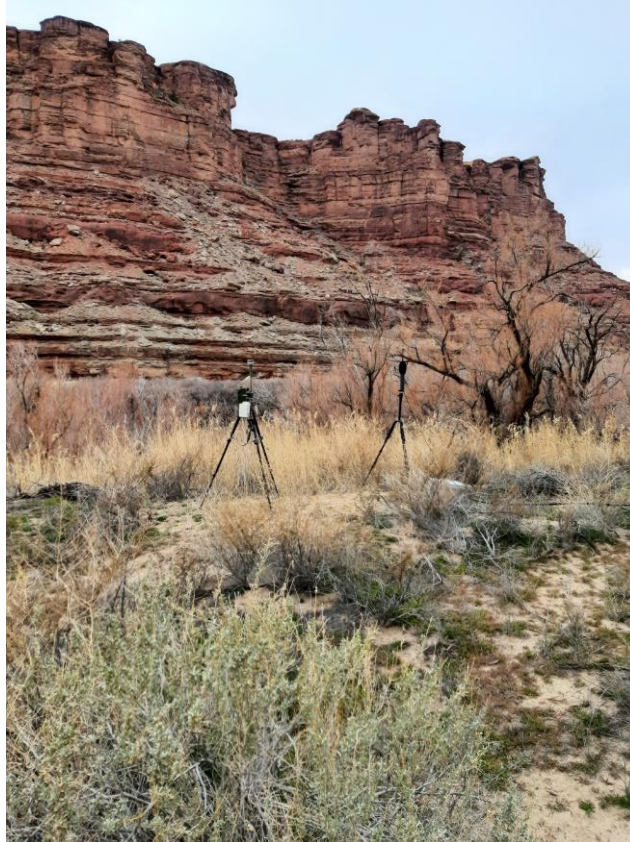

Canyonlands National Park

Snapshot Acoustic Monitoring Report, River Management Plan Study, 2024 – 2026



Acoustic monitoring in Canyonlands National Park

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Introduction

This snapshot report presents acoustical data gathered by the National Park Service Southeast Utah Group at Canyonlands National Park (CANY) across four seasons from 2024 - 2026. Data were analyzed by Natural Sounds and Night Skies Division (NSNSD).

This study arose from the (CANY) river management planning efforts. CANY established sound monitoring stations along the Colorado River and Green River corridor to sample the river soundscape before and through the busy river season. Therefore, across four seasons from 2024 - 2026, data were collected at four sites to provide park managers with information about the acoustical environment, sources of noise, and the existing ambient sound levels within the park. In these deployments, sound pressure level (SPL) was measured continuously every second by a calibrated sound level meter. Other equipment included an anemometer to collect wind speed and a digital audio recorder collecting continuous recordings to document sound sources. Because off-site listening analyses require considerable time to complete, their results have only been partially returned and will be included only in an appendix of report. Once fully completed, the findings will be presented in the final comprehensive report.

Study Area

This report covers results from an acoustic inventory conducted at four sites over four seasons from 2024 - 2026 (Table 1, Figure 1). Site CANY015 and CANY016 were visited three times across summer, fall, and spring in 2024 and 2025. Sites CANY019 and CANY020 were visited once in the winter of 2026.

Table 1. Metadata for acoustical monitoring sites at Canyonlands National Park from 2024 - 2026. River Management Zones are defined as: **Primitive**: The park's most wild and undeveloped qualities are preserved with lowest visitor encounters among the zones. **Semi-Primitive**: The park's natural setting may have subtle modification to enhance safety or provide modest visitor services and visitor encounters moderate to high.

Site	Site Name	Dates	River Management Zone Type	Potential Watercraft	Elevation (m)	Latitude	Longitude
CANY015	Green River across from Taylor Canyon	7/1/2024 - 10/31/2024; 5/23/2025 - 6/30/2025	Primitive	Nonmotorized, outboard motors, no commercial jetboats	3950	38.47544	-110.0030
CANY016	Colorado River at Lathrop Day Use	7/1/2024 - 10/31/2024; 5/20/2025 - 6/30/2025	Semi-Primitive	Nonmotorized, outboard motors, commercial jetboats allowed	3920	38.36988	-109.7737
CANY019	Green River upstream Stove Camp	2/12/2026 - 3/18/2026	Primitive	Nonmotorized, outboard motors, no commercial jetboats	3920	38.23898	-109.8943
CANY020	Colorado River west side of The Loop	2/12/2026 - 3/18/2026	Semi-Primitive	Nonmotorized, outboard motors, commercial jetboats allowed	3950	38.24355	-109.8418

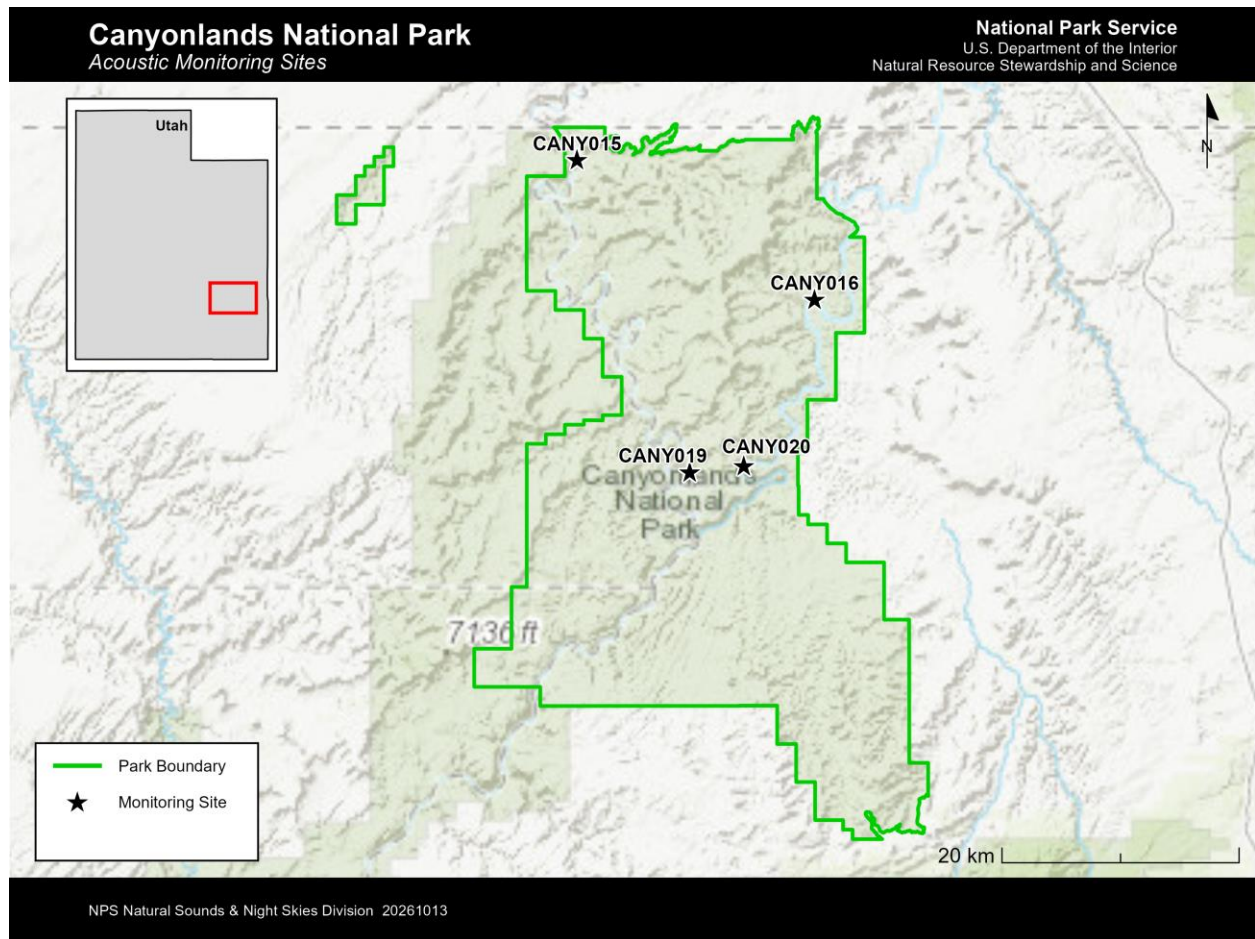


Figure 1. Study sites in Canyonlands National Park, UT, USA.

Methods

Automatic Monitoring

A Larson Davis sound level meter (SLM) type 831 was deployed at four monitoring sites. The SLM continuously recorded one-third-octave band sound pressure levels (SPL) and met ANSI Type 1 standards (ANSI 1968 [R2020], 1983 [R2006], 1992 [2018]). These data were used to compute the metrics described in Calculation of Metrics.

