Sound levels along Hermit Road in Grand Canyon National Park

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Introduction

Hermit Road, stretching between Grand Canyon Village and Hermit's Rest, is to provide a more "rural" experience to Grand Canyon National Park visitors (NPS, 1995). The seven mile road, also called West Rim Drive, incorporates numerous overlooks as it skirts the canyon rim. Since the road is closed to private vehicles for much of the year, Hermit Road provides an opportunity for visitors to escape the crowds often found near Grand Canyon Village and the Canyon View Information Plaza (CVIP).

During a nine month period, visitors can experience the road through walking, biking, taking a tour bus, or shuttle bus. Shuttle buses run from March 1st to November 30th from one hour before sunrise to one hour after sunset. In March, October and November the shuttle bus schedule is as follows: every 30 minutes from sunrise to 9:30 am, every 15 minutes from 9:30 am to sunset, and every 30 minutes from sunset to one hour after sunset. April through September, the shuttle has longer running hours, operating every 30 minutes from sunrise to 7:30 am, every 15 minutes from 7:30 am to sunset, and every 30 minutes from sunset to one hour after sunset. Along Hermit Road, the shuttle buses stop at eight overlooks and points heading west and return to two of those stops (Mohave and Hopi Points) on their way east.

Numerous types of vehicles are allowed on Hermit Road, including shuttle buses, tour buses, delivery and service vehicles, and private vehicles (only those private vehicles that have a hiking permit or an accessibility permit during the nine-month closure).

Shuttle buses do not run along Hermit Road from December 1st to February 28th because of the potential for snow and ice on the road. During this time period, private vehicles (without permits) are allowed to use the road, although it may also be temporarily closed due to ice and snow conditions. Acoustic data collection was not conducted during this period.

Tour aircraft fly nearby the road and are audible at certain times and places. The Grand Canyon National Park airport is located 11.5 km southeast of the road, and the Dragon air tour corridor, with 300-400 flights per day in the summer, is located immediately to the west of Hermit's Rest. In addition, the park helicopter flies over the Abyss to access Phantom Ranch and other inner canyon destinations for maintenance, emergency, and other missions. Depending on need, the park helicopter may fly from zero to four times per day over the Abyss in the summer.

The Grand Canyon railway, bringing passengers from Williams to Grand Canyon Village, operates twice a day. The terminus in the Village is very near the east end of Hermit Road, and the tracks approach within 2 km of the road in other areas. The train whistles several times in the Village to warn motorists at crossings.

Typical sound levels, including human noise as well as natural sounds, at Grand Canyon Village range from 50 to 60 dBA (USFS and USDA, 1993). The rural experience on Hermit Road allows more opportunities for hearing natural sounds such as bird songs and calls, insects, and wind. This report documents the existing sound levels along Hermit Road in support of the Hermit Road Environmental Assessment (NPS, 2006).

Soundscape Definitions (courtesy of the Natural Sounds Program)
Audibility: Audibility is the ability of animals with normal hearing, including humans, to hear a given sound. Audibility is affected by the hearing ability of the animal, other simultaneous interfering sounds or stimuli, and by the frequency content and amplitude of the sound.
Decibel (dB): A logarithmic measure of sound. The decibel provides the possibility of representing a large span of signal levels in a simple manner as opposed to using the basic unit Pascal. The difference between the sound pressure for silence versus a loud sound is a factor of 1,000,000:1 or more, therefore it is less cumbersome to use a small range of equivalent values: 0 to 130 decibels.
A-Weighted decibel (dBA): A-weighting de-emphasizes the high (6.3 kHz and above) and low (below 1 kHz) frequencies, and emphasizes the frequencies between 1 kHz and 6.3 kHz, in an effort to simulate the relative response of human hearing.
Frequency: The number of times per second that the wave of sound repeats itself. It can be expressed in cycles per second, or Hertz (Hz).
L_{max} and L_{min}: The maximum and minimum sound pressure level for a given period.
L_{50}: The sound pressure level, in decibels, exceeded 50 percent of the time (the median).
L_{90}: The sound pressure level, in decibels, exceeded 90 percent of the time. This approximates the decibel level of the natural sounds in a non-natural environment.
Noise Free Interval (NFI): The length of the continuous period of time during which there is silence or only natural sounds are audible.
Octave: The interval between two frequencies having a ratio of 2:1.
One-third octave band: A frequency band whose cutoff frequencies have a ratio of 2 to one-third (approximately 1.26). Humans have the ability to differentiate one-third octaves.

