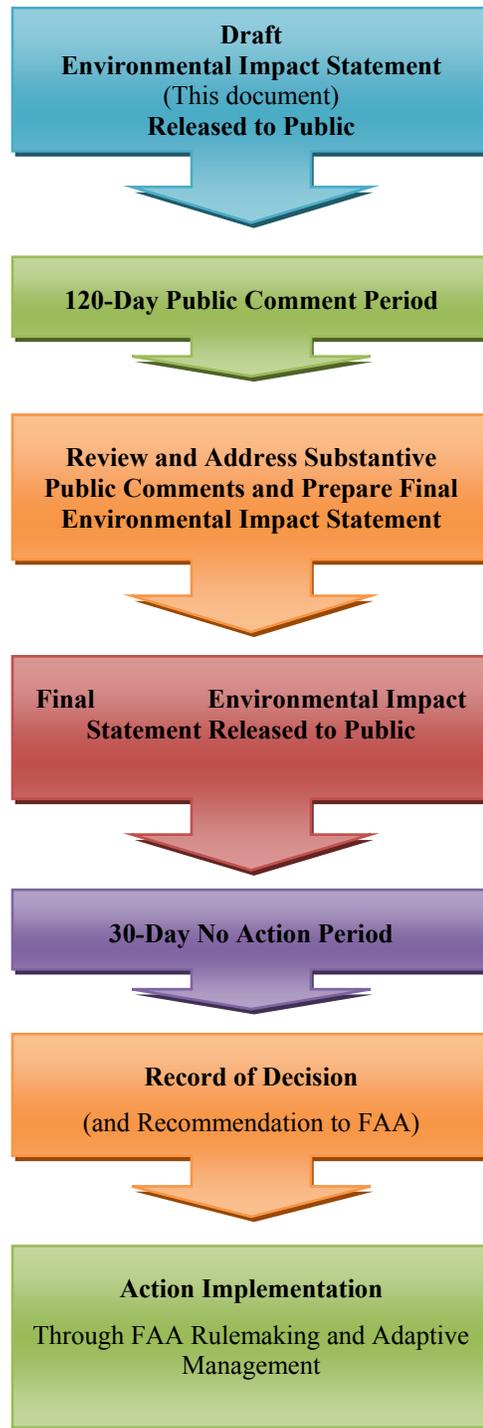


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In this EIS, Impact Topics under Each Alternative are Analyzed by						
Effects	Direct	Metrics	Percent Time Audible	Time Frame	Peak Season	Factors in this table are combined and assessed to reach a conclusion about each Alternative's combined effects, as shown in Figure 4.1 and summarized in Table 2.6
	Indirect		Average Sound Level		Off-Peak Season	
	Beneficial		Distance			
	Adverse		Percent Time Above			
Intensity	Negligible	Area	Marble Canyon	Peak and Off-Peak Season Change in Alternatives E, F, and NPS Preferred		
	Minor		East End			
	Moderate		Central			
	Major		West End			
Duration	Short Term	Management Zone	Developed			
	Long Term		Non-Wilderness			
Context	Localized		Wilderness			
	Regional	Cumulative Impacts	Alternative impacts plus impacts from other past, present, and reasonably foreseeable future actions			
Timing	Sensitive Times and/or Frequency of Impact	Time Frame	Base Year			
			Ten-Year Forecast			
Each Term Above Is Defined in Each Alternative		Definition of Each Term Above Remains the Same for All Alternatives				
All Above Terms are Defined in this Methodology Section						

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FIGURE 4.5 THE EIS PROCESS STEP FOUR



1 **SOUNDSCAPE**

3 **General Methodology**

Soundscape

4
5 Methods and impact thresholds used for Soundscapes analysis in this EIS were developed specifically for
6 circumstances at GCNP, and are not necessarily intended to be used or set precedents for use, in other national
7 parks. In the thresholds below, all aspects of aircraft noise intensity and duration including, but not limited to,
8 aircraft Percent Time Audible and Average Sound Level are included in the term *aircraft noise intensity*.
9

10 Because Soundscapes are recognized as a resource throughout the national park system, for the purpose of this EIS
11 these thresholds apply to other NPS-managed lands within the SFRA boundary, including NPS lands in Lake Mead
12 National Recreation Area, Glen Canyon National Recreation Area, and Grand Canyon-Parashant National
13 Monument. The conclusion for this section addresses overall impact to all NPS units in the SFRA in addition to
14 Grand Canyon National Park.
15

16 Soundscape impact analysis is presented 1) by Zone (Developed, Non-Wilderness, Wilderness) emphasizing
17 Contour Analysis data in GCNP, 2) by Area (Marble Canyon, East End, Central, West End) emphasizing Location
18 Point data in the SFRA, 3) for NPS Units in the SFRA but Outside GCNP, 4) Cumulative Impacts, and 5)
19 Conclusion.
20

21 A summary of impacts across Alternatives is provided at the end of Soundscapes in Summary of Impacts, All
22 Alternatives, Soundscape.
23

24 All metrics modeled in noise analysis were reviewed and considered even if not listed in threshold definitions.
25

26 **NPS Impact Intensity 27 Threshold Descriptions**

General Methodology

Soundscape

29 **Threshold Levels**

Soundscape

31 <i>Negligible</i>	Aircraft noise rarely audible, aircraft audible less than or equal to 5% of the 12-hour day used in 32 this analysis. Natural sounds predominate 33	
	Average aircraft noise intensity in a specific area less than or equal to 15 dBA 34 35	
36 <i>Minor</i>	Aircraft noise audible for a small portion of applicable time periods, aircraft audible greater than 37 5% and less than or equal to 10% of the 12-hour day 38	
	Average aircraft noise intensity in a specific area greater than 15 dBA and less than or equal to 25 39 dBA 40 41	
42 <i>Moderate</i>	Aircraft noise audible for an intermediate portion of applicable time periods, aircraft audible 43 greater than 10% and less than or equal to 25% of the 12-hour day 44	
	Average aircraft noise intensity in a specific area greater than 25 dBA and less than or equal to 35 45 dBA 46 47	
48 <i>Major</i>	Aircraft noise audible for a large portion of applicable time periods, aircraft audible greater than 49 25% of the 12-hour day 50	
	Average aircraft noise intensity in a specific area greater than 35 dBA 51 52	

53 **Type of Impact**

Soundscape

54
55 *Adverse* Impacts detract from achieving substantial restoration of natural quiet, increase aircraft noise
56 intensity, and/or duration of aircraft noise events

1	<i>Beneficial</i>	Impacts contribute toward achieving substantial restoration of natural quiet, decrease aircraft noise intensity, and/or duration of aircraft noise events	
2			
3	Context		Soundscape
4			
5	<i>Regional</i>	Impacts affect majority of the park or SFRA, or multiple backcountry use areas, attraction sites, trails, or flight routes	
6			
7			
8	<i>Localized</i>	Impacts affect a small area, such as a single backcountry use area, a specific attraction site, a specific trail, or flight route	
9			
10			
11	<i>Park</i>	Non-natural sound has greatest intensity of impact in NPS areas in the Wilderness Zone, then Non-Wilderness Zone, and least in the Developed Zone. For example, an Average Sound Level consistent with the moderate intensity level definition in the Wilderness Zone may be considered a minor intensity impact in the Developed Zone while the same level in the Non-Wilderness Zone may be considered minor-to-moderate, depending on other factors including duration and timing	
12	<i>Management</i>		
13	<i>Zone</i>		
14			
15			
16			
17	Duration		Soundscape
18			
19	<i>Short Term</i>	Impacts associated with individual, infrequent, and/or non-repetitive actions impact Soundscape only during and shortly after specified actions	
20			
21			
22	<i>Long Term</i>	Impacts persist well beyond completion of individual actions, generally impacting Soundscape longer than the day action occurs. Related actions frequent or repetitive over more than a few days would also be considered long-term impacts	
23			
24			
25			
26	Timing	Frequency of occurrence and time of day can be important considerations in assessing Soundscape impacts. Seasonality and sensitive time periods are described in impact topics where most relevant (Visitor Use and Experience, Wildlife), and not in Soundscape analysis	
27			
28			
29			
30	Background Information		Soundscape
31			
32		In national park units, Soundscape is the aggregate of all sounds in an area; it is the park's total acoustic environment. In a national park setting, Soundscape can be composed of both natural ambient sound and a variety of human-made sounds. Natural Soundscapes are composed completely of natural sounds without the presence of human-made sounds (NPS 2006b). The NPS recognizes the natural Soundscape of each national park unit as an inherent resource, and manages this resource to "restore degraded Soundscapes to the natural conditions wherever possible, and protect natural Soundscapes from degradation due to noise" (NPS 2006b).	
33			
34			
35			
36			
37			
38			
39		This section describes potential noise impacts of the Alternatives using various noise metrics to determine the extent to which each Alternative would 1) achieve and improve substantial restoration of natural quiet, and 2) result in impacts to Soundscape in NPS units in the study area.	
40			
41			
42			
43		The NPS considers a park's natural Soundscape to be a resource just like other natural and cultural resources found in a park. Soundscapes have their own inherent value that is susceptible to impacts from air-tours. Soundscapes can also serve as a guide to evaluating impacts to other park resources such as wildlife, cultural resources, and visitor experience. Noise modeling results for each Alternative were used to determine level of impact aircraft overflights might have on Soundscapes of NPS lands in the SFRA.	
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FIGURE 4.6 ALTERNATIVE A PERCENT TIME AUDIBLE BASE YEAR

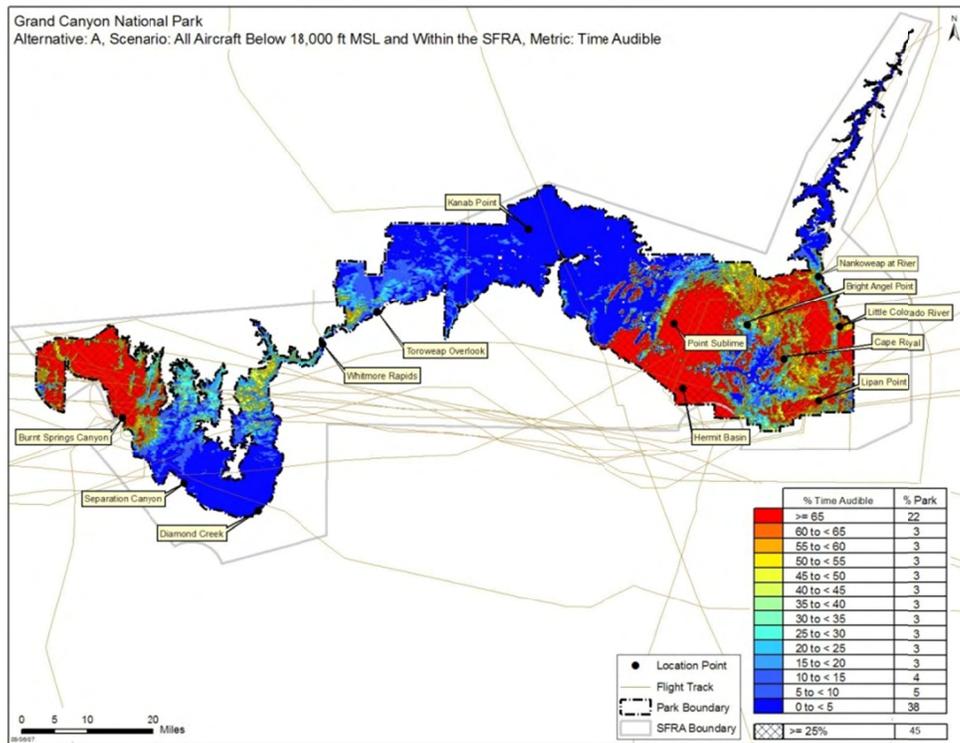
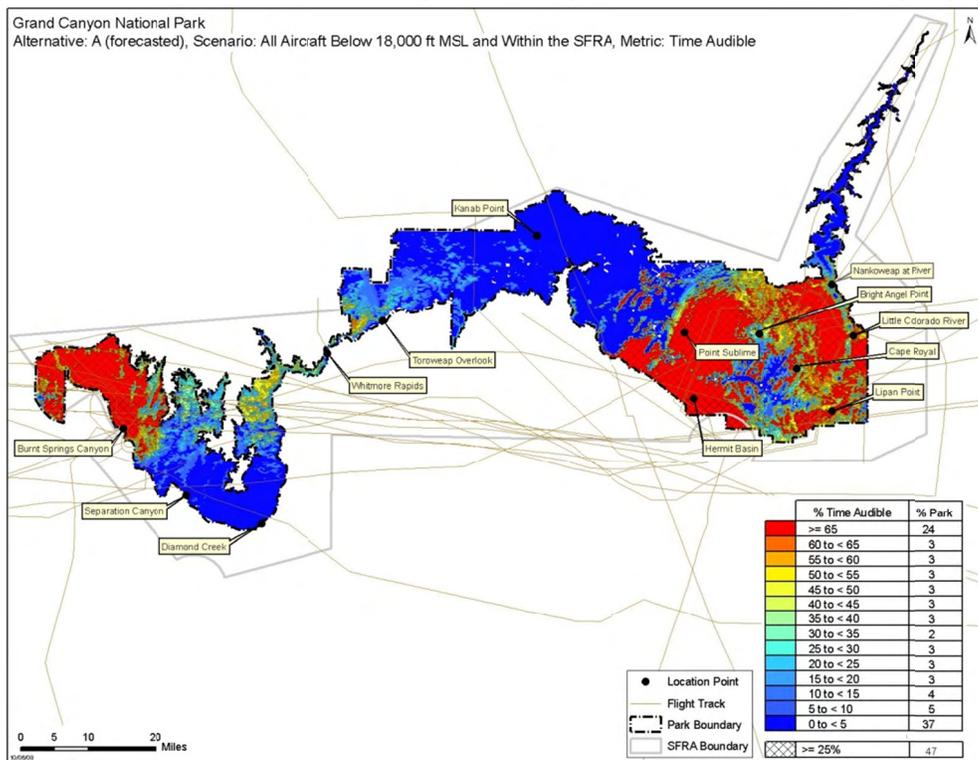