Acoustic monitoring equipment is commonly used to assess environmental noise. The NPS employs similar instrumentation but configures it to withstand the harsh conditions of national parks (National Park Service 2013). The microphone, with environmental shroud, was mounted 1.5 m above ground to approximate human ear height. A digital audio recorder captured continuous audio throughout the deployment, and an anemometer placed 2–3 m from the microphone recorded local wind conditions.

Each sampling station consisted of:

- Type 1 sound level meter
- Microphone with environmental shroud
- Preamplifier
- 12 V battery pack
- Ultrasonic anemometer (wind speed)
- Digital audio recorder

Each sampling station was designed to collect:

- Flat-weighted, time-average sound level ($L_{Zeq,1s}$) for each one-third octave frequency band, 12.5 – 20,000 Hz in dB re 20 μ Pa [collected by Type 1 sound level meter].
- A-weighted, time-average sound level ($L_{Aeq,1s[12.5-20000Hz]}$) in dB re 20 μ Pa [collected by Type 1 sound level meter].
- Continuous wind speed at 30-second timesteps [collected by anemometer].
- Continuous digital audio recordings [.mp3 format].

Monitoring Period

It is typical to monitor a minimum of 25 days to capture daily differences within a sampling period that occur at each site within a reasonable margin of error (Betchkal 2017). For this study, the monitoring period averaged 65 days (37 – 122 days) across 4 sites.

Calculation of Metrics

The status of the acoustical environment can be characterized by sound level (L_{A50} , L_{A90} , L_{A10} , L_{Aeq}) and frequency content, and event durations (through off-site listening). NPS uses descriptive figures and metrics to interpret these characteristics.

Two fundamental descriptors are existing ambient (L_{A50}) and natural ambient (L_{Anat}) sound levels. These are both examples of percentile levels, where each L_x value refers to the sound level that is exceeded x % of the time. The L_{A50} represents the median sound level and is drawn from a full dataset (removing data with wind speed > 5 m/s to eliminate error from microphone distortion (Lyons et al. 2021)).

Trained technicians will be analyzing the audio data to measure how often noise sources were audible, but this analysis is not fully available for snapshot reporting. Instead, CANY015 has been partially analyzed for audibility, and we will present these results in Appendix A. Without sound source identification, natural ambient sound levels (L_{Anat}) and percent audibility cannot be calculated. However, the L_{A90} measurement can be utilized as a proxy to L_{Anat} since it quantifies quiet or residual ambient conditions (ASA/ANSI S12.18 1994 [R2009]). The L_{A90} is the sound level exceeded 90% of the time (10th percentile) for a specified time period (e.g. hourly, day, night).

In this document, “sound pressure level” refers to broadband (12.5 Hz – 20,000 Hz), A-weighted, 1-second time averaged sound level ($L_{Aeq,1s[12.5-20000Hz]}$). Sound levels are measured on a logarithmic scale relative to the reference sound pressure for atmospheric sources, 20 μ Pa. The logarithmic scale is a useful way to express the wide range of sound pressures perceived by the human ear. Sound levels are reported in decibels (dB). A-weighting is applied to sound levels to account for the response of the human ear (Harris, 1998). To approximate human hearing sensitivity, A-weighting discounts sounds below 1 kHz and above 6 kHz. For reference, Table 2 provides examples of sound levels measured in parks compared to sound levels of common sources.

Table 2. Sound level examples.

Park Sound Sources	Common Sound Sources	Sound Level dB*
Volcano crater (HALE)	Human breathing at 3m	10
Leaves rustling (CANY)	Whispering	20
Crickets at 5m (ZION)	Residential area at night	40
Conversation at 5m (WHMI)	Car at 15 m, 30 mph	60
Cruiser motorcycle at 15m (BLRI)	Curbside of busy street	80
Thunder (ARCH)	Jackhammer at 2 m	100
Military jet at 100m AGL (YUCH)	Train horn at 1 m	120

*dB re 20 μ Pa A-weighted broadband (12.5 Hz – 20 kHz), sound level measured over varied measurement durations and at the distances indicated.

Preliminary Results

Overall, existing ambient sound levels (L_{A50}) at sites within CANY ranged from 17.9 – 33.9 dB during the day and 16.3 – 48 dB at night during the sampling period. The L_{A90} (10th percentile, used as a proxy for background sound level per ANSI/ASA S3/SC1.100-2014) ranged from 16.5 – 29.2 dB during the day and 15.8 – 45 dB at night.

Table 3. Summary of sound levels at Canyonlands National Park (CANY) in summer, 2024. Included for each site, 90th percentile (L_{A10}), existing (L_{A50}), natural (L_{Anat}) and 10th percentile (L_{A90}) ambient sound levels (dB re 20 μ Pa, A-weighted broadband, 12.5 Hz—20 kHz) during the day (0700-1900) and night (1900-0700).

Site Name	Time	L_{A10}	L_{A50}	L_{Anat}	L_{A90}
CANY015	Day	32.5	24.5		20.4
CANY015	Night	40.1	35.9		32.3
CANY016	Day	34.1	25.1		22.3
CANY016	Night	50.5	48.0		45.0

Table 4. Summary of sound levels at Canyonlands National Park (CANY) in fall, 2024. Included for each site, 90th percentile (L_{A10}), existing (L_{A50}), natural (L_{Anat}) and 10th percentile (L_{A90}) ambient sound levels (dB re 20 μ Pa, A-weighted broadband, 12.5 Hz—20 kHz) during the day (0700-1900) and night (1900-0700).

Site Name	Time	L_{A10}	L_{A50}	L_{Anat}	L_{A90}
CANY015	Day	32.2	24.0	21.2	20.9
CANY015	Night	41.1	36.0	33.3	30.5
CANY016	Day	34.0	25.7		22.0
CANY016	Night	40.5	37.1		33.7

Table 5. Summary of sound levels at Canyonlands National Park (CANY) in spring, 2025. Included for each site, 90th percentile (L_{A10}), existing (L_{A50}), natural (L_{Anat}) and 10th percentile (L_{A90}) ambient sound levels (dB re 20 μ Pa, A-weighted broadband, 12.5 Hz—20 kHz) during the day (0700-1900) and night (1900-0700).

Site Name	Time	L_{A10}	L_{A50}	L_{Anat}	L_{A90}
CANY015	Day	39.4	33.9	30.9	29.2
CANY015	Night	39.2	34.8	33.2	30.7
CANY016	Day	43.0	32.3		28.2
CANY016	Night	38.6	33.8		31.2

Table 6. Summary of sound levels at Canyonlands National Park (CANY) in winter, 2026. Included for each site, 90th percentile (L_{A10}), existing (L_{A50}), natural (L_{Anat}) and 10th percentile (L_{A90}) ambient sound levels (dB re 20 μ Pa, A-weighted broadband, 12.5 Hz—20 kHz) during the day (0700-1900) and night (1900-0700).

Site Name	Time	L_{A10}	L_{A50}	L_{Anat}	L_{A90}
CANY019	Day	29.5	20.4		18.6
CANY019	Night	22.1	18.3		17.8
CANY020	Day	26.2	17.9		16.5
CANY020	Night	18.4	16.3		15.8

Table(s) 7 - 10 report the percent of time that measured levels at the monitoring locations exceeded four key sound level values. The first value, 35 dB ($L_{Aeq,1s}$), is used by the NPS as an indicator of overall quality of the acoustic environment. Beyond this level, noise begins to negatively affect the visitor experience in an otherwise natural acoustic environment (Betchkal et al. 2023; Pilcher et al. 2009; Watts et al. 2020). Moreover, sound events as low as 35 dB can adversely affect sleeping humans (Haralabidis et al. 2008). The second value addresses the World Health Organization's recommendations that noise levels inside bedrooms remain below 45 dB ($L_{Aeq,1s}$) (Berglund et al. 1999). As wildlife begin to exhibit signs of disturbance at noise levels as low as 40 dB (Shannon et al. 2016), 45 dB also represents a conservative estimate of negative effects on wildlife. The third value, 52 dB ($L_{Aeq,1s}$), is based on the EPA's analysis of speech interference for an individual speaking in a raised voice to an audience at 10 meters (EPA 1974)—an acoustic level that would affect interpretive presentations in parks. The final value, 60 dB ($L_{Aeq,1s}$), marks the point at which normal voice communications at 1 meter begin to be interrupted (EPA 1974); sounds at or exceeding this level would affect conversation between visitors and/or staff.

Table 7. Percent time above metrics for acoustic records collected in Canyonlands National Park (CANY) in summer, 2024. Sound level functional values (in decibels, dB LAeq, 1s re 20 µPa) are shown as the percent of time ANS-weighted sound levels (20–1,250 Hz) and the full measured frequency range (12.5–20,000 Hz) are above those functional values.