Methods
Site Selection
The same sound system equipment was used for all four sites and was moved to a new site after the system had been at each site for at least six weeks. Actual data collected was due to equipment or environmental issues. Sites were selected to represent a variety of acoustic experiences along the road (Table 1) and over a broad range of geographic area (Figure 1). All sites were located south of Hermit Road, away from the canyon rim. In addition, sites were located along flat sections of the road to avoid recording sounds from vehicles accelerating uphill or braking downhill. GRCA007, the site closest to the airport, was located 10.8 km to the north of Grand Canyon Airport. GRCA014 was located 4 km to the east of the Dragon Air Tour Corridor. Jets, propeller planes and helicopters were audible from all four sites.

The sound system at each of the four sites consisted of a Panasonic CF-18 Toughbook laptop, an ANSI Type 1 Larson-Davis sound level meter (model 824), microphone (GRAS 40AE; protected by a foam windscreen) and preamplifier (Larson-Davis 902). This system is known to be accurate to within 1 dBA. An array of solar panels was used to recharge the 12-volt batteries. The sound level meter, microphone and preamplifier had all been calibrated within the year by a certified calibrator. SoundMonitor software SM030301 and SM050329 (© Far North Aquatics, Fairbanks, AK) were both used.

Table 1. Acoustic sites for the 2005 Hermit Road project.

Site	Location	Acoustic Experience
GRCA007	Near the Abyss, 1.6 km south of Hermit Road, 10.8 km north of Grand Canyon Airport	Fewer vehicles but more aircraft noise audible
GRCA012	50 m south of Hermit Road, Across from Hopi Point	Noise from shuttle bus stop and popular overlook
GRCA013	50 m south of Hermit Road, 2.3 km southeast of Pima Point	Noise from passing vehicles and pedestrians; aircraft noise audible
GRCA014	Just south of Hermit Road near the Abyss	Noise from passing vehicles and pedestrians; aircraft noise audible

Sound Recordings

Digital sound recordings were collected at each of the four sites. Ten second recordings were collected every two minutes (720 recordings/24 hours = 2 hours of recordings) and sounds louder than 55 dBA occurring for at least 10 seconds or 75 dBA occurring for at least one second, termed *events*, were also recorded. In the office, the 720 daily recordings were appended and then listened to and logged for sound sources. One week's worth (14 hours) of sound recordings were logged from each of the four sites. Events from each of the sites were also logged and quantified. Percent time audible of non-natural sources was calculated from the office logging data.