FIGURE 4.7 ALTERNATIVE A PERCENT TIME AUDIBLE TEN-YEAR FORECAST



1

FIGURE 4.8 ALTERNATIVE A AVERAGE SOUND LEVEL BASE YEAR

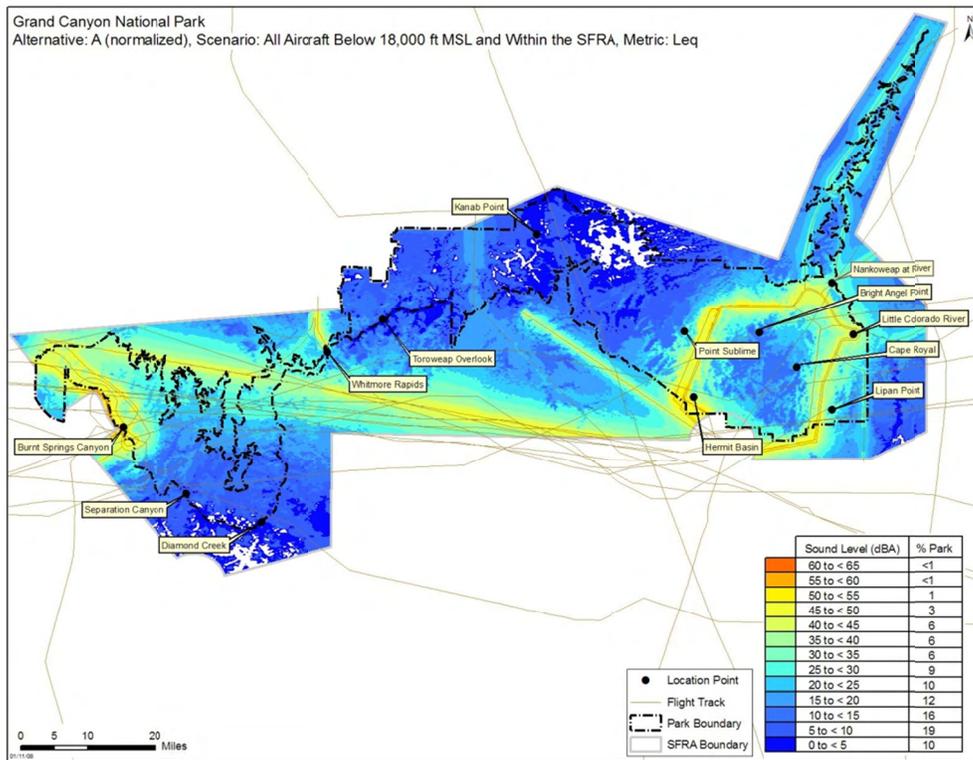
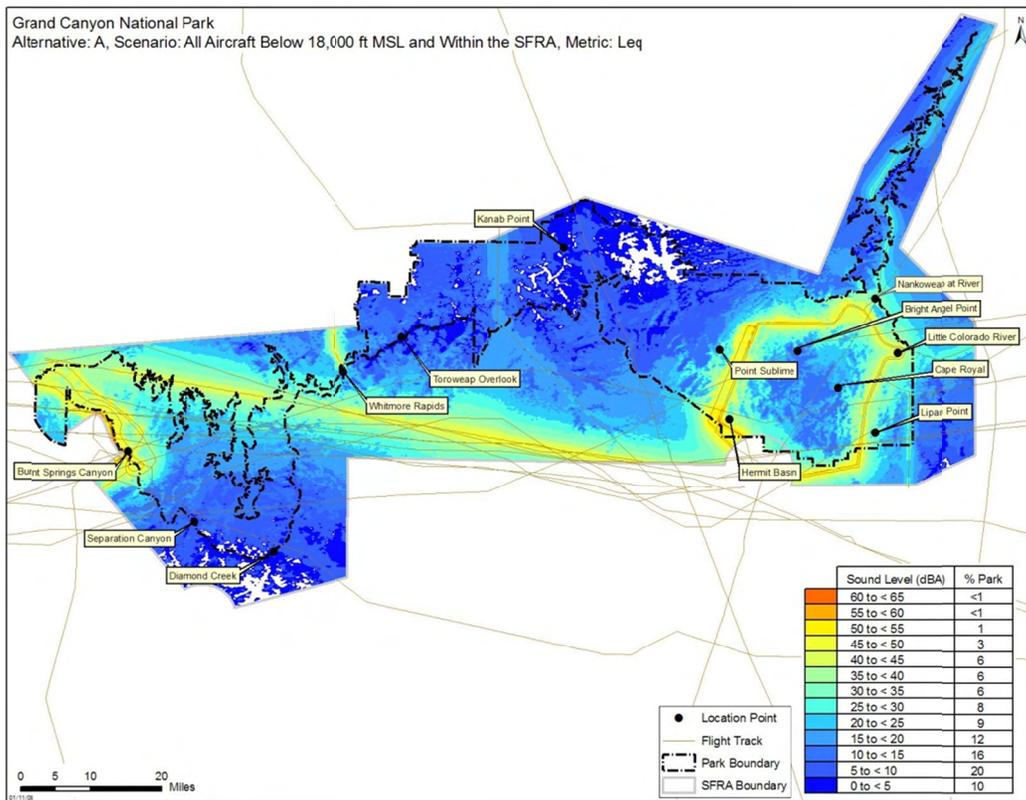


FIGURE 4.9 ALTERNATIVE A AVERAGE SOUND LEVEL TEN-YEAR FORECAST



1 **TABLE 4.2 ALTERNATIVE A PERCENT TIME AUDIBLE CONTOUR ANALYSIS RESULTS^{abc}**

Percent Time Audible	Base Year (Percent of Zone)				Ten-Year Forecast (Percent of Zone)			
	Developed Zone	Non-Wilderness Zone	Wilderness Zone	In GCNP	Developed Zone	Non-Wilderness Zone	Wilderness Zone	In GCNP
Percent Park Restored				55%				53%
≥ 25	88%	79%	43%	45%	90%	80%	45%	47%
10 to < 25	6%	8%	10%	10%	5%	7%	10%	10%
5 to < 10	1%	3%	6%	5%	1%	2%	6%	5%
> 0 to < 5	5%	11%	40%	38%	5%	11%	39%	37%

^aDue to rounding differences, totals shown in this table may differ from Appendix D by up to 2%

^bBecause limited ambient data were available outside GCNP, contours for Percent Time Audible were computed only within GCNP boundaries; Average Sound Level contours were computed in the entire SFRA

^cColumns do not always sum to 100% because contours include blank areas to indicate where aircraft noise was not audible or was below 0 dBA

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TABLE 4.3 ALTERNATIVE A AVERAGE SOUND LEVEL CONTOUR ANALYSIS RESULTS^{ab}

Average Sound Level	Base Year (% of Zone)					Ten-Year Forecast (% of Zone)				
	Developed Zone	Non-Wilderness Zone	Wilderness Zone	In GCNP	In SFRA	Developed Zone	Non-Wilderness Zone	Wilderness Zone	In GCNP	In SFRA
≥ 35	10%	21%	15%	16%	15%	24%	33%	22%	23%	14%
25 to < 35	55%	37%	12%	14%	15%	74%	57%	26%	28%	21%
15 to < 25	33%	28%	21%	22%	27%	2%	10%	38%	37%	41%
> 0 to < 15	3%	14%	48%	46%	40%	0%	1%	13%	13%	24%

^aDue to rounding differences, totals shown in this table may differ from Appendix D by up to 2%

^bColumns do not always sum to 100% because contours include blank areas to indicate where aircraft noise was not audible or was below 0 dBA

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ALTERNATIVE A NO ACTION/CURRENT CONDITION SOUNDSCAPE

Alternative A would continue all aspects of current management for general aviation and air-tour operations in the SFRA and, under NEPA, serves as the baseline against which to compare Action Alternatives. Alternative A would achieve Substantial Restoration of Natural Quiet in 55% of the park 75 to 100% of the day Base Year, and 53% of the park Ten-Year Forecast, as shown in Table 4.2 and 4.3.

Alternative A noise modeling mapped results (all aircraft below 18,000 feet MSL and in the SFRA scenario) for Percent Time Audible and Average Sound Level are shown on Figures 4.6 through 4.9. Tables 4.2 and 4.3 present Contour Analysis results computed for Percent Time Audible and Average Sound Level, respectively, for Alternative A. Table 4.4 presents Location Point results computed for all metrics for Alternative A. Unless otherwise stated, Alternative A metric values discussed in the text are taken from these figures and tables. NOTE: Blank areas in contour maps indicate where aircraft noise was not audible or below 0 dBA.