Site Name	Frequency Range	Time above sound level (% of daytime hours, 07:00–19:00)				Time above sound level (% of nighttime hours, 19:00–07:00)			
		35 dB	45 dB	52 dB	60 dB	35 dB	45 dB	52 dB	60 dB
CANY015	Full (12.5-20,000)	8.22	0.67	0.09	0	66.59	3.88	0.29	0
CANY015	ANS (20-1,250)	5.08	0.3	0.03	0	1.53	0.08	0	0
CANY016	Full (12.5-20,000)	12.26	1.75	0.27	0.02	83.82	73.84	19.48	0
CANY016	ANS (20-1,250)	3.27	0.62	0.12	0.00	0.55	0.01	0.00	0

Table 8. Percent time above metrics for acoustic records collected in Canyonlands National Park (CANY) in fall, 2024. Sound level functional values (in decibels, dB LAeq, 1s re 20 µPa) are shown as the percent of time ANS-weighted sound levels (20–1,250 Hz) and the full measured frequency range (12.5–20,000 Hz) are above those functional values.

Site Name	Frequency Range	Time above sound level (% of daytime hours, 07:00–19:00)				Time above sound level (% of nighttime hours, 19:00–07:00)			
		35 dB	45 dB	52 dB	60 dB	35 dB	45 dB	52 dB	60 dB
CANY015	Full (12.5-20,000)	6.94	0.81	0.11	0.00	56.98	26.97	0.49	0
CANY015	ANS (20-1,250)	5.58	0.58	0.06	0.00	1.10	0.05	0.00	0
CANY016	Full (12.5-20,000)	11.57	1.53	0.39	0.03	65.99	14.81	0.07	0
CANY016	ANS (20-1,250)	5.21	1.00	0.23	0.02	0.50	0.01	0.00	0

Table 9. Percent time above metrics for acoustic records collected in Canyonlands National Park (CANY) in spring, 2025. Sound level functional values (in decibels, dB LAeq, 1s re 20 µPa) are shown as the

percent of time ANS-weighted sound levels (20–1,250 Hz) and the full measured frequency range (12.5–20,000 Hz) are above those functional values.

		Time above sound level (% of daytime hours, 07:00–19:00)				Time above sound level (% of nighttime hours, 19:00–07:00)			
Site Name	Frequency Range	35 dB	45 dB	52 dB	60 dB	35 dB	45 dB	52 dB	60 dB
CANY015	Full (12.5-20,000)	45.44	2.30	0.22	0.01	48.03	2.72	0.31	0.03
CANY015	ANS (20-1,250)	4.55	0.37	0.03	0.00	1.13	0.03	0.00	0.00
CANY016	Full (12.5-20,000)	33.69	7.76	1.91	0.21	44.82	6.36	1.98	0.16
CANY016	ANS (20-1,250)	8.09	1.29	0.37	0.06	1.55	0.03	0.00	0.00

Table 10. Percent time above metrics for acoustic records collected in Canyonlands National Park (CANY) in winter, 2026. Sound level functional values (in decibels, dB LAeq, 1s re 20 µPa) are shown as the percent of time ANS-weighted sound levels (20–1,250 Hz) and the full measured frequency range (12.5–20,000 Hz) are above those functional values.

		Time above sound level (% of daytime hours, 07:00–19:00)				Time above sound level (% of nighttime hours, 19:00–07:00)			
Site Name	Frequency Range	35 dB	45 dB	52 dB	60 dB	35 dB	45 dB	52 dB	60 dB
CANY019	Full (12.5-20,000)	3.49	0.34	0.06	0	1.02	0.07	0	0
CANY019	ANS (20-1,250)	2.05	0.24	0.04	0	0.70	0.04	0	0
CANY020	Full (12.5-20,000)	1.93	0.24	0.04	0	0.53	0.01	0	0
CANY020	ANS (20-1,250)	1.35	0.12	0.01	0	0.40	0.00	0	0

Sound levels are often measured over narrow frequency bands (typically in one-third octave bands between 12.5 Hz – 20 kHz) because these smaller bands closely represent how humans distinguish between frequencies of sound. In this study, we examine how often sound levels exceeded key values in two frequency ranges. The top value in each split-cell of Table(s) 7 - 10 uses the full frequency range (12.5 Hz – 20 kHz) collected, whereas the bottom value focuses on a more limited range of frequencies where many motorized noise sources produce sound energy (20 – 1,250 Hz). This Natural Sounds modification to A-weighting (referred to as A-weighted Natural Sounds (ANS) weighting, ASA/ANSI S3/SC1.100-2014 [2020]) eliminates high-frequency sound (leaf rustle, equipment noise, and biologic sounds) allowing for more accurate comparisons of low-frequency ambient sound levels across different land use types (e.g., urban, protected areas; ASA/ANSI S3/SC1.100-2014 [2020]). This frequency weighting scheme improves ambient sound level measurements in quiet environments. At CANY015, the 35 dB (LAeq,1s) threshold was exceeded during spring 2025 for 45.4% of the daytime and 48% of the nighttime. Between 20 and 1,250 Hz, sound levels exceeded the 35 dB functional threshold for less than 5% of daytime and nighttime measurements, indicating that higher-frequency natural sounds contributed most to these exceedances. Using the ANS frequency range, the 45 and 52 dB functional effect levels were rarely exceeded at any site in any season, including summer 2024 at CANY016. At this site, elevated full-frequency exceedances at these thresholds (73.84% and 19.48% of nighttime hours, respectively) were not reflected in the ANS-weighted values (0.01% and 0.00%), indicating these exceedances were driven by high-frequency sound rather than low-frequency noise sources. Importantly, speech interruption (between two people 1 meter apart) occurs at 60 dB (LAeq,1s) and this level was rarely exceeded at any of the sites in any season.

Frequency content

To determine the effect that noise has on the acoustic environment, it is useful to examine percentile metrics across a frequency range. The percentile sound levels for 33 one-third octave band frequencies over the day and night periods are shown in Figure 2 – Figure 9. Examining the sound energy in each one-third octave band (combined with digital audio recordings) allows acoustic technicians to determine what types of sounds are contributing to the overall sound levels at a site. The grayed areas of Figure 2 – Figure 9 represent sound levels outside of the typical range of human hearing. The percentile levels (L_x) are also shown for each one-third octave band. They represent the sound levels exceeded x percent of the measurement period. For example, L_{90} is the sound level that has been exceeded 90% of the time, and only the quietest 10% of the samples can be found below this point. On the other hand, the L_{10} is the sound level that has been exceeded 10% of the time, and 90% of the measurements are quieter than the L_{10} . The bold portion of the column represents the difference between L_{50} and L_{nat} . The height of this bold portion is a measure of the contribution of anthropogenic noise to the existing sound levels at this site. The size of this portion of the column is directly related to the percent time that human caused sounds are audible. When bold portions of the column do not appear the natural and existing sound levels were either very close to each other or were equal. The typical frequency levels for transportation, conversation, and songbirds are presented on the figure as examples for interpretation of the data. These ranges are estimates and are not vehicle-, species-, or habitat-specific.

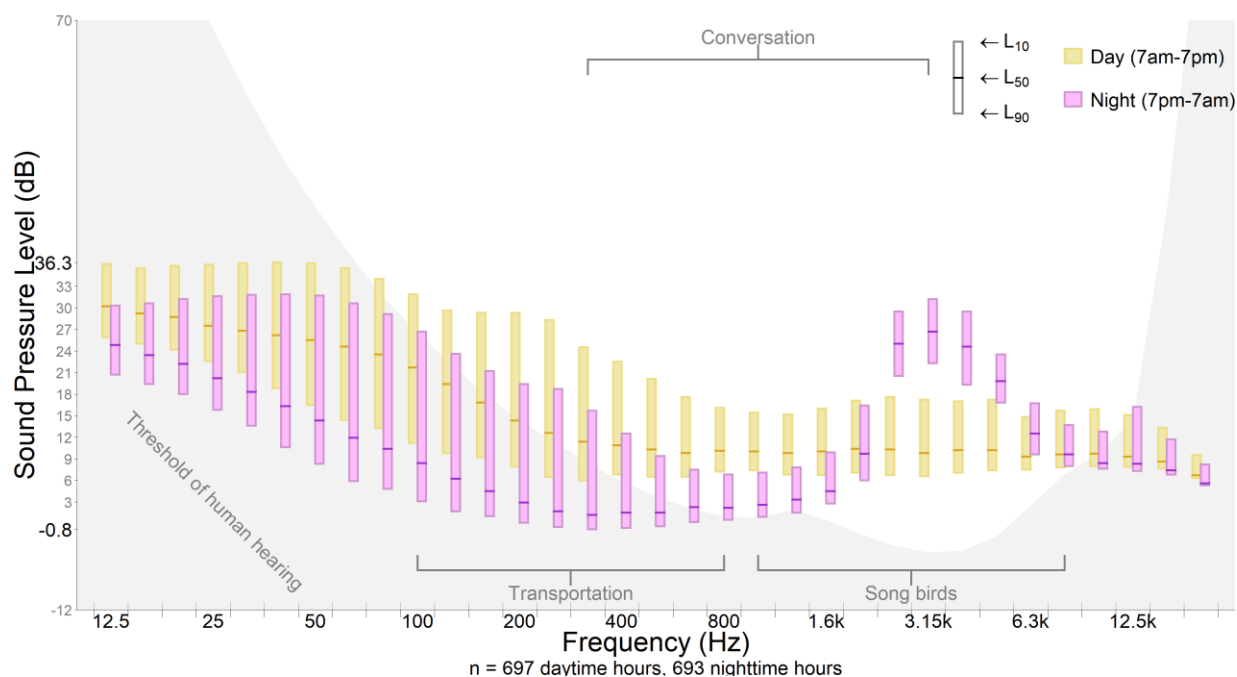


Figure 2. Day and night percentile sound pressure levels for 33 one-third octave bands at CANY015 in summer, 2024. For each bar, the bold color indicates the range of existing (L_{50} ; upper) and natural (L_{nat} ; lower) sound pressure levels. L_{nat} is not included in this graph since off-site listening has not yet been completed.