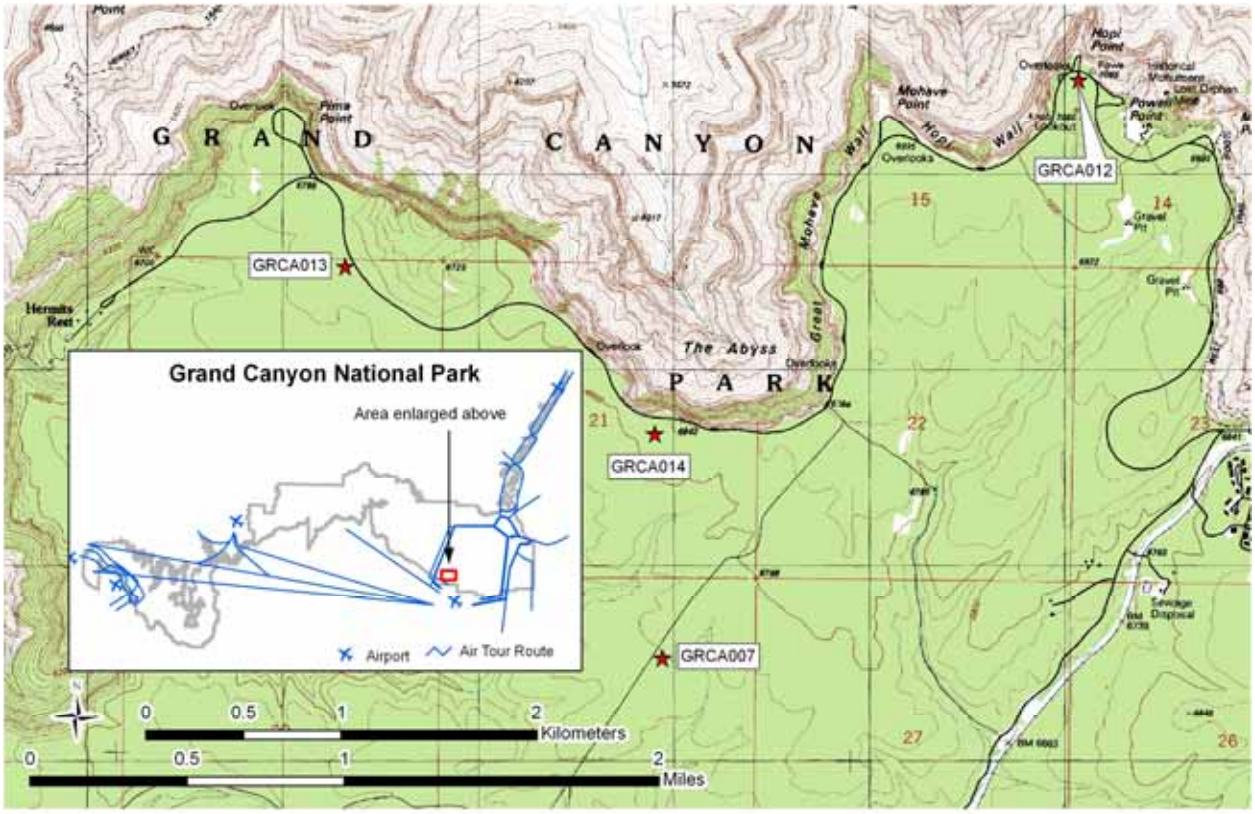

Figure 1. Location of Hermit Road field sites.

Sound Pressure Level Data
Sound pressure level (SPL) data over each of the one-third octave bands between 12.5 and 20,000 Hz was collected every second at each of the sites. Of the four sites, GRCA014 had the shortest run-time of 24 days; therefore, 24 days of data were analyzed for each of the sites (Table 2). These data were used to calculate the L_{min}, L_{max}, L_{50}, and L_{90} from 0700 to 1900 (daytime hours). Although the buses operate on Hermit Road longer than the above hours, daytime hours were analyzed to be consistent with other sound studies. Data were also generated to include the hours when buses were running (0400 to 2100) and for nighttime hours (1900 to 0700; see Appendix).

Table 2. Dates of data collection, office logging and SPL analysis for each of the four sites.

Site	**Dates of field data collection**	**WAV Files Logged**	**SPL Files Analyzed**
GRCA007	3/16/05 to 5/17/05	5/10/05 to 5/16/05	4/23/05 to 5/16/05
GRCA012	6/30/05 to 8/17/05	7/3/05 to 7/9/05	7/1/05 to 7/24/05
GRCA013	8/17/05 to 9/30/05	8/18/05 to 8/23/05, 8/31/05[1]	8/18/05 to 9/10/05
GRCA014	9/30/05 to 11/15/05	10/1/05 to 10/7/05	10/1/05 to 10/16/05, 10/26/05 to 10/28/05 11/3/05 to 11/7/05[2]

Observer Logging
Multiple times at each site, observers listened and logged what they heard for an hour. Sounds were recorded on standardized logging sheets in 10 second intervals (not necessarily in order of loudness). Observers logged more than 25 m from the sound systems to avoid influencing the sound data, but close enough to hear the same sounds that the systems were recording. Among the four sites, 13 hours of observer logging was conducted. The mean and maximum noise free intervals were calculated using observer logging data.

Results
Since only one sound system was available for this project, the four sites were not collecting data concurrently, but rather in sequence (see Table 2). It is therefore difficult to compare the data from one site to another or to definitively say that one site is louder than another, for example. GRCA013 has the lowest sustained sound levels with a median sound level of 29.50 dBA and an L_{90} of 23.30 dBA (Table 3). The consistently loudest site, not surprisingly is GRCA012 which is located south of the Hopi Point bus stop. The L_{90} at the four sites has a range of only 3.0 dBA, indicating that the natural sound level at each of these four sites is of a similar intensity.

Thunder was the loudest sound at 93.1 dBA, and was recorded at GRCA013 during the 1400 hour on 23 August 2005. The quietest sounds of 15.6 dBA were recorded at GRCA007 at 1900 on 11 April 2005. The L_{min} values at the Hermit Road sites ranged from 15.6 to 18.0 dBA. The L_{min} values at all sites are close to the noise floor of the instruments (15 dBA) indicating that

[1] A full day of data was not collected on 8/24/05; therefore 8/31/05 was used instead.
[2] Due to power failures at this site, the system was not running for a continuous 24 days.

actual sound levels may be lower. (In laboratory conditions, lower dBA measurements have been collected, but the L_{min} values measured at the Hermit Road sites are representative of consistently quiet data.)