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Developed Zone (about 2% of GCNP) Alternative A Soundscape

With exception of a very small area at Tuweep, all GCNP Developed Zone areas are in the East End. Audibility calculations for the Developed Zone added 10 dBA to natural ambient sound levels due to the Dual-Zone System explained further in Chapter 4, Methodology. As such, analysis considers Developed Zone management objectives which accept presence of many non-natural sound sources (increased background ambient sound levels) including most of the park’s visitors and their activities, presence of paved roads and motorized transportation, and developed

1 facilities. **Alternative A is not analyzed for Peak and Off-Peak Season because there are no seasonal route**
 2 **changes in this Alternative.**

3
 4 **TABLE 4.4 ALTERNATIVE A LOCATION POINT RESULTS^{ab}**

Location Point Grouping		Base Year					Ten-Year Forecast				
		TAUD ^c	L _{Aeq12} ^d	TALA35 dBA ^e	TALA45 dBA ^e	TALA55 dBA ^e	TAUD	L _{Aeq12}	TALA35 dBA	TALA45 dBA	TALA55 dBA
Marble Canyon	Max	3%	24 dBA	1%	0%	0%	3%	25 dBA	2%	0%	0%
	Median	2%	14 dBA	0%	0%	0%	2%	16 dBA	0%	0%	0%
	Min	0%	0 dBA	0%	0%	0%	0%	0 dBA	0%	0%	0%
East End	Max	100%	49 dBA	100%	51%	5%	100%	49 dBA	100%	57%	5%
	Median	64%	28 dBA	5%	0%	0%	67%	29 dBA	6%	0%	0%
	Min	0%	6 dBA	0%	0%	0%	0%	7 dBA	0%	0%	0%
Central	Max	22%	27 dBA	4%	0%	0%	25%	27 dBA	5%	0%	0%
	Median	1%	10 dBA	0%	0%	0%	1%	10 dBA	0%	0%	0%
	Min	0%	0 dBA	0%	0%	0%	0%	0 dBA	0%	0%	0%
West End	Max	93%	47 dBA	71%	29%	4%	95%	48 dBA	81%	33%	5%
	Median	19%	22 dBA	1%	0%	0%	21%	23 dBA	1%	0%	0%
	Min	0%	0 dBA	0%	0%	0%	0%	0 dBA	0%	0%	0%
All Location Points	Max	100%	49 dBA	100%	51%	5%	100%	49 dBA	100%	57%	5%
	Median	9%	17 dBA	0%	0%	0%	10%	18 dBA	0%	0%	0%
	Min	0%	0 dBA	0%	0%	0%	0%	0 dBA	0%	0%	0%

^aBecause limited ambient data were available outside GCNP, contours for Percent Time Audible were computed only in GCNP boundaries; Average Sound Level (L_{Aeq12}) contours were computed in the entire SFRA

^bMax refers to maximum Location Point value for a Location Point grouping for each respective specific metric; conversely, Min refers to minimum Location Point value. Median characterizes the central tendency of the results. That is, 50% of results are above the median; 50% below. The median, as opposed to the arithmetic mean, is more appropriate for data not normally distributed

^cTAUD = Percent Time Audible

^dL_{Aeq12} = Average Sound Level

^eTALA35 dBA, TALA45 dBA, and TALA55 dBA = Percent of time during the 12-hour day used in this analysis that aircraft sounds exceed 35, 45, and 55 dBA, respectively

5
 6
 7 *Developed Zone* *Alternative A* *Soundscape*
 8 *Base Year*
 9 Average Sound Level would generally be greater than 25 dBA in 65% of the Developed Zone (25 to 35 dBA in
 10 55% of the Developed Zone, and greater than 35 dBA in 10%). Percent Time Audible would generally be greater
 11 than 25% of the day in 88% of the Developed Zone, and 10 to 25% Percent Time Audible in 6% of the
 12 Developed Zone. Thus the majority of the Developed Zone would experience moderate to major adverse impacts
 13 due to amount of air-tour activity in both Zuni Point and Dragon Corridors. Although major adverse impacts
 14 would occur, effects would be a mix of short and long term given amount of visitor activity and presence of non-
 15 natural sound sources.

16
 17 *Developed Zone* *Alternative A* *Soundscape*
 18 *Ten-Year Forecast*

19 Because Alternative A includes growth in operations, but does not include quiet-technology incentives or
 20 conversion requirements, adverse impacts would increase to 98% of the Developed Zone experiencing Average
 21 Sound Level greater than 25 dBA, and 95% of the Developed Zone with air-tour aircraft Percent Time Audible
 22 greater than 10% of the day (areas with moderate to major adverse impacts). This would represent a minor to
 23 moderate adverse change in impacts due to forecasted increase in air-tour operations from Base Year to Ten-
 24 Year Forecast.
 25
 26

1 **Non-Wilderness Zone (4% of GCNP) Alternative A Soundscape**

2
3 Almost all Non-Wilderness Zone areas are located in East End (exceptions are a few Central area dirt road
4 corridors). A portion of the Non-Wilderness Zone is in the Dual-Zone area where 10 dBA is added to natural
5 ambient sound levels for audibility calculations; this portion is generally close to Developed Zone areas with
6 motorized noise sources, although there is a strip of Non-Wilderness Zone on Marble Canyon's east side. The
7 majority of the Non-Wilderness Zone is in the area where natural ambient sound levels are used directly as the basis
8 for audibility calculations in this EIS, consistent with Non-Wilderness Zone management objectives that call for
9 mostly natural conditions to prevail in the Zone.

10
11 *Non-Wilderness Zone Alternative A Soundscape*
12 *Base Year*

13 Average Sound Level would generally be greater than 25 dBA in 58% of the Non-Wilderness Zone (25 to 35
14 dBA in 37%, and greater than 35 dBA in 21%). Percent Time Audible would generally be greater than 25% of
15 the day in 79% of the Non-Wilderness Zone, and 10 to 25% Percent Time Audible in 8% of the Non-Wilderness
16 Zone (areas with moderate to major adverse impacts). Thus the majority of the Non-Wilderness Zone would
17 experience moderate to major adverse impacts due to amount of air-tour activity in Zuni Point and Dragon
18 Corridors. Although long-term major adverse impacts would occur, some effects would be short term given
19 amount of visitor activity and presence of non-natural sound sources in some of the Zone.

20
21 *Non-Wilderness Zone Alternative A Soundscape*
22 *Ten-Year Forecast*

23 Because Alternative A includes growth in operations but does not include quiet-technology incentives or
24 conversion requirements, adverse impacts would increase to 90% of the Non-Wilderness Zone with Average
25 Sound Level greater than 25 dBA, and 87% of the Non-Wilderness Zone with air-tour aircraft Percent Time
26 Audible greater than 10% of the day (areas with moderate to major adverse impacts). This would represent a
27 minor to moderate adverse change in impact due to forecasted increase in air-tour operations from Base Year to
28 Ten-Year Forecast.

29
30 **Wilderness Zone (about 94% of GCNP) Alternative A Soundscape**

31
32 In the Wilderness Zone, results vary to a greater degree than in Developed and Non-Wilderness Zones due to the
33 Wilderness Zone's increased size and geographic extent compared to the others. Most of the Wilderness Zone is in
34 the area where natural ambient sound levels are used directly in audibility calculations in the Dual-Zone System
35 acoustic approach to noise modeling. Exceptions are West End and Marble Canyon.

36
37 *Wilderness Zone Alternative A Soundscape*
38 *Base Year*

39 Average Sound Level would generally be greater than 25 dBA in 27% of the Wilderness Zone (25 to 35 dBA in
40 12%, and greater than 35 dBA in 15%). Percent Time Audible would generally be greater than 25% of the day in
41 43% of the Wilderness Zone, and 10 to 25% Percent Time Audible in 8% of the Wilderness Zone (areas with
42 moderate to major adverse impacts). Thus, percentage of the Wilderness Zone experiencing moderate to major
43 adverse impacts would be almost half, and impacts would mostly be concentrated in East and West Ends as
44 shown in Figures 4.6 to 4.9. In the Wilderness Zone, major adverse impacts would mostly be long-term with
45 reduced visitor use and absence of non-natural sound sources in the Zone.

46
47 *Wilderness Zone Alternative A Soundscape*
48 *Ten-Year Forecast*

49 Because Alternative A includes growth in operations, but does not include quiet-technology incentives or
50 conversion requirements, adverse impacts would increase to 48% of the Zone with Average Sound Level greater
51 than 25 dBA, and 55% of the Wilderness Zone with air-tour aircraft Percent Time Audible greater than 10% of
52 the day (areas with moderate to major adverse impacts). This would represent a negligible to minor adverse
53 change in impacts due to forecasted increase in air-tour operations from Base Year to Ten-Year Forecast.

1 considered major adverse Base Year (Average Sound Level would range 40 to 50 dBA) with negligible increases
2 Ten-Year Forecast.

3
4 **Cumulative Impacts**

Alternative A

Soundscape

5
6 Other than air-tour aircraft sounds, impacts on Soundscape result from sounds of high-altitude aircraft above 18,000
7 feet MSL and, to a lesser degree, aircraft below 18,000 feet MSL and outside the SFRA. Throughout GCNP, these
8 aircraft produce Average Sound Level 22 to 31 dBA. Audibility of high-altitude aircraft varies throughout the park
9 as presented below. Noise from other sources (vehicles, building noise) is mostly concentrated in the Developed
10 Zone (2% of the park), although there is a small component added primarily from vehicles on remote roads,
11 motorboats on the Colorado River, and mining activities. Especially in terms of Percent Time Audible, though, noise
12 generated by aircraft above and outside the SFRA contributes the most non-natural noise over most of the SFRA and
13 overwhelms any localized cumulative benefits realized under the Alternatives.

14
15 At Location Points in Marble Canyon and nearby areas, noise from aircraft above and outside the SFRA Percent
16 Time Audible is 16 to 36% of the day. At East End Location Points, except those close to the river, aircraft above
17 and outside the SFRA are audible 27 to 71% of the day. At Central Location Points, noise from aircraft above and
18 outside the SFRA is audible 16 to 65% of the day. At West End Location Points, noise from aircraft above and
19 outside the SFRA is audible 12 to 51% of the day. Average Sound Level from aircraft above and outside the SFRA
20 would generally be less than 30 dBA in all areas.

21
22 Cumulative noise from aircraft flying over 18,000 feet, as well as aircraft flying below 18,000 feet but outside the
23 SFRA's lateral extents, would have minor to moderate localized short-term adverse impacts in the entire SFRA;
24 however, long-term impacts would be major adverse (aircraft Percent Time Audible would generally be greater than
25 25%). There are no areas in GCNP where the natural Soundscape would not be adversely affected by aircraft noise
26 at least some of the time. When effects of air-tour aircraft in Alternative A are added to these effects, overall, there
27 would be a long-term moderate to major adverse cumulative impact in the study area.

28
29 **Conclusion**

Alternative A

Soundscape

30
31 Under Alternative A, a range of aircraft Average Sound Level and Percent Time Audible would affect GCNP
32 Soundscapes. Alternative A would achieve Substantial Restoration of Natural Quiet in 55% of the park 75 to 100%
33 of the day Base Year; which would decrease slightly to 53% of the park Ten-Year Forecast due to increases in air-
34 tour operations (a negligible change in impacts).

35
36 Because Alternative A includes growth in operations, but no quiet-technology conversion requirements, noise
37 impacts would increase Base Year to Ten-Year Forecast in all Zones and areas. However, increases in impacts
38 would generally be negligible. Near busy air-tour corridors, such as those in East End, changes might not be
39 discernable as some affected areas already experience close to 100% audibility. However, for areas where Percent
40 Time Audible is less than, but close to 25%, future increases might jeopardize achievement of substantial restoration
41 of natural quiet.

42
43 *Conclusion by Zone*
44 *Ten-Year Forecast*

Alternative A

Soundscape

45 Wilderness Zone (94% of GCNP); area of moderate to major adverse impacts would be 48 to 55% of the Zone.

46
47 Non-Wilderness Zone (about 4% of GCNP); area of moderate to major adverse impacts would be 87 to 90% of the
48 Zone.

49
50 Developed Zone (about 2% of GCNP); area of moderate to major adverse impacts would be 95 to 98% of the Zone.

51
52 *Conclusion by Area*

Alternative A

Soundscape

53 In Marble Canyon, Central areas, and West End's southern portion, localized long- and short-term impacts would
54 generally be negligible to minor adverse (Average Sound Level would often be less than 15 dBA and Percent Time
55 Audible less than 5%). Greatest exposure to noise impacts would occur under and near East and West End heavily-
56 used air-tour routes where long- and short-term major adverse impacts would occur Base Year and Ten-Year

1 Forecast (aircraft Average Sound Level 40 to 50 dBA, and Percent Time Audible greater than 65%). Away from
 2 routes amid Flight-free Zones, impacts would be negligible to minor adverse.