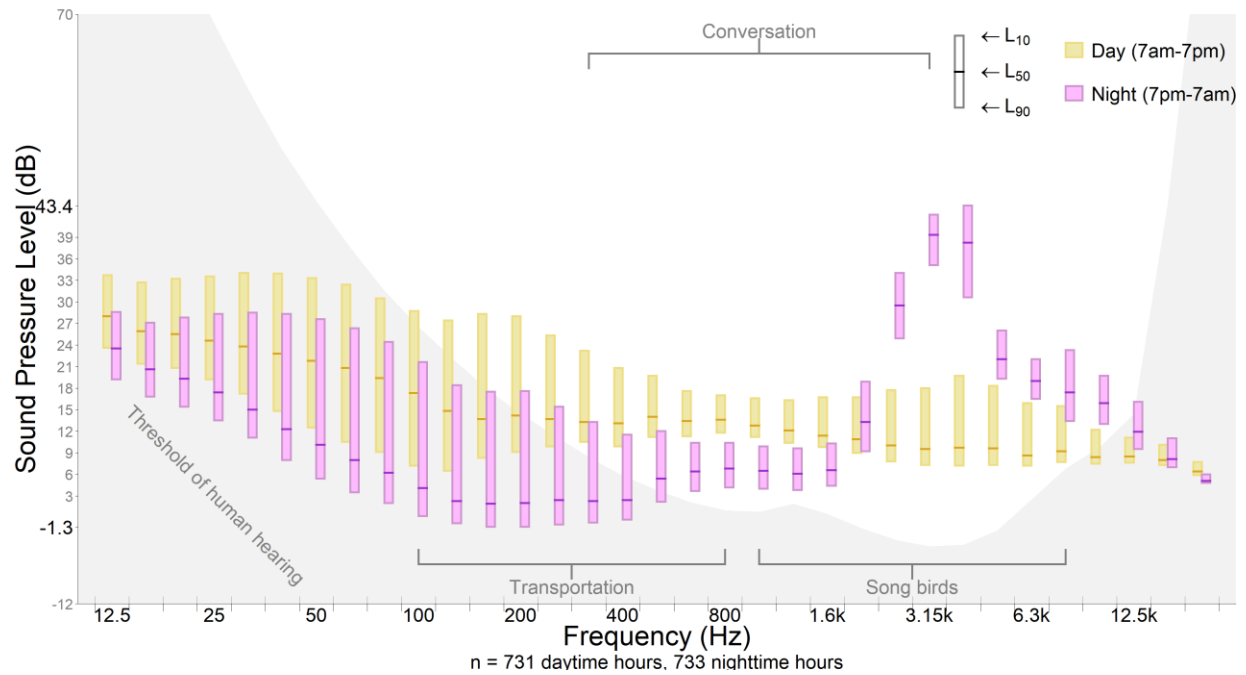


Figure 3. Day and night percentile sound pressure levels for 33 one-third octave bands at CANY016 in summer, 2024. For each bar, the bold color indicates the range of existing (L_{50} ; upper) and natural (L_{nat} ; lower) sound pressure levels. L_{nat} is not included in this graph since off-site listening has not yet been completed.

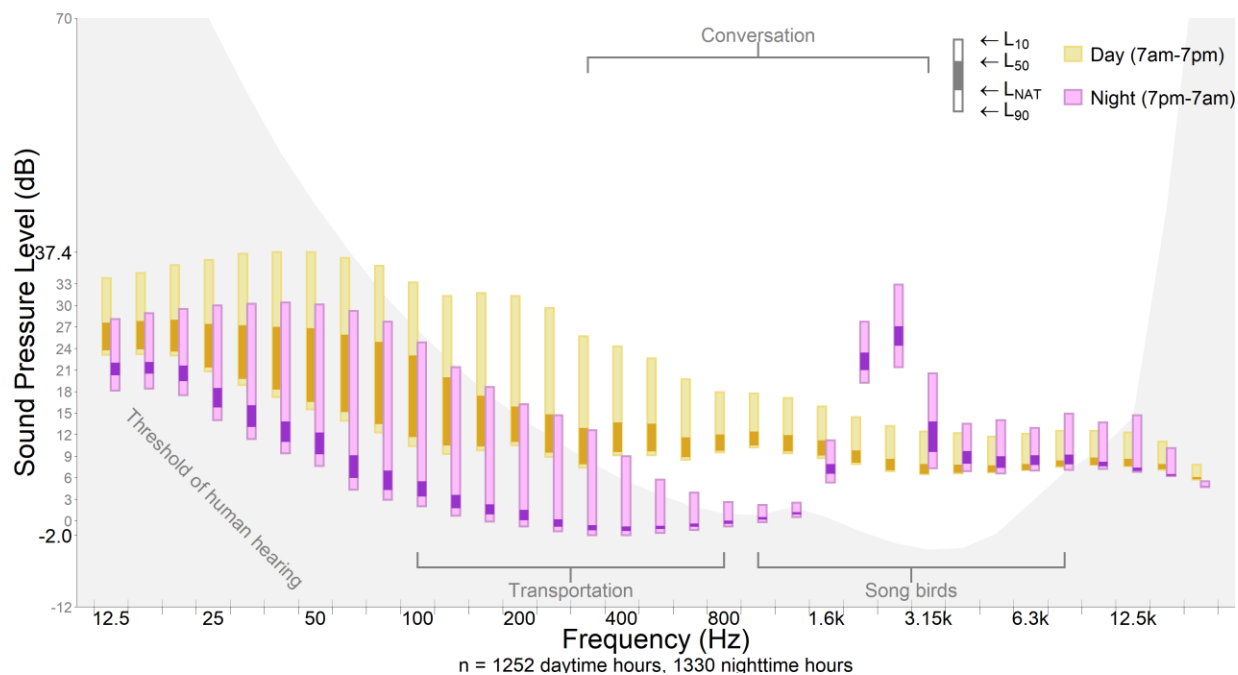


Figure 4. Day and night percentile sound pressure levels for 33 one-third octave bands at CANY015 in fall, 2024. For each bar, the bold color indicates the range of existing (L_{50} ; upper) and natural (L_{nat} ; lower) sound pressure levels.