Table 3. L_{50}, L_{90}, L_{min} and L_{max} for each of the four sites (0700 to 1900) for the 24 days analyzed

Site	L_{50} dBA	L_{90} dBA	L_{min} dBA	L_{max} dBA	Number of hours analyzed
GRCA007	31.9	26.3	15.6	83.2	283
GRCA012	34.7	26.1	18.0	75.9	287
GRCA013	29.5	23.3	17.4	93.1	287
GRCA014	30.8	25.9	17.0	77.1	282

Of the fourteen sounds heard at the Hermit Road sites, nine were heard at all four sites. These include: unknown aircraft, high altitude jets, propeller planes, helicopters, vehicles, train rumble or whistle, wind, birds and insects.

GRCA012 had the highest percent time audible of vehicles and the highest percent time non-natural sounds audible (Table 4). This is not surprising since this site was located south of Hopi Point, a popular overlook where there is also a shuttle bus stop. Hopi Point is also one of two shuttle bus stops along Hermit Road where shuttle buses stop in both directions. The bus noise at GRCA012 may have masked aircraft noise resulting in the shortest percent time audible, 17%, of aircraft. People were also heard the most at this site, 61% of the time, and this was the only site where building sounds (closing of doors on portable toilets) were heard. The high amount of development at this site is most likely the cause of the lowest percent time audible of naturally caused sounds (77%).

Due to the proximity of GRCA012, GRCA013 and GRCA014 to Hermit Road, vehicle sounds may have masked some aircraft noise. Of these three sites, aircraft had a greater percent time audible at GRCA013 (Table 4). Although GRCA014 is closer to the Dragon air tour corridor, GRCA013 had lower L_{50} and L_{90} levels allowing more aircraft to be heard. GRCA014 had the lowest percent time audible of non-natural sounds of 58%.

Vehicles were heard the least at GRCA007 (Table 4). Vehicle noise may have been impeded at GRCA007 by a combination of the distance to Hermit Road (1.6 km) and wind. During the week of 5/10/05 to 5/16/05 the percent time audible of wind during daytime hours (0700 to 1900) was 56%. This high amount of wind could have decreased the audibility of cars on Hermit Road. The longer distance to Hermit Road may have also been the cause for this site to have the highest percent time audible of naturally caused sounds of 99%. Birds were also heard the most at this site (82% time audible).
GRCA007 also had the highest percent time audible of aircraft. This may have been due to the lower vehicle noise caused by distance from Hermit Road and the proximity of the Grand Canyon Airport (10.8 km) allowing more aircraft noise to be heard.

Table 4. Average percent time audible of sound sources at Hermit Road sites, daytime hours (0700 to 1900)

Sound Source	**GRCA007**	**GRCA012**	**GRCA013**	**GRCA014**
Aircraft Unknown	6.7	1.4	2.0	1.2
High Altitude Jet	24.0	11.7	22.4	15.4
Propeller Plane	5.4	1.7	2.0	4.4
Helicopter	38.1	1.7	32.5	16.5
Vehicle	2.3	72.1	33.2	20.6
Train	0.7	0.6	0.3	1.2
People	0.0	61.3	0.7	0.3
Building Sounds	0.0	1.7	0.0	0.0
Non-natural Other/Unknown	1.3	2.0	2.0	2.0
Wind	56.0	16.9	21.3	64.8
Thunder	0.0	0.0	4.2	0.0
Bird	82.4	55.3	49.9	22.9
Insect	24.9	30.0	24.6	19.6
Natural Other/Unknown	1.6	0.6	0.5	1.1
Total Aircraft	70.6	16.4	57.1	37.1
Total Road Vehicles	2.3	72.1	33.2	20.6
Total Non-natural	74.1	94.4	86.8	57.9
Total Natural	99.4	77.0	80.4	86.2

The noise free intervals (NFI's), calculated from the field observer log data indicate that the shortest mean and maximum NFI's occur at GRCA012, where the bus stop is located (Table 5). The longest mean NFI, 0.23 minutes, occurs at GRCA007 and the longest maximum NFI occurs at GRCA013. Due to time constraints in the field, only one hour of observer logging was conducted at GRCA014 which may not represent the true mean and maximum NFI for that site.