3
 4 **Cumulative Impacts**

Alternative A

Soundscape

5
 6 Cumulative impacts from all actions would be long term moderate to major adverse due primarily to high aircraft
 7 Percent Time Audible levels.

8
 9 **ALTERNATIVE E**

ALTERNATING SEASONAL USE

SOUNDSCAPE

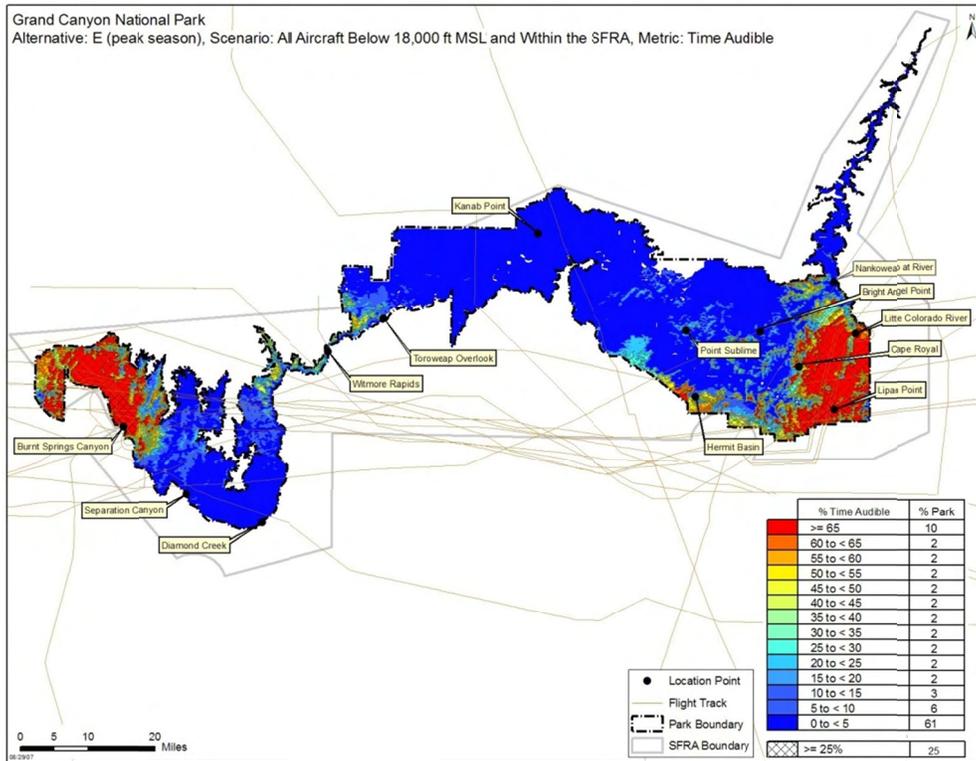
10
 11 Alternative E, Alternating Seasonal Use, would maximize park area in Flight-free Zones, and seasonally alternate
 12 use of Zuni Point and Dragon Corridor routes.

13
 14 Base Year Peak Season, Alternative E would achieve Substantial Restoration of Natural Quiet in 75% of the park 75
 15 to 100% of the day. This represents moderate beneficial change in impacts with a 20% increase in park area restored
 16 as shown in Table 4.23 compared to Alternative A. Base Year Off-Peak Season Alternative E would achieve
 17 Substantial Restoration of Natural Quiet in 78% of the park as shown in Table 4.23. This represents moderate
 18 beneficial change in impacts with a 23% increase in park area restored compared to Alternative A.

19
 20 Ten-Year Forecast Peak Season Substantial Restoration of Natural Quiet would be achieved in 84% of the park as
 21 shown in Table 4.24. This represents major beneficial change in impacts with a 31% increase in park area restored
 22 compared to Alternative A. Ten-Year Forecast Off-Peak Season Substantial Restoration of Natural Quiet would be
 23 achieved in 86% of the park as shown in Table 4.24. This represents major beneficial changes in impacts compared
 24 to Alternative A with a 33% increase in park area restored.

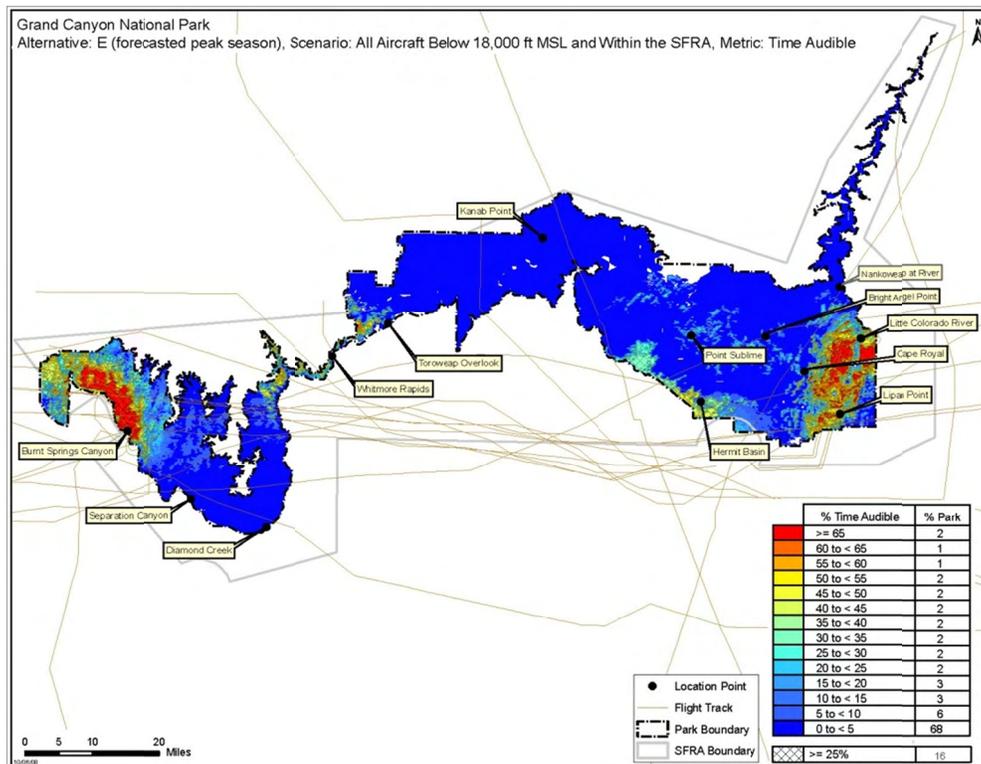
25
 26 Mapped results of noise modeling for Alternative E for Percent Time Audible and Average Sound Level are shown
 27 in Figures 4.10 through 4.17. Table 4.5 through 4.10 present Contour Analysis and Location Point results computed
 28 for Alternative E Peak and Off-Peak Seasons, respectively, and includes comparisons with Alternative A, No
 29 Action/Current Condition.

FIGURE 4.10 ALTERNATIVE E PERCENT TIME AUDIBLE BASE YEAR PEAK SEASON



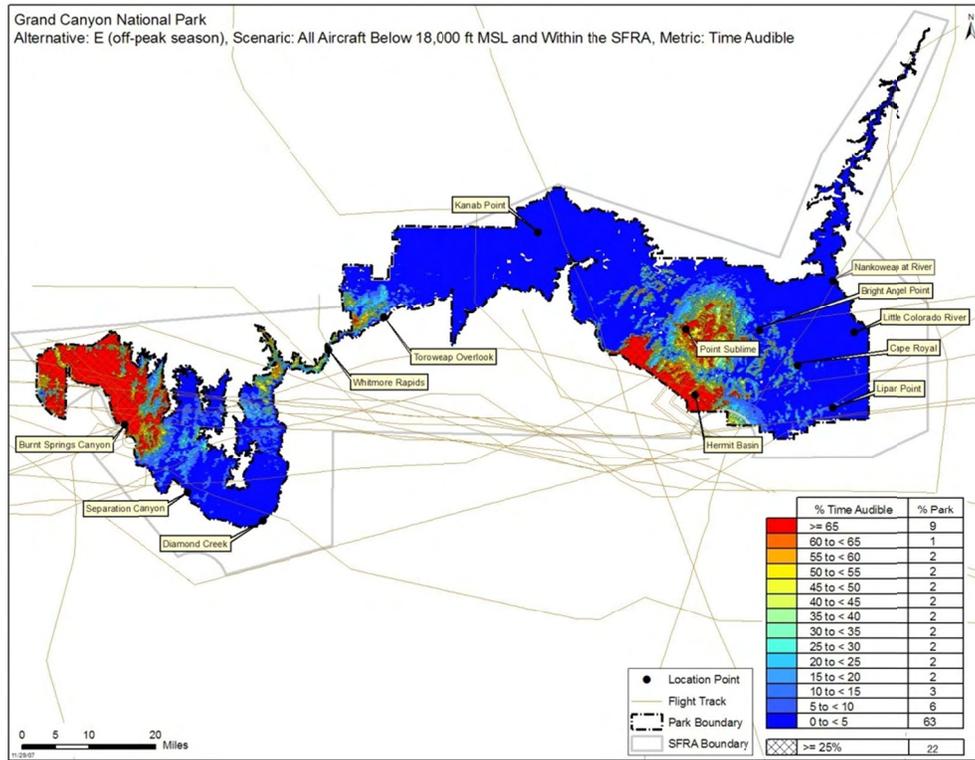
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FIGURE 4.11 ALTERNATIVE E PERCENT TIME AUDIBLE TEN-YEAR FORECAST PEAK SEASON



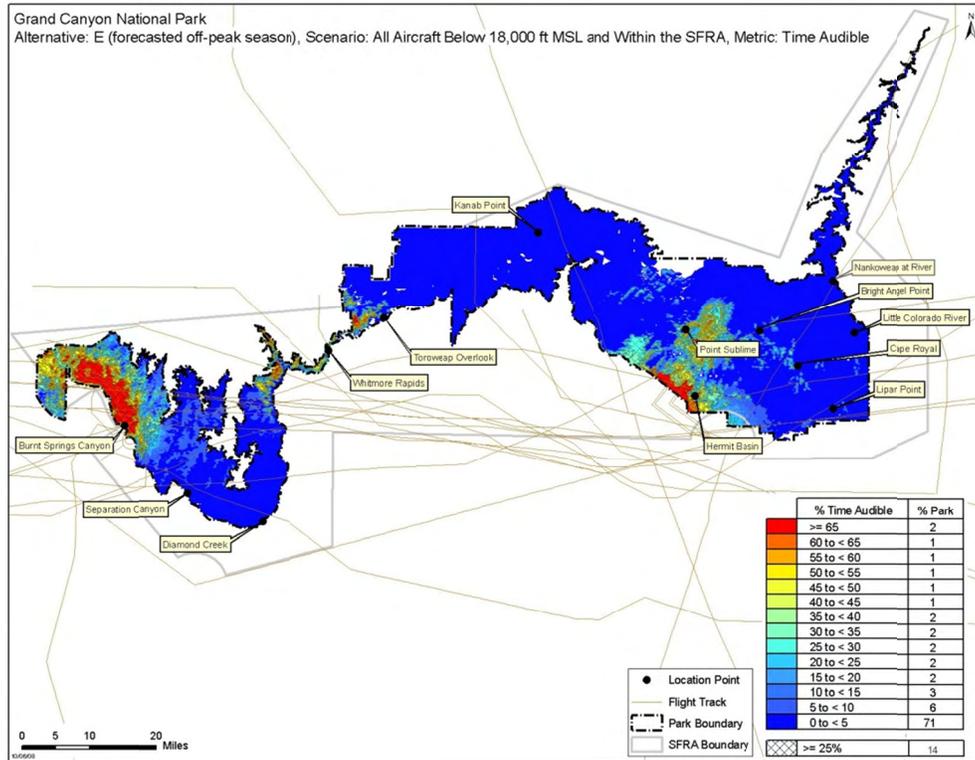
4

FIGURE 4.12 ALTERNATIVE E PERCENT TIME AUDIBLE BASE YEAR OFF-PEAK SEASON



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FIGURE 4.13 ALTERNATIVE E PERCENT TIME AUDIBLE TEN-YEAR FORECAST OFF-PEAK SEASON