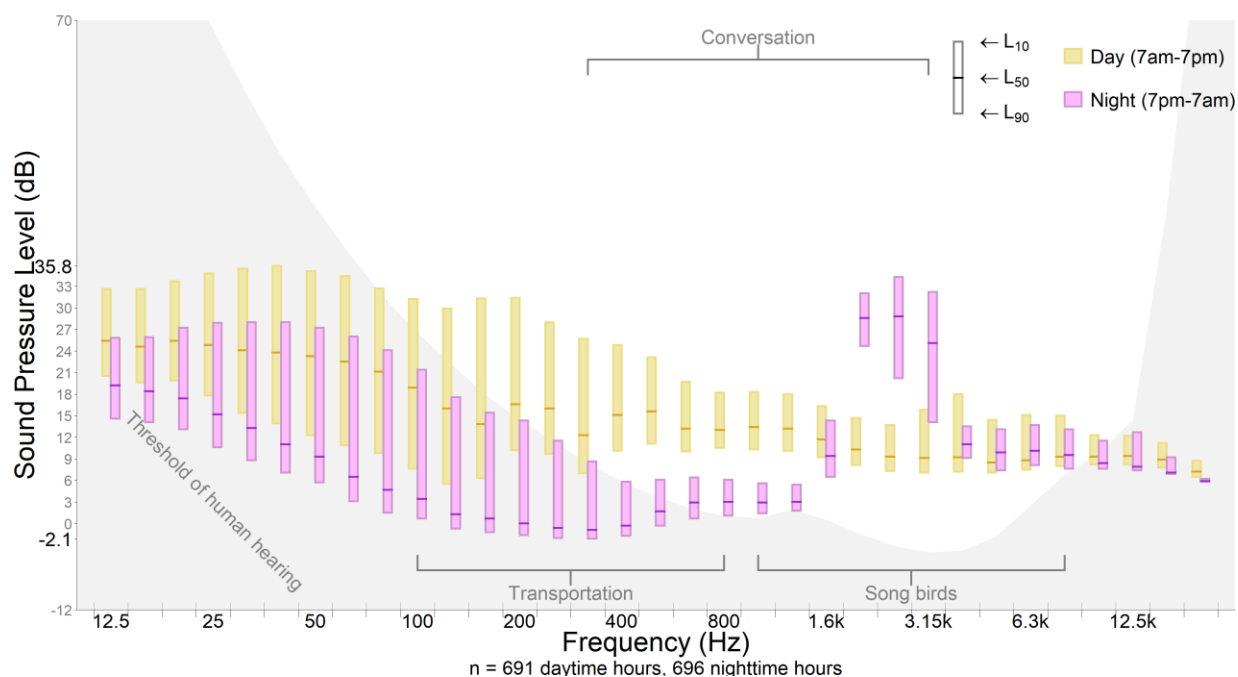


Figure 5. Day and night percentile sound pressure levels for 33 one-third octave bands at CANY016 in fall, 2024. For each bar, the bold color indicates the range of existing (L_{50} ; upper) and natural (L_{nat} ; lower) sound pressure levels. L_{nat} is not included in this graph since off-site listening has not yet been completed.

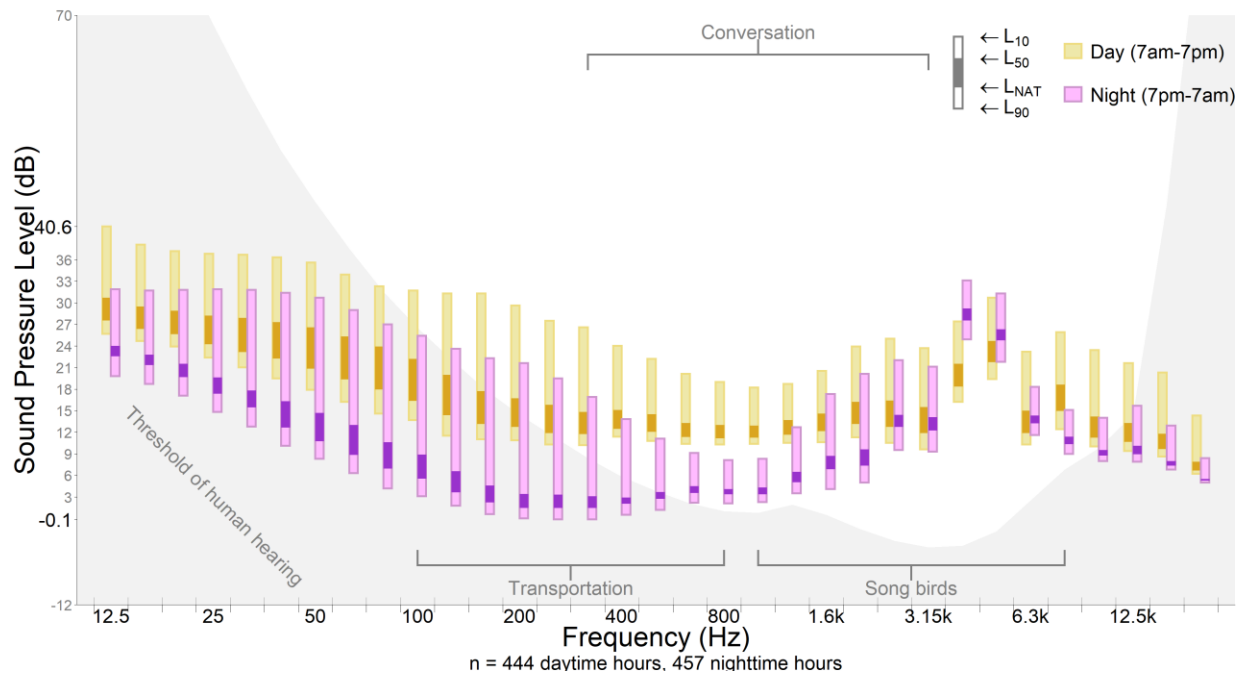


Figure 6. Day and night percentile sound pressure levels for 33 one-third octave bands at CANY015 in spring, 2025. For each bar, the bold color indicates the range of existing (L_{50} ; upper) and natural (L_{nat} ; lower) sound pressure levels.

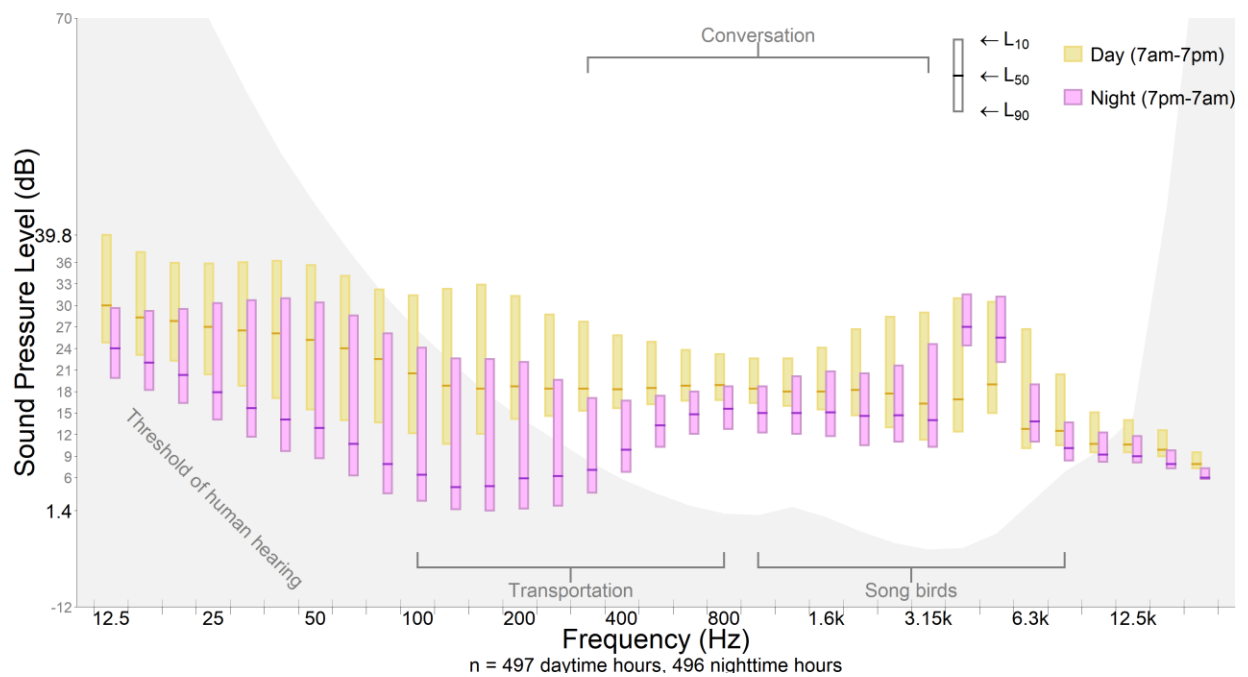


Figure 7. Day and night percentile sound pressure levels for 33 one-third octave bands at CANY016 in spring, 2025. For each bar, the bold color indicates the range of existing (L₅₀; upper) and natural (L_{nat}; lower) sound pressure levels. L_{nat} is not included in this graph since off-site listening has not yet been completed.