Table 5. Mean and Maximum Noise Free Interval (NFI) Data

Site	**Mean NFI (min)**	**Max. NFI (min)**	**Number of hours analyzed**
GRCA007	0.23	0.37	4
GRCA012	0.14	0.14	5
GRCA013	0.20	0.40	3
GRCA014	0.20	0.20	1

Events

GRCA012 had the highest percentage of loud events caused by non-natural sources (62.5%). Vehicles caused 60.5% of the non-natural sounds, due to the proximity of this site to the bus stop at Hopi Point (Table 6). Although GRCA007 was not the quietest site, it did have the most natural-caused events due to wind, thunder and rain (94.5% total). GRCA013 had 90.4% naturally caused events. GRCA014, the site closest to the Dragon air tour corridor (10.8 km), had the highest number of events due to helicopters at 13.9%.

Table 6. Percentage of loud events caused by each sound source at the four sites.

Source	GRCA007	GRCA012	GRCA013	GRCA014
Jet	4.4	1.5	6.1	1.3
Propeller plane	---[3]	---	0.7	---
Helicopter	1.1	---	1.4	13.9
Vehicle	---	60.5	1.4	---
Ambulance/police siren	---	0.5	---	---
Wind	83.5	33.4	54.8	81.0
Rain	3.3	---	2.7	---
Thunder	7.7	1.0	32.9	3.8
Bird	---	0.5	---	---
Insect	---	2.6	---	---
Total	100	100	100	100

Conclusions

Although GRCA007 was located the farthest away from Hermit Road (1.6 km), it was not the quietest site. This is due to wind sounds and its closer proximity to Grand Canyon Airport. It did, however, have the highest percent time audible of natural sounds. The highest percent time audible of aircraft and the lowest percent time audible of vehicles occurred at this site. GRCA007 had the most naturally caused loud events and the highest L_{90}, indicating that the loudest natural sounds took place there.

GRCA012, however, had the highest L_{50}, indicating that the loudest non-natural sounds occurred at this location next to Hopi Point. In addition, this site also had the shortest mean and maximum NFI, the highest percent time audible of vehicles and of non-natural sound sources. The shuttle buses and other vehicles that went past or stopped near this site were responsible for 60% of the loud events.

The most consistently quiet site, GRCA013 which was 2.3 km southeast of Pima Point along a less busy part of the road, had the lowest L_{50} and L_{90} values and the longest maximum NFI.

GRCA014, near the Abyss, had the highest percentage of loud events caused by helicopters, possibly due to the park helicopter flying to Phantom Ranch. This site had the lowest percent time audible of non-natural sounds. It also had the second lowest L_{50}, indicating that it is a quiet site.

In summary, more human oriented sounds are encountered near shuttle bus stops and Canyon overlooks. Away from bus stops and overlooks more aircraft and natural sounds are audible. Average decibel levels encountered along the road ranged from 30 to 35 dBA. This is considerably quieter than at Grand Canyon Village where typical sound levels are 15-30 dBA louder, indicating that Hermit Road has kept its rural character.

[3] Indicates this sound did not cause any loud events at this site.

Literature Cited

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Appendix

GRCA007, 4/23/05 to 5/16/05, 04:00 to 21:00, median hourly dBA and one-third octave band dB (12.5-20,000 Hz; n = 403 hours)

Freq	**L_{min}**	**L_{max}**	**L_{50}**	**L_{90}**
dBA	15.1	83.2	30.1	24.3
12.5	10.8	82.8	38.0	31.3
15.8	11.0	86.0	35.8	30.0
20	8.9	85.4	34.3	29.1
25	8.0	85.0	36.1	30.1
31.5	2.9	83.4	34.6	28.8
40	0.3	84.2	35.3	29.0
50	-3.6	85.1	34.0	27.5
63	-1.2	84.9	32.7	26.1
80	-2.3	85.5	32.5	25.6
100	-4.6	83.8	31.2	24.0
125	-5.1	81.2	28.8	21.5
160	-5.6	78.9	26.5	19.1
200	-5.2	79.3	24.4	17.0
250	-5.1	79.3	23.5	16.7
315	-4.3	80.0	22.8	16.7
400	-3.6	79.3	23.7	17.8
500	-2.9	78.1	24.1	17.8
630	-2.3	76.2	22.6	16.0
800	-1.6	75.4	20.1	13.0
1000	-0.6	71.6	16.7	9.7
1250	0.3	70.2	12.9	6.9
1600	1.2	66.0	9.7	5.2
2000	2.1	61.7	7.4	4.4
2500	2.9	58.0	7.0	4.7
3150	3.6	60.2	6.9	5.1
4000	4.2	58.3	7.1	5.4
5000	4.6	55.7	6.4	5.6
6300	4.9	55.9	6.0	5.6
8000	5.0	58.2	5.9	5.7
10000	5.0	55.2	5.8	5.7
12500	4.4	54.8	5.3	5.1
16000	3.6	52.1	4.6	4.4
20000	2.3	48.4	3.3	3.2