4

FIGURE 4.14 ALTERNATIVE E AVERAGE SOUND LEVEL BASE YEAR PEAK SEASON

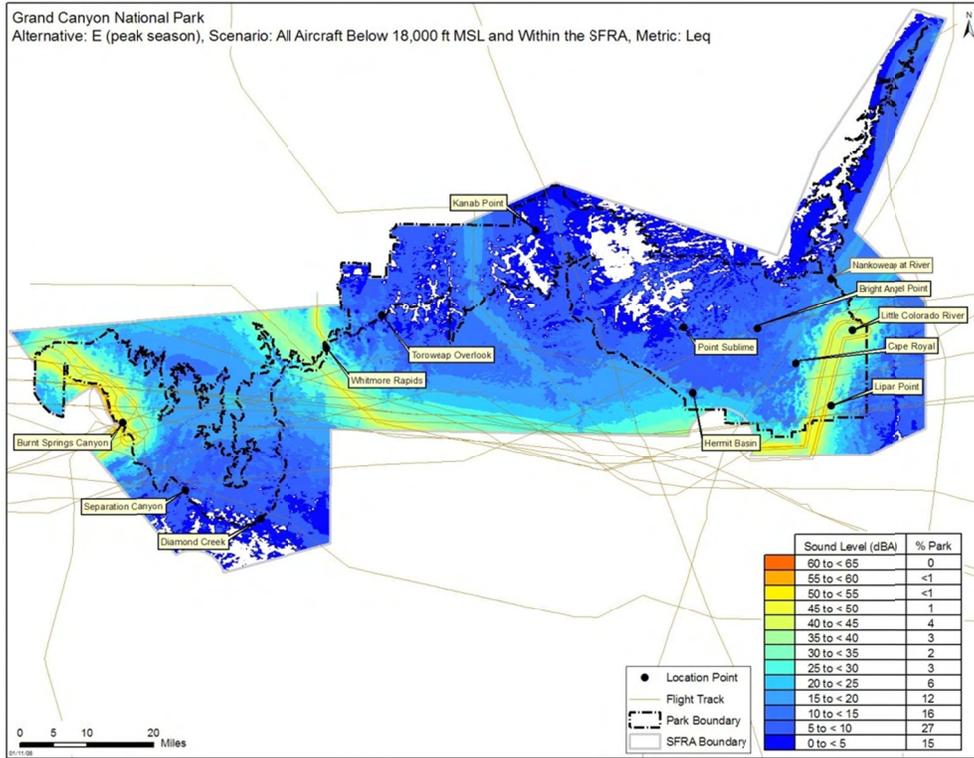


FIGURE 4.15 ALTERNATIVE E AVERAGE SOUND LEVEL TEN-YEAR FORECAST PEAK SEASON

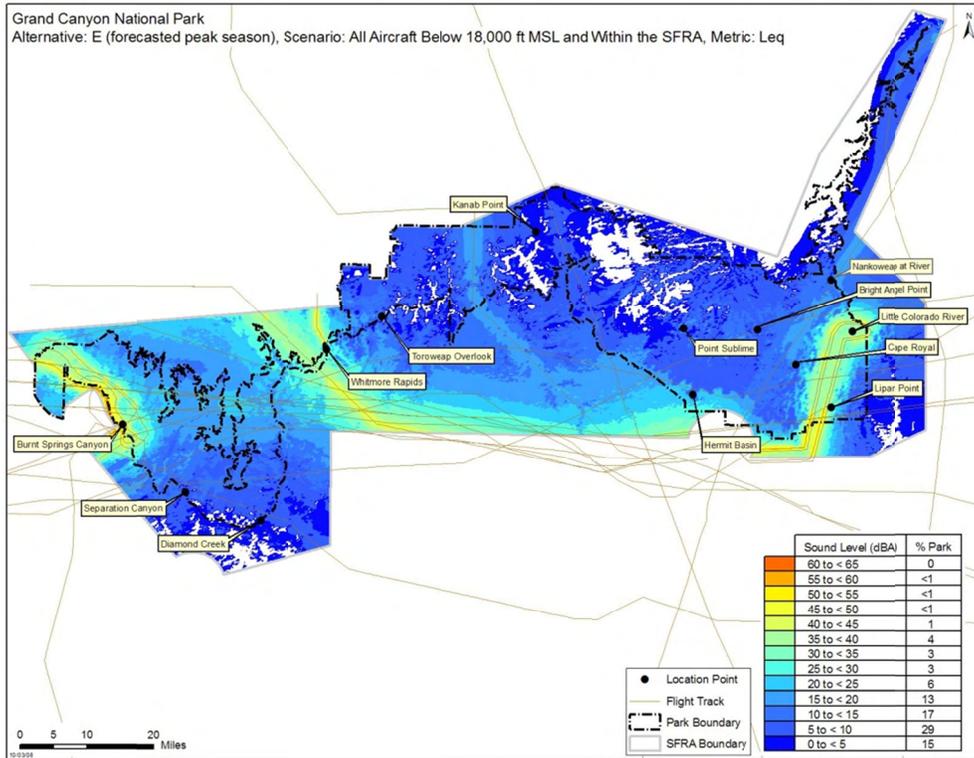


FIGURE 4.16 ALTERNATIVE E AVERAGE SOUND LEVEL BASE YEAR OFF-PEAK SEASON

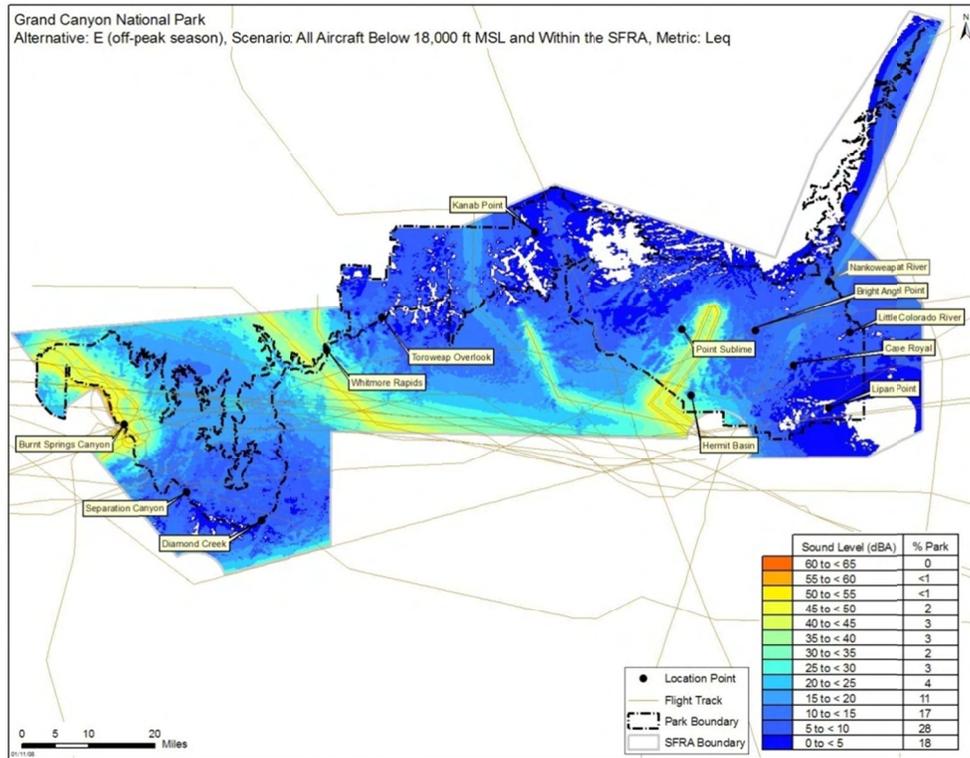
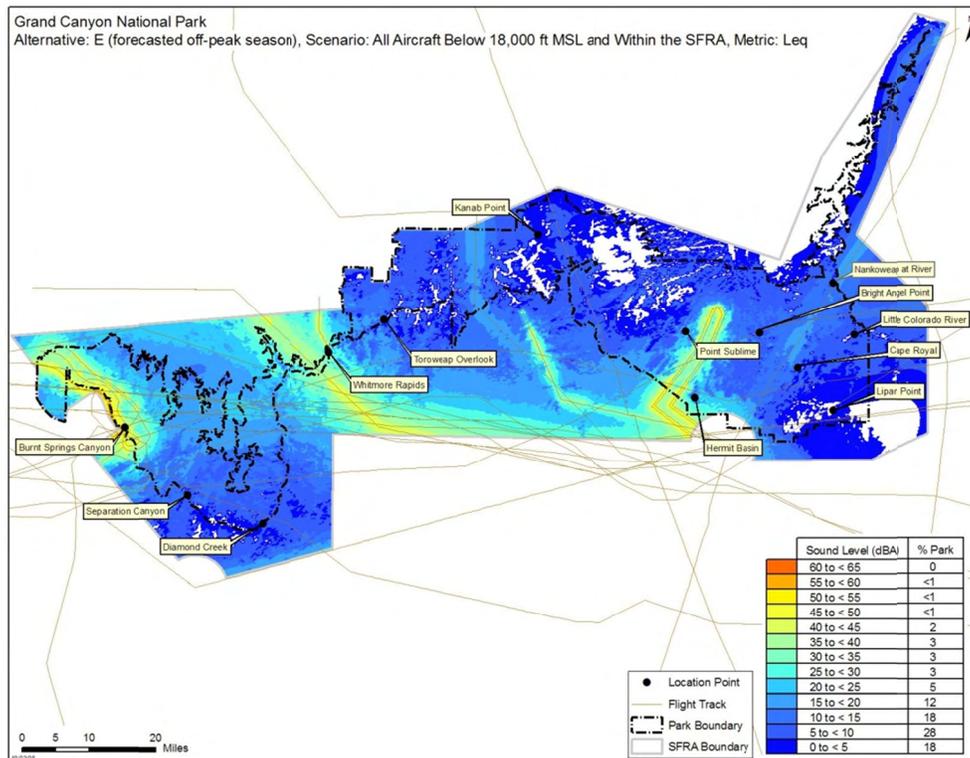


FIGURE 4.17 ALTERNATIVE E AVERAGE SOUND LEVEL TEN-YEAR FORECAST OFF-PEAK SEASON



1

1 **TABLE 4.5 ALTERNATIVE E PERCENT TIME AUDIBLE CONTOUR ANALYSIS RESULTS**
 2 **PEAK SEASON^{a,b,c}**

Percent Time Audible	Base Year (Percent of Zone)				Ten-Year Forecast (Percent of Zone)			
	Developed Zone	Non-Wilderness Zone	Wilderness Zone	In GCNP	Developed Zone	Non-Wilderness Zone	Wilderness Zone	In GCNP
Percent Park Restored				75%				84%
≥ 25	52%	52%	23%	25%	26%	21%	16%	16%
10 to < 25	17%	13%	7%	7%	32%	18%	8%	8%
5 to < 10	15%	5%	6%	6%	16%	15%	6%	6%
> 0 to < 5	16%	31%	63%	61%	25%	44%	69%	68%
Percent of Zone Difference in Percent Time Audible Contour Results with Alternative A								
≥ 25	36%	27%	20%	21%	64%	59%	29%	30%
10 to < 25	-11%	-5%	4%	3%	-27%	-12%	3%	2%
5 to < 10	-14%	-2%	0%	0%	-15%	-13%	0%	-1%
> 0 to < 5	-11%	-20%	-23%	-23%	-20%	-33%	-30%	-30%