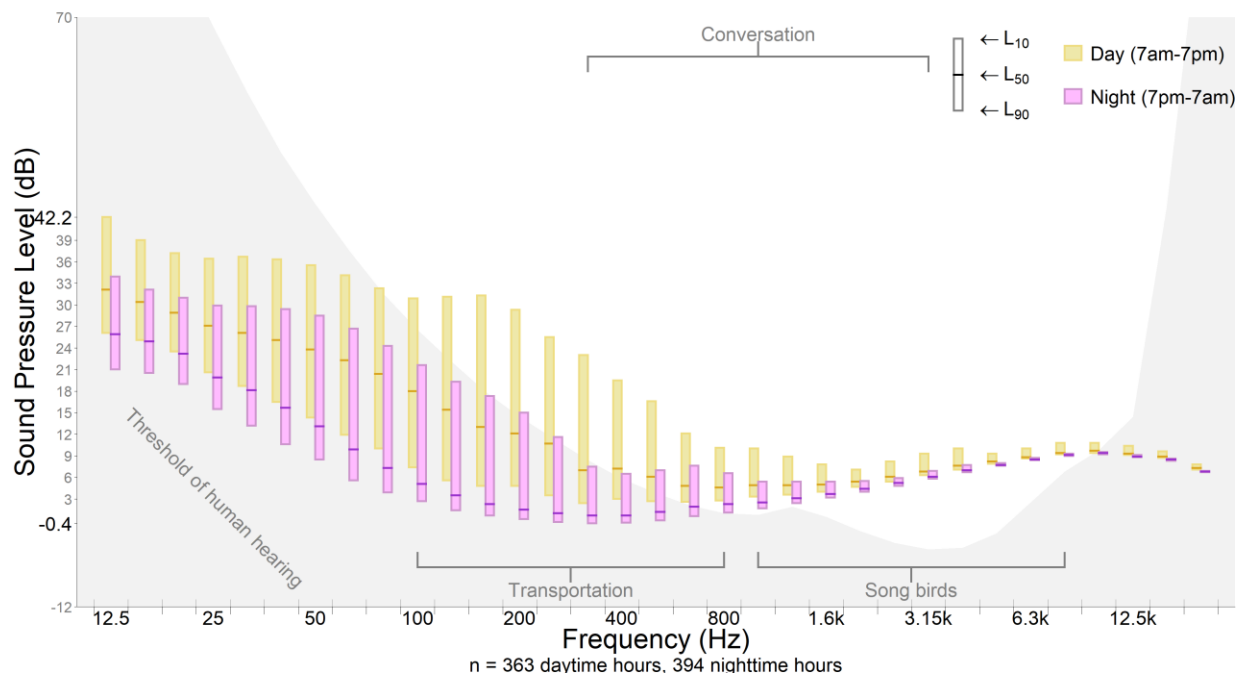


Figure 8. Day and night percentile sound pressure levels for 33 one-third octave bands at CANY019 in winter, 2026. For each bar, the bold color indicates the range of existing (L_{50} ; upper) and natural (L_{nat} ; lower) sound pressure levels. L_{nat} is not included in this graph since off-site listening has not yet been completed.

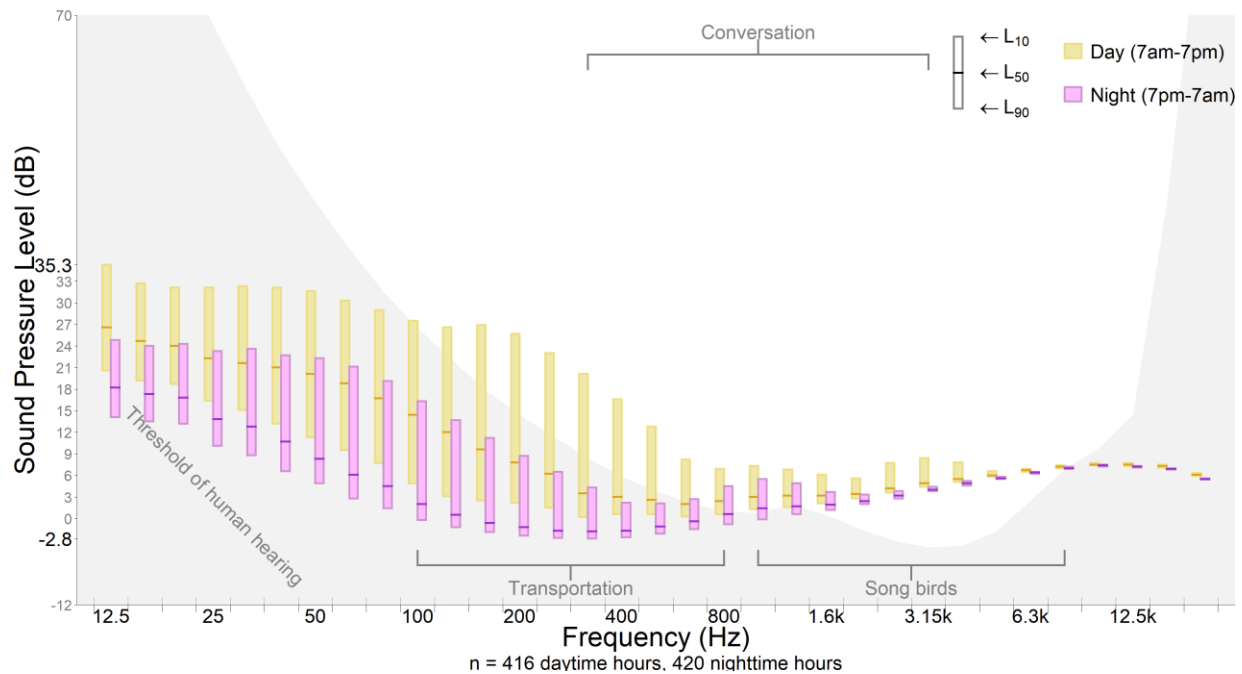


Figure 9. Day and night percentile sound pressure levels for 33 one-third octave bands at CANY020 in winter, 2026. For each bar, the bold color indicates the range of existing (L_{50} ; upper) and natural (L_{nat} ; lower) sound pressure levels. L_{nat} is not included in this graph since off-site listening has not yet been completed.

Sound Level: Hourly Percentile Levels

To characterize the park's acoustic environment, hourly A-weighted percentile sound levels (L_{A90} , L_{Anat} , L_{A50} , and L_{A10}) are reported (Figure 10 – Figure 17). These values are derived from the broadband (12.5 Hz – 20 kHz) A-weighted, 1-second time averaged sound levels ($L_{Aeq,1s}$) within each hour. For instance, in Figure 12, the L_{A50} (median) sound level for CANY015 during the fall at 8:00 hour is 22.3 dB. On the other hand, the sound level exceeded 10% of the time (L_{A10}) for the same hour at this site is 31.7 dB, meaning 90% of the measurement period is quieter. The larger the difference between the horizontal L_{A50} line and the L_{A90} (lower whisker), the greater the difference of the existing sound level from the quietest conditions. At CANY015, existing sound levels are closest to natural conditions in the early morning hours but depart from natural conditions for most of the

day (Figure 12, Figure 14). In general, higher natural ambient sound levels occurred in the late evening and early morning hours and are largely due to insect activity (Figures 10 – 13).

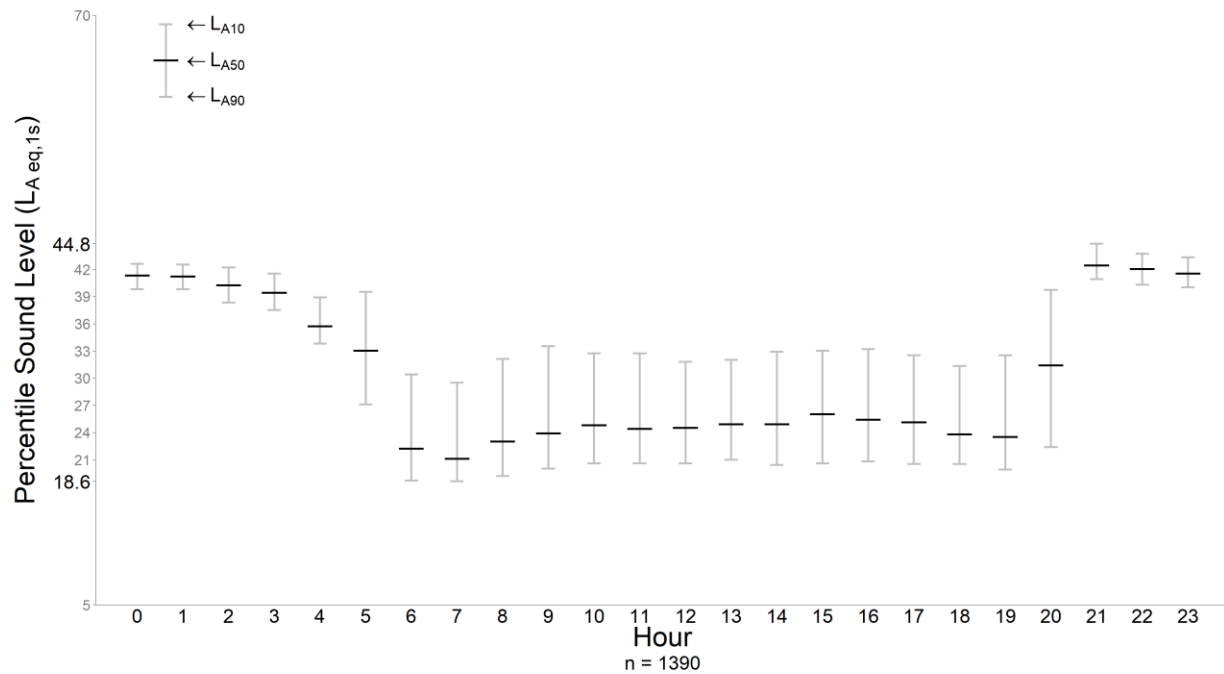


Figure 10. Hourly percentile sound levels ($L_{Aeq,1s}$), in dB re 20 μ Pa, at CANY015 in summer, 2024. L_{nat} is not included in this graph since off-site listening has not yet been completed.