GRCA012, 7/1/05 to 7/24/05, 04:00 to 21:00, median hourly dBA and one-third octave band dB (12.5-20,000 Hz; n = 407 hours)

Freq	**L_{min}**	**L_{max}**	**L_{50}**	**L_{90}**
dBA	17.5	75.9	34.1	25.5
12.5	14.9	83.1	41.0	34.0
15.8	15.4	82.0	38.8	32.6
20	14.7	81.1	40.8	33.4
25	16.0	80.0	41.6	35.3
31.5	14.3	83.9	40.4	34.0
40	9.5	86.8	44.5	36.4
50	9.0	85.3	42.2	34.7
63	8.0	86.8	40.3	33.2
80	10.8	84.6	41.4	32.2
100	7.5	80.2	39.0	30.4
125	9.5	82.0	38.1	27.2
160	1.7	84.6	33.8	23.1
200	-1.3	75.5	28.6	19.5
250	-0.8	73.0	24.8	16.5
315	-0.7	70.7	22.8	15.3
400	0.2	72.4	23.4	15.9
500	0.6	68.0	23.5	15.7
630	1.0	67.1	22.6	14.4
800	1.4	65.7	21.4	12.8
1000	2.1	64.4	19.8	11.0
1250	2.7	65.4	17.8	9.6
1600	3.6	74.6	15.3	8.5
2000	4.3	55.2	12.7	7.5
2500	5.0	54.8	10.1	7.0
3150	5.7	62.1	8.6	7.1
4000	6.2	61.5	8.0	7.3
5000	6.6	57.6	7.8	7.4
6300	6.8	61.8	7.8	7.5
8000	6.9	65.0	7.8	7.6
10000	6.9	67.6	7.6	7.5
12500	6.5	69.6	7.6	7.4
16000	6.2	59.6	7.7	7.6
20000	5.4	55.8	7.2	7.1

GRCA013, 8/18/05 to 9/10/05, 04:00 to 21:00, median hourly dBA and one-third octave band dB (12.5-20,000 Hz; n = 407 hours)

Freq	**L_{min}**	**L_{max}**	**L_{50}**	**L_{90}**
dBA	17.0	93.1	29.3	22.9
12.5	4.6	86.3	39.6	31.2
15.8	7.5	84.7	37.0	30.3
20	6.0	83.9	37.1	30.1
25	6.1	84.2	39.5	32.3
31.5	6.3	84.7	38.0	30.9
40	1.6	85.5	39.2	31.9
50	1.3	85.1	37.2	30.1
63	-0.5	85.3	34.9	27.8
80	-0.8	84.4	33.6	26.4
100	-3.5	84.6	32.5	24.5
125	-3.7	86.1	29.1	21.1
160	-4.2	86.9	26.8	18.4
200	-4.5	86.4	25.0	15.9
250	-3.6	87.4	23.1	14.5
315	-3.9	87.8	21.5	13.3
400	-2.3	86.6	20.7	12.6
500	-1.4	85.2	19.9	11.3
630	-0.7	85.5	18.0	10.0
800	0.4	85.2	15.3	8.6
1000	1.1	83.9	12.3	7.1
1250	2.1	83.2	9.7	6.3
1600	3.1	82.5	7.5	5.7
2000	4.1	81.8	7.1	5.8
2500	4.8	80.0	6.8	6.2
3150	5.5	78.1	7.0	6.6
4000	6.1	75.9	7.2	6.9
5000	6.4	73.6	7.4	7.2
6300	6.3	71.3	7.6	7.3
8000	6.1	68.2	7.7	7.6
10000	5.2	65.5	7.6	7.5
12500	4.9	62.9	7.5	7.3
16000	3.8	60.0	7.5	7.4
20000	1.5	57.3	6.9	6.8

GRCA014, 10/1/05 to 11/7/05[4], 04:00 to 21:00, median hourly dBA and one-third octave band dB (12.5-20,000 Hz; n = 402 hours)