^aDue to rounding differences, totals in this table may differ from Appendix D by up to 2%

^bBecause limited ambient data were available outside GCNP, contours for Percent Time Audible were computed only in GCNP boundaries; Average Sound Level contours were computed in the entire SFRA

^cColumns do not always sum to 100% because contours include blank areas to indicate where aircraft noise was not audible or was below 0 dBA

3
 4
 5 **TABLE 4.6 ALTERNATIVE E AVERAGE SOUND LEVEL CONTOUR ANALYSIS RESULTS^{a,b}**

Average Sound Level	Base Year (Percent of Zone)					Ten-Year Forecast (Percent of Zone)				
	Developed Zone	Non-Wilderness Zone	Wilderness Zone	In GCNP	In SFRA	Developed Zone	Non-Wilderness Zone	Wilderness Zone	In GCNP	In SFRA
≥ 35	7%	6%	8%	8%	8%	5%	5%	6%	6%	6%
25 to < 35	12%	13%	5%	6%	9%	7%	10%	5%	5%	9%
15 to < 25	59%	41%	16%	18%	24%	62%	38%	18%	19%	24%
> 0 to < 15	22%	39%	60%	59%	51%	25%	47%	62%	61%	51%
Percent of Zone Difference in Average Sound Level Contour Results with Alternative A										
≥ 35	3%	15%	7%	7%	7%	19%	27%	16%	17%	8%
25 to < 35	43%	24%	7%	8%	7%	67%	47%	21%	23%	11%
15 to < 25	-26%	-13%	5%	4%	3%	-61%	-29%	20%	18%	16%
> 0 to < 15	-20%	-25%	-12%	-13%	-11%	-25%	-46%	-48%	-48%	-27%

^aDue to rounding differences, totals in this table may differ from Appendix D by up to 2%

^bColumns do not always sum to 100% because contours include blank areas to indicate where aircraft noise was not audible or was below 0 dBA

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1 **TABLE 4.7 ALTERNATIVE E LOCATION POINT RESULTS PEAK SEASON ^a**

Location Point Grouping		Base Year					Ten-Year Forecast				
		TAUD ^b	L _{Aeq12} ^c	TALA 35 dBA ^d	TALA 45 dBA ^d	TALA 55 dBA ^d	TAUD	L _{Aeq12}	TALA 35 dBA	TALA 45 dBA	TALA 55 dBA
Marble Canyon	Max	1%	13 dBA	0%	0%	0%	1%	13 dBA	0%	0%	0%
	Median	0%	0 dBA	0%	0%	0%	0%	0 dBA	0%	0%	0%
	Min	0%	0 dBA	0%	0%	0%	0%	0 dBA	0%	0%	0%
East End	Max	88%	53 dBA	54%	15%	5%	66%	51 dBA	46%	12%	4%
	Median	17%	13 dBA	0%	0%	0%	10%	12 dBA	0%	0%	0%
	Min	0%	0 dBA	0%	0%	0%	0%	1 dBA	0%	0%	0%
Central	Max	15%	18 dBA	0%	0%	0%	16%	19 dBA	0%	0%	0%
	Median	1%	7 dBA	0%	0%	0%	1%	8 dBA	0%	0%	0%
	Min	0%	0 dBA	0%	0%	0%	0%	0 dBA	0%	0%	0%
West End	Max	92%	47 dBA	70%	28%	4%	84%	46 dBA	65%	23%	4%
	Median	5%	18 dBA	0%	0%	0%	4%	19 dBA	0%	0%	0%
	Min	0%	0 dBA	0%	0%	0%	0%	0 dBA	0%	0%	0%
All Location Points	Max	92%	53 dBA	70%	28%	5%	84%	51 dBA	65%	23%	4%
	Median	1%	11 dBA	0%	0%	0%	1%	10 dBA	0%	0%	0%
	Min	0%	0 dBA	0%	0%	0%	0%	0 dBA	0%	0%	0%
Difference in Location Points Results with Alternative A											
Marble Canyon	Max	2%	11 dBA	1%	0%	0%	2%	12 dBA	1%	0%	0%
	Median	1%	14 dBA	0%	0%	0%	2%	16 dBA	0%	0%	0%
	Min	0%	0 dBA	0%	0%	0%	0%	2 dBA	0%	0%	0%
East End	Max	12%	-4 dBA	46%	36%	0%	34%	-2 dBA	54%	45%	1%
	Median	47%	15 dBA	5%	0%	0%	58%	17 dBA	6%	0%	0%
	Min	0%	6 dBA	0%	0%	0%	0%	6 dBA	0%	0%	0%
Central	Max	8%	9 dBA	4%	0%	0%	9%	9 dBA	4%	0%	0%
	Median	0%	3 dBA	0%	0%	0%	1%	3 dBA	0%	0%	0%
	Min	0%	0 dBA	0%	0%	0%	0%	0 dBA	0%	0%	0%
West End	Max	1%	0 dBA	1%	0%	0%	12%	2 dBA	17%	10%	1%
	Median	14%	4 dBA	0%	0%	0%	17%	4 dBA	1%	0%	0%
	Min	0%	0 dBA	0%	0%	0%	0%	0 dBA	0%	0%	0%
All Location Points	Max	8%	-4 dBA	30%	23%	0%	16%	-2 dBA	36%	3400%	100%
	Median	7%	5 dBA	0%	0%	0%	9%	8 dBA	0%	0%	0%
	Min	0%	0 dBA	0%	0%	0%	0%	0 dBA	0%	0%	0%

^aMax refers to maximum Location Point value for a Location Point grouping for each respective specific metric; conversely, Min refers to minimum Location Point value. The median characterizes the central tendency of the results. That is, 50% of results are above the median; 50% are below. The median, as opposed to the arithmetic mean, is more appropriate for data not normally distributed

^bTAUD = Percent Time Audible

^cL_{Aeq12} = Average Sound Level

^dTALA35 dBA, TALA45 dBA, and TALA55 dBA = Percent of time during the 12-hour day used in this analysis that aircraft sounds exceed 35, 45, and 55 dBA, respectively

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1 **TABLE 4.8 ALTERNATIVE E PERCENT AUDIBLE CONTOUR ANALYSIS RESULTS**
 2 **OFF-PEAK SEASON^{abc}**

Percent Percent Time Audible	Base Year (Percent of Zone)				Ten-Year Forecast (Percent of Zone)			
	Developed Zone	Non- Wilderness Zone	Wilderness Zone	In GCNP	Developed Zone	Non- Wilderness Zone	Wilderness Zone	In GCNP
% Park Restored				78%				86%
≥ 25	31%	26%	22%	22%	17%	14%	14%	14%
10 to < 25	17%	13%	7%	8%	32%	18%	6%	7%
5 to < 10	14%	10%	6%	6%	13%	11%	5%	6%
> 0 to < 5	36%	49%	64%	63%	35%	53%	72%	71%
% of Zone Difference in TAUD Contour Results with Alternative A								
≥ 25	57%	53%	21%	23%	73%	66%	31%	32%
10 to < 25	-11%	-5%	3%	3%	-27%	-12%	4%	3%
5 to < 10	-13%	-8%	0%	0%	-13%	-9%	0%	0%
> 0 to < 5	-32%	-38%	-24%	-25%	-31%	-42%	-34%	-34%

^aDue to rounding differences, totals in this table may differ from Appendix D by up to 2%

^bBecause limited ambient data were available outside GCNP, contours for Percent Time Audible were computed only in GCNP boundaries; Average Sound Level contours were computed in the entire SFRA

^cColumns do not always sum to 100% because contours include blank areas to indicate where aircraft noise was not audible or was below 0 dBA

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TABLE 4.9 ALTERNATIVE E AVERAGE SOUND LEVEL CONTOUR ANALYSIS RESULT OFF-PEAK SEASON^{ab}

Average Sound Level	Base Year (Percent of Zone)					Ten-Year Forecast (Percent of Zone)				
	Developed Zone	Non- Wilderness Zone	Wilderness Zone	In GCNP	In SFRA	Developed Zone	Non- Wilderness Zone	Wilderness Zone	In GCNP	In SFRA
≥ 35	0%	1%	8%	7%	8%	0%	0%	5%	5%	6%
25 to < 35	6%	11%	5%	5%	9%	5%	11%	5%	5%	10%
15 to < 25	48%	26%	15%	15%	21%	48%	23%	17%	17%	23%
> 0 to < 15	45%	55%	64%	63%	53%	46%	58%	64%	64%	53%
Percent of Zone Difference in Average Sound Level Contour Results with Alternative A										
≥ 35	10%	20%	8%	8%	6%	24%	32%	17%	18%	8%
25 to < 35	49%	26%	7%	8%	6%	70%	46%	21%	23%	11%
15 to < 25	-15%	3%	7%	6%	6%	-47%	-13%	22%	19%	18%
> 0 to < 15	-43%	-41%	-16%	-18%	-12%	-46%	-58%	-51%	-51%	-28%

^aDue to rounding differences, totals in this table may differ from Appendix D by up to 2%

^bColumns do not always sum to 100% because contours include blank areas to indicate where aircraft noise was not audible or was below 0 dBA

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1 **TABLE 4.10 ALTERNATIVE E LOCATION POINT RESULTS OFF-PEAK SEASON^a**

Location Point Grouping		Base Year					Ten-Year Forecast				
		TAUD ^b	L _{Aeq12} ^c	TALA35 dBA ^d	TALA45 dBA ^d	TALA55 dBA ^d	TAUD	L _{Aeq12}	TALA35 dBA	TALA45 dBA	TALA55 dBA
Marble Canyon	Max	1%	13 dBA	0%	0%	0%	1%	13 dBA	0%	0%	0%
	Median	0%	0 dBA	0%	0%	0%	0%	0 dBA	0%	0%	0%
	Min	0%	0 dBA	0%	0%	0%	0%	0 dBA	0%	0%	0%
East End	Max	93%	46 dBA	34%	10%	3%	78%	44 dBA	29%	7%	2%
	Median	1%	8 dBA	0%	0%	0%	1%	9 dBA	0%	0%	0%
	Min	0%	0 dBA	0%	0%	0%	0%	0 dBA	0%	0%	0%
Central	Max	25%	26 dBA	1%	0%	0%	20%	24 dBA	1%	0%	0%
	Median	1%	8 dBA	0%	0%	0%	1%	8 dBA	0%	0%	0%
	Min	0%	0 dBA	0%	0%	0%	0%	0 dBA	0%	0%	0%
West End	Max	96%	48 dBA	82%	32%	5%	88%	46 dBA	74%	24%	4%
	Median	5%	19 dBA	0%	0%	0%	4%	20 dBA	0%	0%	0%
	Min	0%	0 dBA	0%	0%	0%	0%	1 dBA	0%	0%	0%
All Location Points	Max	96%	48 dBA	82%	32%	5%	88%	46 dBA	74%	24%	4%
	Median	2%	9 dBA	0%	0%	0%	1%	10 dBA	0%	0%	0%
	Min	0%	0 dBA	0%	0%	0%	0%	0 dBA	0%	0%	0%
Difference in Location Points Results with Alternative A											
Marble Canyon	Max	2%	11 dBA	1%	0%	0%	2%	12 dBA	1%	0%	0%
	Median	1%	14 dBA	0%	0%	0%	2%	16 dBA	0%	0%	0%
	Min	0%	0 dBA	0%	0%	0%	0%	2 dBA	0%	0%	0%
East End	Max	7%	3 dBA	66%	41%	2%	21%	6 dBA	71%	50%	3%
	Median	63%	20 dBA	5%	0%	0%	66%	19 dBA	6%	0%	0%
	Min	0%	6 dBA	0%	0%	0%	0%	7 dBA	0%	0%	0%
Central	Max	-3%	1 dBA	3%	0%	0%	6%	3 dBA	4%	0%	0%
	Median	0%	2 dBA	0%	0%	0%	1%	2 dBA	0%	0%	0%
	Min	0%	0 dBA	0%	0%	0%	0%	0 dBA	0%	0%	0%
West End	Max	-3%	0 dBA	-11%	-4%	0%	8%	2 dBA	8%	9%	2%
	Median	14%	3 dBA	0%	0%	0%	17%	3 dBA	1%	0%	0%
	Min	0%	-4 dBA	0%	0%	0%	0%	-1 dBA	0%	0%	0%
All Location Points	Max	4%	2 dBA	18%	19%	0%	12%	3 dBA	26%	33%	2%
	Median	7%	7 dBA	0%	0%	0%	9%	8 dBA	0%	0%	0%
	Min	0%	0 dBA	0%	0%	0%	0%	0 dBA	0%	0%	0%