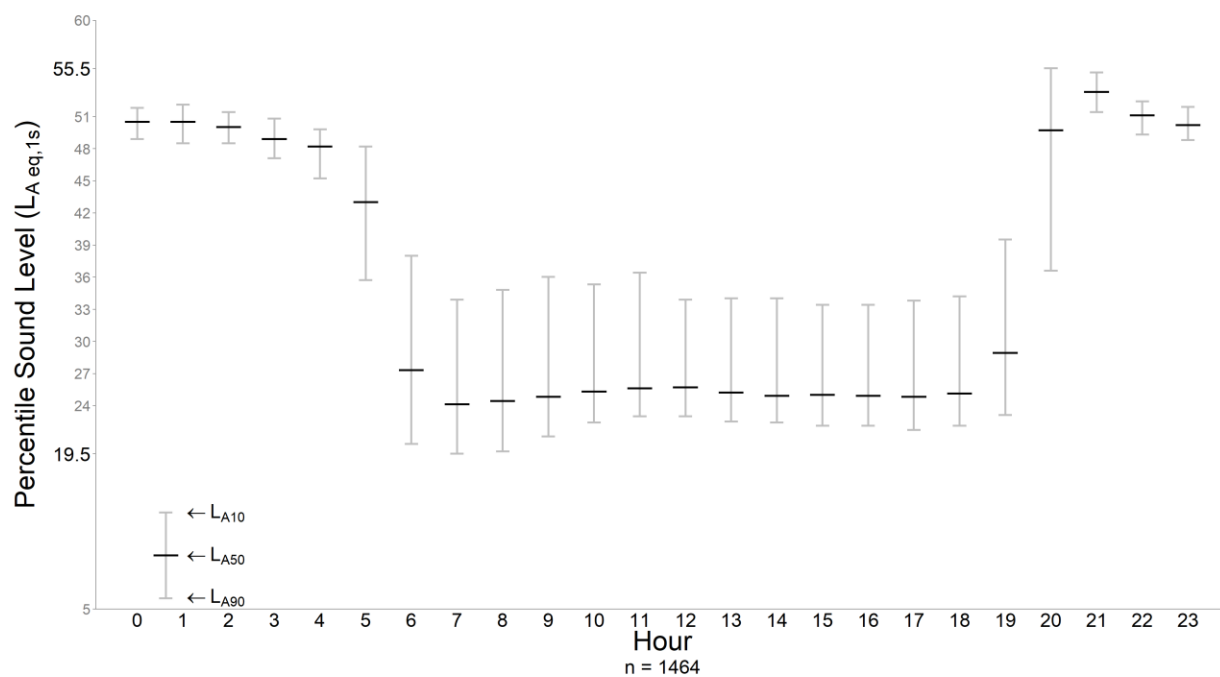


Figure 11. Hourly percentile sound levels ($L_{Aeq,1s}$), in dB re 20 μ Pa, at CANY016 in summer, 2024. L_{nat} is not included in this graph since off-site listening has not yet been completed.

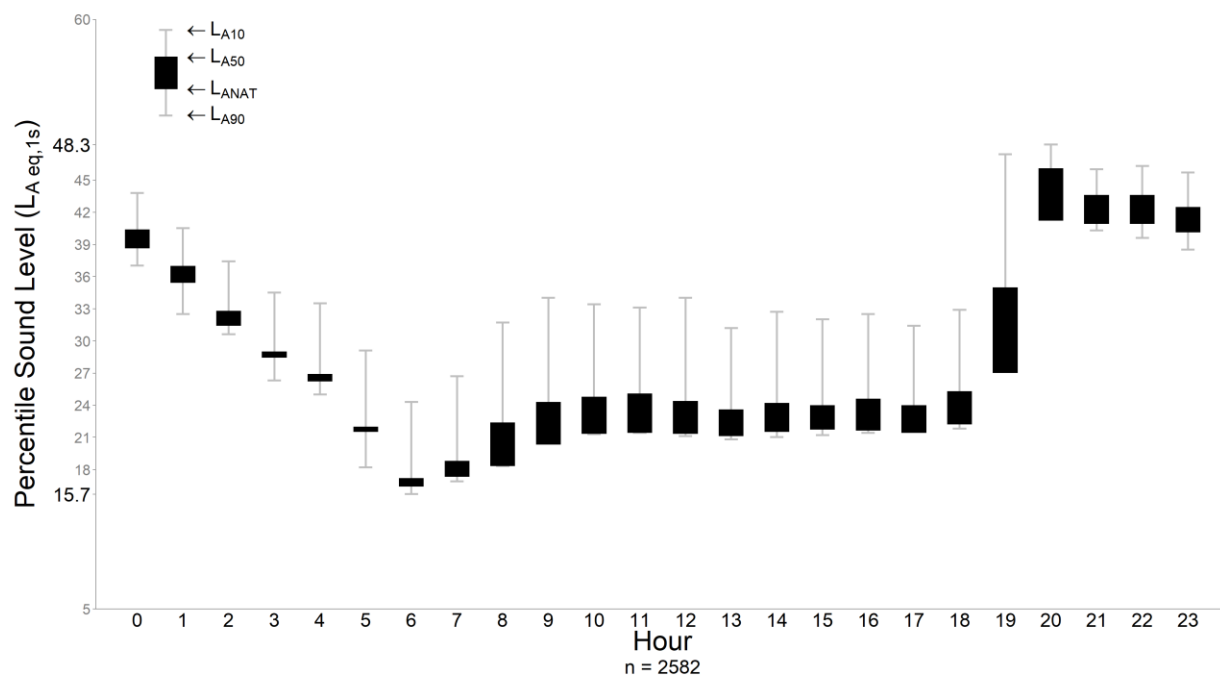


Figure 12. Hourly percentile sound levels ($L_{Aeq,1s}$), in dB re 20 μ Pa, at CANY015 in fall, 2024. L_{nat} is not included in this graph since off-site listening has not yet been completed.

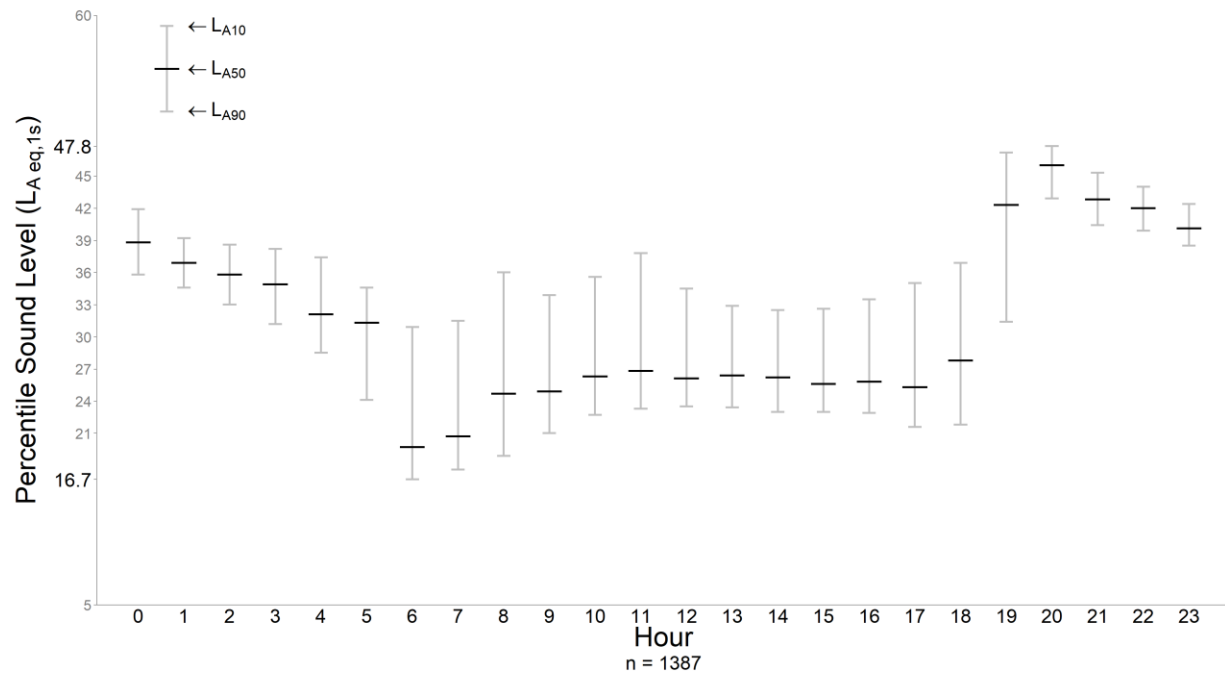


Figure 13. Hourly percentile sound levels ($L_{Aeq,1s}$), in dB re 20 μ Pa, at CANY016 in fall, 2024. L_{nat} is not included in this graph since off-site listening has not yet been completed.