Freq	L_{min}	L_{max}	L_{50}	L_{90}
dBA	16.8	77.1	30.0	25.0
12.5	12.3	87.1	38.9	32.5
15.8	11.6	84.2	37.1	31.7
20	7.8	82.9	36.8	31.4
25	4.3	81.2	37.1	31.4
31.5	8.7	81.3	36.1	30.2
40	3.8	83.9	36.5	30.3
50	2.1	83.6	35.3	29.1
63	3.1	81.5	33.9	27.8
80	-1.9	83.2	32.3	26.6
100	-2.9	79.2	30.9	24.5
125	-3.5	77.4	28.1	21.4
160	-4.5	78.7	25.8	19.2
200	-4.4	78.1	24.2	17.5
250	-3.8	76.1	22.8	17.1
315	-3.3	75.0	22.3	17.0
400	-2.8	72.6	23.1	17.6
500	-1.6	71.8	23.2	17.8
630	-1.0	74.0	21.8	16.5
800	0.2	69.4	19.4	14.0
1000	1.0	67.4	16.2	11.0
1250	2.0	61.9	13.2	7.9
1600	3.0	59.9	11.3	6.7
2000	3.7	59.7	10.1	6.3
2500	4.5	57.9	7.0	6.0
3150	5.2	55.9	6.8	6.4
4000	5.8	53.5	7.1	6.8
5000	6.3	51.4	7.3	7.1
6300	6.7	49.4	7.5	7.3
8000	5.8	55.7	7.6	7.4
10000	5.6	59.2	7.6	7.5
12500	4.0	61.4	7.5	7.4
16000	3.6	66.5	7.4	7.3
20000	2.8	54.2	6.8	6.6

[4] Actual dates analyzed 10/1/05 to 10/16/05, 1026/05 to 10/28/05, 11/3/05 to 11/7/05.

GRCA007, 4/23/05 to 5/16/05, 19:00 to 07:00, median hourly dBA and one-third octave band dB (12.5-20,000 Hz; n = 255 hours)

Freq	**L_{min}**	**L_{max}**	**L_{50}**	**L_{90}**
dBA	15.1	76.8	20.4	16.9
12.5	8.8	82.2	28.9	24.9
15.8	9.7	86.0	27.2	23.1
20	8.3	85.4	26.3	22.4
25	5.7	84.2	25.1	20.6
31.5	2.9	83.4	24.2	18.6
40	-0.5	84.2	23.5	17.1
50	-3.6	84.2	21.1	14.5
63	-2.6	84.6	18.6	12.6
80	-3.2	85.5	20.7	13.3
100	-5.6	83.3	15.0	9.0
125	-5.3	80.1	14.1	8.0
160	-5.6	77.8	12.1	5.8
200	-5.4	74.6	9.1	2.6
250	-5.2	77.1	8.6	2.8
315	-4.4	74.3	8.9	3.5
400	-3.6	72.4	9.4	4.1
500	-3.0	72.0	8.8	3.5
630	-2.5	70.1	5.6	1.9
800	-1.6	68.4	3.8	1.3
1000	-0.6	65.5	2.9	1.3
1250	0.3	66.7	2.9	1.7
1600	1.2	66.0	3.0	2.4
2000	2.0	56.7	3.6	3.1
2500	2.9	55.5	4.2	3.8
3150	3.6	60.2	4.7	4.4
4000	4.1	56.1	5.2	4.9
5000	4.6	54.5	5.5	5.3
6300	4.9	53.7	5.7	5.5
8000	5.1	50.0	5.7	5.6
10000	5.0	50.4	5.7	5.6
12500	4.4	50.4	5.1	5.0
16000	3.6	49.8	4.3	4.2
20000	2.3	48.7	3.1	3.0

GRCA012, 7/1/05 to 7/24/05, 19:00 to 07:00, median hourly dBA and one-third octave band dB (12.5-20,000 Hz; n = 288 hours)

Freq	**L_{min}**	**L_{max}**	**L_{50}**	**L_{90}**
dBA	17.3	70.5	28.9	22.1
12.5	10.6	84.1	34.5	29.3
15.8	13.3	83.9	32.8	27.9
20	13.0	86.0	32.3	27.0
25	14.6	84.1	32.1	26.7
31.5	12.8	81.3	31.6	26.0
40	7.3	82.3	31.0	24.1
50	7.0	83.1	29.5	22.7
63	7.1	82.7	28.3	22.1
80	9.5	77.9	26.6	21.0
100	6.8	78.3	24.9	18.5
125	7.1	82.0	24.1	19.3
160	0.4	84.6	21.1	14.8
200	-2.6	71.2	19.6	12.6
250	-2.8	69.7	19.9	12.1
315	-1.9	67.1	20.7	12.6
400	-1.2	65.1	21.7	13.4
500	-0.3	61.1	22.4	13.7
630	0.4	59.2	22.0	13.2
800	1.0	64.8	20.7	11.2
1000	1.9	58.4	18.2	9.1
1250	2.5	59.8	15.3	7.2
1600	3.5	56.1	12.4	6.0
2000	4.3	55.1	9.5	5.7
2500	5.0	54.8	7.6	6.0
3150	5.6	59.1	7.0	6.4
4000	6.2	61.5	7.1	6.8
5000	6.5	57.6	7.3	7.1
6300	6.8	59.3	7.4	7.2
8000	6.9	59.0	7.5	7.4
10000	6.9	54.1	7.5	7.3
12500	6.5	52.0	7.4	7.3
16000	6.2	52.2	7.5	7.4
20000	5.4	55.8	7.0	6.9