^aMax refers to maximum Location Point value for a Location Point grouping for each respective specific metric; conversely, Min refers to minimum Location Point value. The median characterizes the central tendency of the results. That is, 50% of results are above the median; 50% are below. The median, as opposed to the arithmetic mean, is more appropriate for data not normally distributed

^bTAUD = Percent Time Audible

^cL_{Aeq12} = Average Sound Level

^dTALA35 dBA, TALA45 dBA, and TALA55 dBA = Percent of time during the 12-hour day used in this analysis that aircraft sounds exceed 35, 45, and 55 dBA, respectively

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1 **Developed Zone (about 2% of GCNP) Alternative E Soundscape**
 2

3 With exception of a very small Developed Zone area at Tuweep, all GCNP Developed Zone areas are in East End.
 4 Developed Zone audibility calculations added 10 dBA to natural ambient sound levels due to the Dual-Zone System
 5 acoustic approach explained in Chapter 4, Methodology. As such, analysis considers Developed Zone management
 6 objectives which accept presence of many non-natural sound sources (increased background ambient sound levels)
 7 including most of the park's visitors and their activities, presence of paved roads and motorized transportation, and
 8 developed facilities.
 9

10 *Developed Zone Alternative E Soundscape*
 11 *Base Year Peak Season*

12 Average Sound Level would generally be 25 dBA or more in 19% of the Developed Zone; that is, Average
 13 Sound Level would be 25 to 35 dBA in 12% of the Zone (moderate adverse impact) and greater than 35 dBA in
 14 7% of the Zone (major adverse impact). Percent Time Audible would generally be 10% or more in 69% of the
 15 Zone; that is Percent Time Audible of 10 to 25% in 17% of the Zone (moderate adverse impact) and greater
 16 than 25% in 52% of the Zone (major adverse impact). This would represent a reduction of 46% in area with
 17 Average Sound Level 25 dBA or more, and a reduction of 25% in area of 10% or more Percent Time Audible
 18 compared to Alternative A (a 25 to 46% reduction in areas of moderate to major adverse impact), resulting in a
 19 moderate to major beneficial change in impacts compared to Alternative A.
 20

21 *Developed Zone Alternative E Soundscape*
 22 *Base Year Off-Peak Season*

23 Average Sound Level would generally be greater than 25 dBA in 6% of the Developed Zone; that is, Average
 24 Sound Level would be 25 to 35 dBA in 6% of the Zone (moderate adverse impact) and no areas greater than 35
 25 dBA in the Zone (no areas of major adverse impact in terms of Average Sound Level). Percent Time Audible
 26 would generally be 10% or more of the day in 48% of the Zone; that is 10 to 25% Percent Time Audible in 17%
 27 of the Zone (moderate adverse impact) and Percent Time Audible greater than 25% in 31% of the Zone (major
 28 adverse impact). This would represent a reduction of 59% in area with Average Sound Level of 25 dBA or more,
 29 and a reduction of 46% in area of 10% or more Percent Time Audible compared to Alternative A (a 46 to 59%
 30 reduction in areas of moderate to major adverse impact), resulting in a major beneficial change in impacts
 31 compared to Alternative A.
 32

33 *Developed Zone Alternative E Soundscape*
 34 *Ten-Year Forecast Peak Season*

35 Average Sound Level would generally be greater than 25 dBA in 12% of the Developed Zone; that is, Average
 36 Sound Level would be 25 to 35 dBA in 7% of the Zone (moderate adverse impact), and greater than 35 dBA in
 37 5% of the Zone (major adverse impact). Percent Time Audible would generally be 10% or more in 58% of the
 38 Zone; that is, 10 to 25% Percent Time Audible in 32% of the Zone (moderate adverse impact), and greater than
 39 25% Percent Time Audible in 26% of the Zone (major adverse impact). This would represent a reduction of 86%
 40 in area with Average Sound Level of 25 dBA or more, and a reduction of 37% in area of 10% or more Percent
 41 Time Audible compared to Alternative A (a 37 to 86% reduction in areas of moderate to major adverse impact),
 42 resulting in a major beneficial change in impacts compared to Alternative A.
 43

44 *Developed Zone Alternative E Soundscape*
 45 *Ten-Year Forecast Off-Peak Season*

46 Average Sound Level would generally be greater than 25 dBA in 5% of the Developed Zone; that is, Average
 47 Sound Level would be 25 to 35 dBA in 5% of the Zone (moderate adverse impact), and no areas in the Zone
 48 would be greater than 35 dBA (no areas of major adverse impact). Percent Time Audible would generally be
 49 10% or more in 49% of the Zone; that is, 10 to 25% Percent Time Audible in 32% of the Zone (moderate
 50 adverse impact), and greater than 25% Percent Time Audible in 17% of the Zone (major adverse impact). This
 51 would represent a reduction of 94% in area with Average Sound Level of 25 dBA or more, and a reduction of
 52 46% in area of 10% or more Percent Time Audible compared to Alternative A (a 10 to 94% reduction in areas of
 53 moderate to major adverse impact), resulting in a moderate to major beneficial change in impacts compared to
 54 Alternative A.
 55

1 **Non-Wilderness Zone (6% of GCNP) Alternative E Soundscape**
 2

3 Almost all Non-Wilderness Zone areas are located in East End (exceptions are a few Central area dirt road
 4 corridors). A portion of the Non-Wilderness Zone is in the Dual-Zone System area where 10 dBA is added to natural
 5 ambient sound levels for audibility calculations; this portion is generally close to Developed Zone areas with
 6 motorized noise sources, although there is a strip of Non-Wilderness Zone on Marble Canyon's east side. The
 7 majority of the Non-Wilderness Zone is in the area where natural ambient sound levels are used directly as the basis
 8 for audibility calculations, consistent with Non-Wilderness Zone management objectives that call for mostly natural
 9 conditions to prevail in the Zone.

10
 11 *Non-Wilderness Zone Alternative E Soundscape*
 12 *Base Year Peak Season*

13 Average Sound Level would generally be 25 dBA or more in 19% of the Zone; that is, Average Sound Level
 14 would be 25 to 35 dBA in 13% of the Zone (moderate adverse impact), and greater than 35 dBA in 6% of the
 15 Zone (major adverse impact). Percent Time Audible would generally be 10% or more of the day in 65% of the
 16 Zone; that is, 10 to 25% Percent Time Audible in 13% of the Zone (moderate adverse impact), and greater than
 17 25% Percent Time Audible in 52% of the Zone (major adverse impact). This would represent a reduction of 39%
 18 in area with Average Sound Level of 25 dBA or more, and a reduction of 47% in area of 10% or more Percent
 19 Time Audible compared to Alternative A (a 39 to 47% reduction in areas of moderate to major adverse impact),
 20 resulting in a major beneficial change in impacts compared to Alternative A.

21
 22 *Non-Wilderness Zone Alternative E Soundscape*
 23 *Base Year Off-Peak Season*

24 Average Sound Level would generally be greater than 25 dBA in 12% of the Zone; that is, Average Sound Level
 25 would be 25 to 35 dBA in 11% of the Zone (moderate adverse impact), and greater than 35 dBA in one percent
 26 of the Zone (major adverse impact). Percent Time Audible would generally be 10% or more of the day in 39% of
 27 the Zone; that is, 10 to 25% Percent Time Audible in 13% of the Zone (moderate adverse impact), and greater
 28 than 25% Percent Time Audible in 26% of the Zone (major adverse impact). This would represent a reduction of
 29 46% in area with Average Sound Level of 25 dBA or more, and a reduction of 48% in area of 10% or more
 30 Percent Time Audible compared to Alternative A (a 46 to 48% reduction in areas of moderate to major adverse
 31 impact), resulting in a major beneficial change in impacts compared to Alternative A.

32
 33 *Non-Wilderness Zone Alternative E Soundscape*
 34 *Ten-Year Forecast Peak Season*

35 Average Sound Level would generally be greater than 25 dBA in 15% of the Zone; that is, Average Sound Level
 36 would be 25 to 35 dBA in 10% of the Zone (moderate adverse impact), and greater than 35 dBA in 5% of the
 37 Zone (major adverse impact). Percent Time Audible would generally be 10% or more in 39% of the Zone; that
 38 is, 10 to 25% Percent Time Audible in 18% of the Zone (moderate adverse impact), and greater than 25%
 39 Percent Time Audible in 21% of the Zone (major adverse impact). This would represent a reduction of 74% in
 40 area with Average Sound Level of 25 dBA or more, and a reduction of 47% in area of 10% or more Percent
 41 Time Audible compared to Alternative A (a 47 to 74% reduction in areas of moderate to major adverse impact),
 42 resulting in a major beneficial change in impacts compared to Alternative A.

43
 44 *Non-Wilderness Zone Alternative E Soundscape*
 45 *Ten-Year Forecast Off-Peak Season*

46 Average Sound Level would generally be greater than 25 dBA in 11% of the Zone; that is, Average Sound Level
 47 would be 25 to 35 dBA in 11% of the Zone (moderate adverse impact), and no areas of the Zone would be
 48 greater than 35 dBA (no areas of major adverse impact in the Zone). Percent Time Audible would generally be
 49 10% or more in 32% of the Zone; that is, 10 to 25% Percent Time Audible in 18% of the Zone (moderate
 50 adverse impact), and greater than 25% Percent Time Audible in 14% of the Zone (major adverse impact). This
 51 would represent a reduction of 78% in area with Average Sound Level of 25 dBA or more, and a reduction of
 52 61% in area of 10% or more Percent Time Audible compared to Alternative A (a 61 to 78% reduction in areas of
 53 moderate to major adverse impact), resulting in a major beneficial change in impacts compared to Alternative A.