GRCA013, 8/18/05 to 9/10/05, 19:00 to 07:00, median hourly dBA and one-third octave band dB (12.5-20,000 Hz; n = 288 hours)

Freq	**L_{min}**	**L_{max}**	**L_{50}**	**L_{90}**
dBA	17.0	75.3	30.5	26.3
12.5	4.6	82.2	28.7	24.3
15.8	1.6	82.9	27.0	21.9
20	4.6	81.3	25.9	20.4
25	5.4	82.9	24.8	18.5
31.5	4.1	78.7	23.6	16.6
40	0.0	76.6	23.0	13.6
50	0.1	77.7	21.3	11.6
63	-1.2	71.4	19.1	9.8
80	-2.1	70.0	17.3	8.1
100	-4.0	79.3	14.5	5.6
125	-4.6	78.9	12.2	5.0
160	-4.3	78.5	9.7	3.3
200	-4.5	73.4	7.8	2.0
250	-3.7	75.5	6.6	0.5
315	-3.9	73.3	6.5	0.8
400	-2.6	73.7	6.8	1.9
500	-2.0	70.0	5.6	1.7
630	-0.7	68.5	4.7	2.1
800	0.4	67.7	3.9	2.2
1000	1.1	63.2	3.5	2.6
1250	2.0	58.6	3.8	3.3
1600	3.1	56.1	4.6	4.2
2000	4.1	55.4	14.5	10.5
2500	4.8	53.6	23.5	18.2
3150	5.5	51.4	7.0	6.4
4000	6.1	48.7	7.0	6.7
5000	6.4	46.5	7.6	7.2
6300	6.4	51.1	7.4	7.2
8000	6.3	54.5	7.6	7.4
10000	6.6	56.2	7.5	7.4
12500	5.9	59.7	7.4	7.3
16000	5.7	58.2	7.3	7.2
20000	4.7	54.9	6.7	6.6

GRCA014, 10/1/05 to 11/7/05[5], 19:00 to 07:00, median hourly dBA and one-third octave band dB (12.5-20,000 Hz; n = 287 hours)

Freq	L_{min}	L_{max}	L_{50}	L_{90}
dBA	16.8	62.6	25.8	21.9
12.5	9.6	83.0	31.7	27.3
15.8	10.2	79.8	30.9	26.4
20	6.6	79.3	30.0	25.5
25	4.3	77.3	28.9	24.1
31.5	7.3	74.6	27.8	22.9
40	2.7	81.2	26.3	21.0
50	1.5	83.6	25.1	19.9
63	1.5	72.8	24.4	20.3
80	-2.2	73.8	23.9	18.9
100	-3.4	69.4	19.8	15.2
125	-4.2	69.8	18.6	14.5
160	-4.5	65.5	17.7	11.9
200	-4.6	66.4	15.4	9.8
250	-3.8	68.0	16.2	10.0
315	-3.4	64.0	16.6	10.8
400	-2.8	63.6	17.6	12.5
500	-1.8	60.6	17.5	13.1
630	-1.0	51.6	16.6	12.0
800	0.1	49.3	14.0	9.6
1000	1.0	50.8	11.3	6.7
1250	2.0	50.8	8.6	5.1
1600	2.9	49.9	11.1	6.7
2000	3.7	48.0	10.5	6.7
2500	4.5	49.9	6.0	5.5
3150	5.2	42.3	6.3	6.0
4000	5.8	41.2	6.8	6.5
5000	6.3	42.7	7.1	6.9
6300	6.6	42.1	7.3	7.2
8000	6.9	46.5	7.5	7.3
10000	7.0	46.8	7.5	7.4
12500	6.8	51.0	7.4	7.3
16000	6.4	53.0	7.3	7.2
20000	5.2	53.2	6.6	6.5

[5] Actual dates analyzed 10/1/05 to 10/16/05, 1026/05 to 10/28/05, 11/3/05 to 11/7/05.