1 **Wilderness Zone (94% of GCNP) Alternative E Soundscape**
 2

3 In the Wilderness Zone, results vary to a greater degree than in Developed and Non-Wilderness Zones due to the
 4 Wilderness Zone increased size and geographic extent as compared to the others. Most of the Wilderness Zone is in
 5 the area where natural ambient sound levels are used directly in audibility calculations in the Dual-Zone System
 6 acoustic approach to noise modeling. Exceptions are West End and Marble Canyon.
 7

8 *Wilderness Zone Alternative E Soundscape*
 9 *Base Year Peak Season*

10 Average Sound Level would generally be 25 dBA or more in 13% of the Zone; that is, Average Sound Level
 11 would be 25 to 35 dBA in 5% of the Zone (moderate adverse impact), and greater than 35 dBA in 8% of the
 12 Zone (major adverse impact). Percent Time Audible would generally be 10% or more in 30% of the Zone; that
 13 is, one to 25% Percent Time Audible in 7% of the Zone (moderate adverse impact), and greater than 25%
 14 Percent Time Audible in 23% of the Zone (major adverse impact). This would represent a 37% reduction in area
 15 with Average Sound Level of 25 dBA or more and a reduction of 32% in area of 10% or more Percent Time
 16 Audible compared to Alternative A (a 32 to 37% reduction in areas of moderate to major adverse impact),
 17 resulting in a major beneficial change in impacts compared to Alternative A.
 18

19 *Wilderness Zone Alternative E Soundscape*
 20 *Base Year Off-Peak Season*

21 Average Sound Level would generally be greater than 25 dBA in 13% of the Zone; that is, Average Sound Level
 22 would be 25 to 35 dBA in 5% of the Zone (moderate adverse impact) and greater than 35 dBA in 8% of the Zone
 23 (major adverse impact). Percent Time Audible would generally be 10% or more of the day in 29% of the Zone;
 24 that is 10 to 25% Percent Time Audible in 7% of the Zone (moderate adverse impact) and greater than 25%
 25 Percent Time Audible in 22% of the Zone (major adverse impact). This would represent a reduction of 15% in
 26 area with Average Sound Level of 25 dBA or more and a reduction of 24% in area of 10% or more Percent Time
 27 Audible compared to Alternative A (a 15 to 24% reduction in areas of moderate to major adverse impact),
 28 resulting in a moderate beneficial change in impacts compared to Alternative A.
 29

30 *Wilderness Zone Alternative E Soundscape*
 31 *Ten-Year Forecast Peak Season*

32 Average Sound Level would generally be greater than 25 dBA in 11% of the Zone; that is, Average Sound Level
 33 would be 25 to 35 dBA in 5% of the Zone (moderate adverse impact) and greater than 35 dBA in 6% of the Zone
 34 (major adverse impact). Percent Time Audible would generally be 10% or more of the day in 24% of the Zone;
 35 that is, 10 to 25% Percent Time Audible in 8% of the Zone (moderate adverse impact) and greater than 25%
 36 Percent Time Audible in 16% of the Zone (major adverse impact). This would represent a reduction of 37% in
 37 area with Average Sound Level of 25 dBA or more and a reduction of 32% in area of 10% or more Percent Time
 38 Audible compared to Alternative A (a 32 to 37% reduction in areas of moderate to major adverse impact),
 39 resulting in a major beneficial change in impacts compared to Alternative A.
 40

41 *Wilderness Zone Alternative E Soundscape*
 42 *Ten-Year Forecast Off-Peak Season*

43 Average Sound Level would generally be greater than 25 dBA in 10% of the Zone; that is, Average Sound Level
 44 would be 25 to 35 dBA in 5% of the Zone (moderate adverse impact) and greater than 35 dBA in 5% of the Zone
 45 (major adverse impact). Percent Time Audible would generally be 10% or more of the day in 20% of the Zone;
 46 that is, 10 to 25% Percent Time Audible in 6% of the Zone (moderate adverse impact) and greater than 25%
 47 Percent Time Audible in 14% of the Zone (major adverse impact). This would represent a reduction of 38% in
 48 area with Average Sound Level of 25 dBA or more and a reduction of 35% in area of 10% or more Percent Time
 49 Audible compared to Alternative A (a 35 to 38% reduction in areas of moderate to major adverse impact),
 50 resulting in a major beneficial change in impacts compared to Alternative A.
 51

52 **Marble Canyon Alternative E Soundscape**
 53

54 Marble Canyon's west side is in the Wilderness Zone; it's east side in the Non-Wilderness Zone. It is also entirely in
 55 the Dual-Zone System noticeability area in which 10 dBA is added to natural ambient sound levels in calculating
 56 Percent Time Audible (Chapter 4, Methodology). Seasonal use of Dragon and Zuni Point Corridors would not affect

1 this area. In Marble Canyon, based on Figures 4.10 to 4.17, air-tour aircraft Average Sound Level would be barely
 2 audible at less than 15 dBA), due to Bright Angel Flight-free Zone being substantially enlarged by extending its
 3 boundary north to include all of Marble Canyon.

4
 5 *Marble Canyon* *Alternative E* *Soundscape*
 6 *All Scenarios*

7 **Marble Canyon Location Points** Percent Time Audible range zero to one percent, and Average Sound Level
 8 zero to 13 dBA Peak and Off-Peak Seasons. Results would be nearly identical (within Percent Time Audible of
 9 one percent and one dBA Average Sound Level) Base Year to Ten-Year Forecast. These values represent
 10 negligible impacts and negligible to minor beneficial changes in impacts compared to Alternative A.

11
 12 **East End** **Alternative E** **Soundscape**

13
 14 Under Alternative E, as in Alternative A, greatest exposure to noise and visual impacts would continue East End.
 15 However, air-tour sounds would be reduced beneath Dragon Corridor when closed Peak Season and conversely,
 16 beneath Zuni Point Corridor when closed Off-Peak Season. This would result in a major beneficial change in
 17 impacts compared to Alternative A. Alternative E curfews would benefit Soundscape in all East End Management
 18 Zones.

19
 20 *East End* *Alternative E* *Soundscape*
 21 *Base Year Peak Season*

22 **East End Location Points** would range zero to 88% Percent Time Audible (median 17%), and zero to 53 dBA
 23 (median 13 dBA). At some locations, aircraft events would exceed 35 dBA for 54% of the day, 45 dBA for 15%
 24 of the day, and 55 dBA for 5% of the day. Because this represents a 47% reduction in median Percent Time
 25 Audible and a 12% reduction in maximum Percent Time Audible, this would be a moderate to major beneficial
 26 change in East End impacts compared to Alternative A. Localized long- and short-term adverse impacts would
 27 be major in areas near Zuni Point Corridor, and comparable to Alternative A (from Figures 4.10 to 4.17, Average
 28 Sound Level would be 40 to 50 dBA, Percent Time Audible would be greater than 75%). Impacts would be
 29 negligible to minor in areas near Dragon Corridor; a major beneficial change in impacts compared to Alternative
 30 A. Although the majority of Location Points do not experience Average Sound Level greater 35 dBA, two
 31 Location Points (**Grid Location Point 14 and Temple Butte**) show Average Sound Level as high as 45 to 55
 32 dBA with Percent Time Audible 5 to 10%.

33
 34 *East End* *Alternative E* *Soundscape*
 35 *Base Year Off-Peak Season*

36 **East End Location Points** would range zero to 93% Percent Time Audible (median 1%), and zero to 46 dBA
 37 (median 8 dBA). At some locations, aircraft events would exceed 35 dBA for 34% of the day, 45 dBA for 10%
 38 of the day, and 55 dBA for 3% of the day. Because this represents a 63% reduction in median Percent Time
 39 Audible and a 7% reduction in maximum Percent Time Audible, this would be a minor to major beneficial
 40 change in East End impacts compared to Alternative A. Localized long- and short-term adverse impacts would
 41 be major in areas near Dragon Corridor and comparable to Alternative A (from Figures 4.10 to 4.17, Average
 42 Sound Level would be 40 to 50 dBA, Percent Time Audible would be greater than 75%). Impacts would be
 43 negligible to minor adverse in areas near Zuni Point Corridor, a major beneficial change in impacts compared to
 44 Alternative A. Although the majority of Location Points do not experience Average Sound Level greater 35
 45 dBA, three Location Points (**96-mile Camp, Eremita Mesa, and Tower of Ra**) show Average Sound Level as
 46 high as 45 to 55 dBA with Percent Time Audible 5 to 10% of the day.

47
 48 *East End* *Alternative E* *Soundscape*
 49 *Ten-Year Forecast Peak Season*

50 **East End Location Points** would range zero to 66% Percent Time Audible (median 10%); a 20% reduction in
 51 maximum Percent Time Audible Base Year to Ten-Year Forecast, and a 5% reduction in median Percent Time
 52 Audible Base Year to Ten-Year Forecast, because Alternative E includes quiet-technology incentives and
 53 conversion requirements. Average Sound Level would range one to 51 dBA (median 12 dBA), within one dBA
 54 of Average Sound Level Base Year. This represents a 58% reduction in median Percent Time Audible, and a
 55 34% reduction in maximum Percent Time Audible. Impacts would be negligible to minor adverse under and near
 56 Dragon Corridor (a major beneficial change from Alternative A); major adverse under and near Zuni Point

1 Corridor (a negligible change from Alternative A); negligible across North Rim (a moderate to major beneficial
2 change from Alternative A); and negligible to minor adverse away from active routes and amid Bright Angel
3 Flight-free Zone (a negligible change from Alternative A).

4
5 *East End* *Alternative E* *Soundscape*

6 *Ten-Year Forecast Off-Peak Season*

7 **East End Location Points** Percent Time Audible would range zero to 78% (median one percent), and Average
8 Sound Level zero to 44 dBA (median 9 dBA). Compared to Base Year Off-Peak Season, this represents no
9 change in median Percent Time Audible but a 15% reduction in maximum Percent Time Audible; this also
10 represents negligible change in median and Average Sound Level (changes of one and 2 dBA). This represents a
11 66% reduction in median Percent Time Audible, and a 21% reduction in maximum Percent Time Audible, due in
12 large part to Alternative E quiet-technology conversion requirements. Impacts would be major adverse under and
13 near Dragon Corridor (a negligible change from Alternative A); negligible to minor adverse under and near Zuni
14 Point Corridor (a major beneficial change from Alternative A); negligible across North Rim (a moderate to major
15 beneficial change from Alternative A); and negligible to minor adverse away from active routes and amid Bright
16 Angel Flight-free Zone (a negligible change from Alternative A).

17
18 **Central** **Alternative E** **Soundscape**

19
20 The Central area is located in the Wilderness Zone, with exception of a few Non-Wilderness Zone dirt road
21 corridors, and a very small Developed Zone area at Tuweep. The Central area is entirely in the Dual-Zone System
22 audibility area in which natural ambient sound levels are used directly in calculations of Percent Time Audible. This
23 area comprises most of the Toroweap/Shinumo Flight-free Zone, and is transected by two general-aviation corridors.

24
25 *Central* *Alternative E* *Soundscape*

26 *Base and Ten-Year Forecast Peak Season*

27 Base Year **Central area Location Points** range zero to 15% Percent Time Audible (median one percent), and
28 Average Sound Level zero to 18 dBA (median 7 dBA). Impacts would be negligible to minor adverse, a minor
29 beneficial change in impacts compared to Alternative A. Results are nearly identical (one percent and one dBA)
30 Ten-Year Forecast. Modified Blue Direct routes contribute to slightly lower Average Sound Level and Percent
31 Time Audible.

32
33 *Central* *Alternative E* *Soundscape*

34 *Base Year and Ten-Year Forecast Off-Peak Season*

35 **Central area Location Points** Percent Time Audible range zero to 25% (median one percent), and Average
36 Sound Level zero to 26 dBA (median 8 dBA). These increases over Peak Season results are due to increased
37 operations on the modified Blue Direct route Off-Peak Season. There would be negligible changes in impacts
38 Base Year to Ten-Year Forecast. Impacts would range from negligible to moderate adverse with negligible
39 change in impacts compared to Alternative A Base Year Off-Peak Season.

40
41 **West End** **Alternative E** **Soundscape**

42
43 West End is located in the Wilderness Zone and entirely in the Dual-Zone System noticeability area in which 10
44 dBA is added to natural ambient sound levels in Percent Time Audible calculations. Impacts to West End areas tend
45 to be much localized, depending on proximity to Blue Direct and Blue-2/Green-4 routes. Blue-2/Green-4 would be
46 the same as under Alternative A. Blue Direct North would be moved east and shortened over GCNP, and Blue
47 Direct South would be eliminated.

48
49 *West End* *Alternative E* *Soundscape*

50 *Base Year and Ten-Year Forecast Peak Season*

51 **West End Location Points** Percent Time Audible ranges zero to 92% (median 5%), and Average Sound Level
52 zero to 47 dBA (median 18 dBA). At some locations, aircraft events would exceed 35 dBA for 70% of the day,
53 45 dBA for 28% of the day, and 55 dBA for 4% of the day. Peak Season Ten-Year Forecast, Average Sound
54 Level would be essentially unchanged from Base Year, but maximum Percent Time Audible would be reduced
55 8% due to Alternative E quiet-technology conversion requirements. Median Percent Time Audible would be