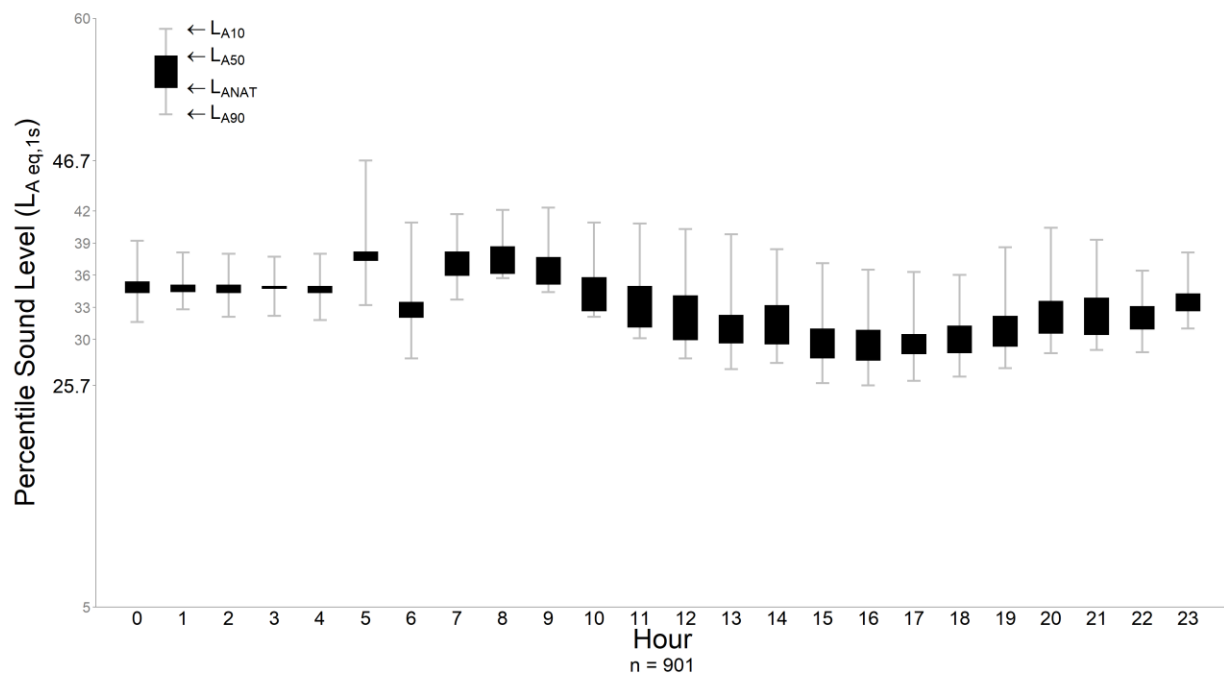


Figure 14. Hourly percentile sound levels ($L_{Aeq,1s}$), in dB re 20 μ Pa, at CANY015 in spring, 2025.

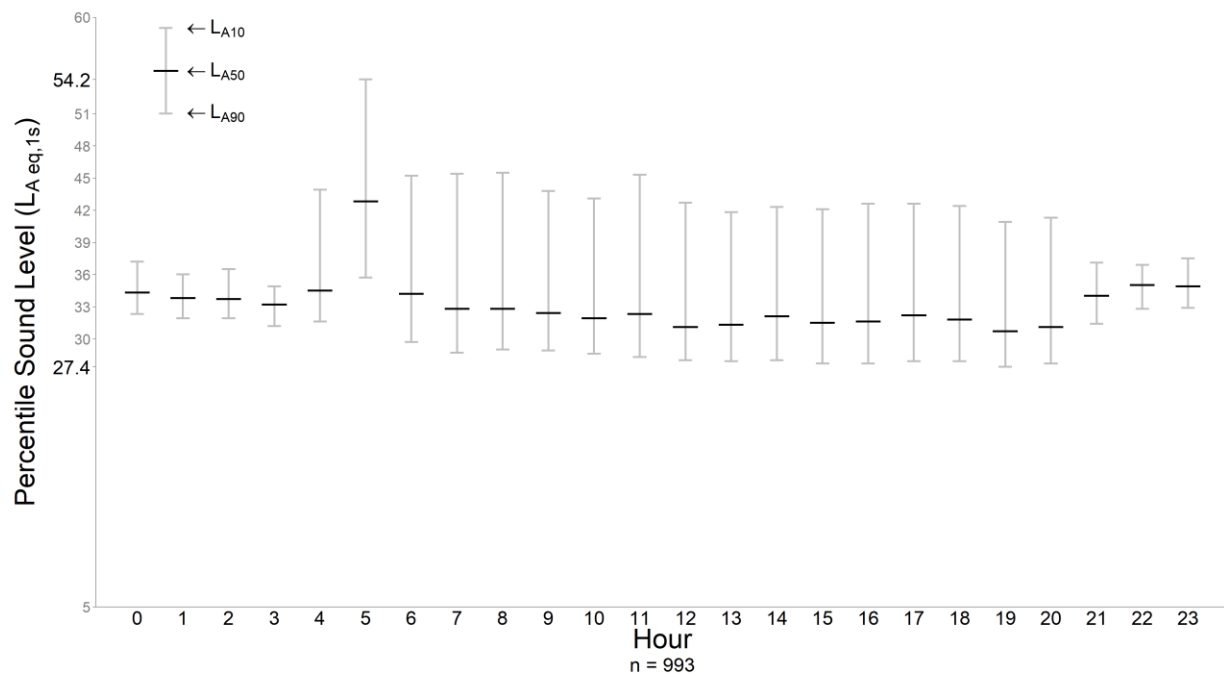


Figure 15. Hourly percentile sound levels ($L_{Aeq,1s}$), in dB re 20 μ Pa, at CANY016 in spring, 2025. L_{nat} is not included in this graph since off-site listening has not yet been completed.

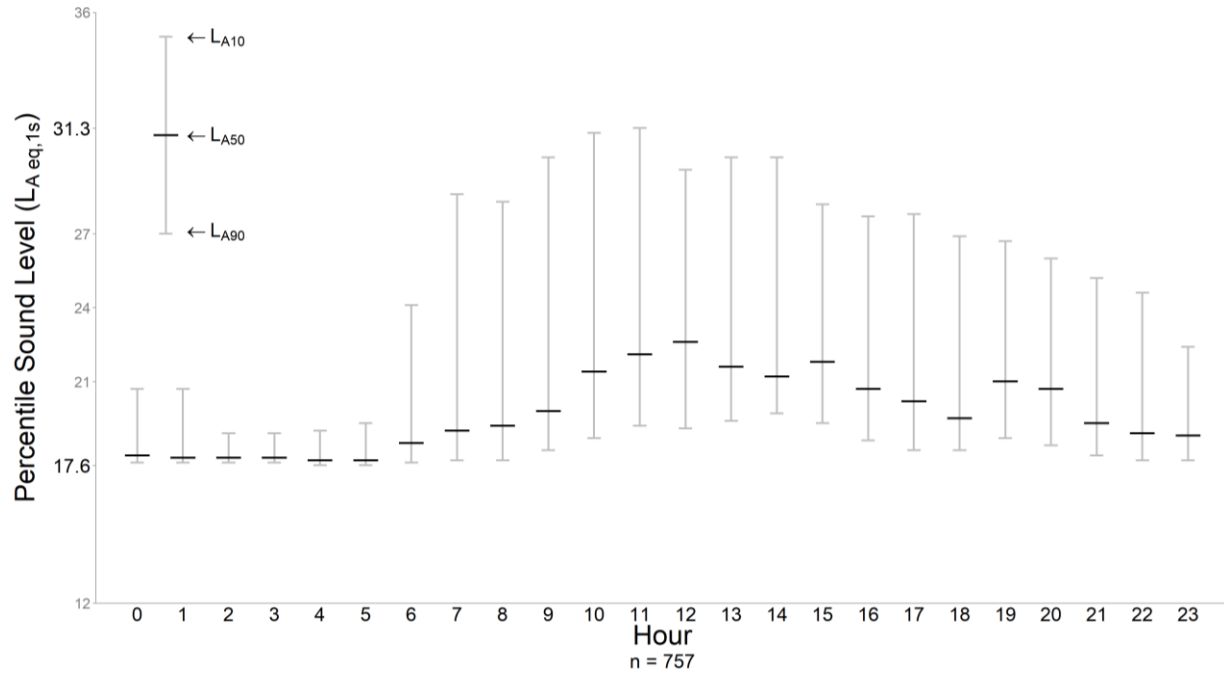


Figure 16. Hourly percentile sound levels ($L_{Aeq,1s}$), in dB re 20 μ Pa, at CANY019 in winter, 2026. L_{nat} is not included in this graph since off-site listening has not yet been completed.

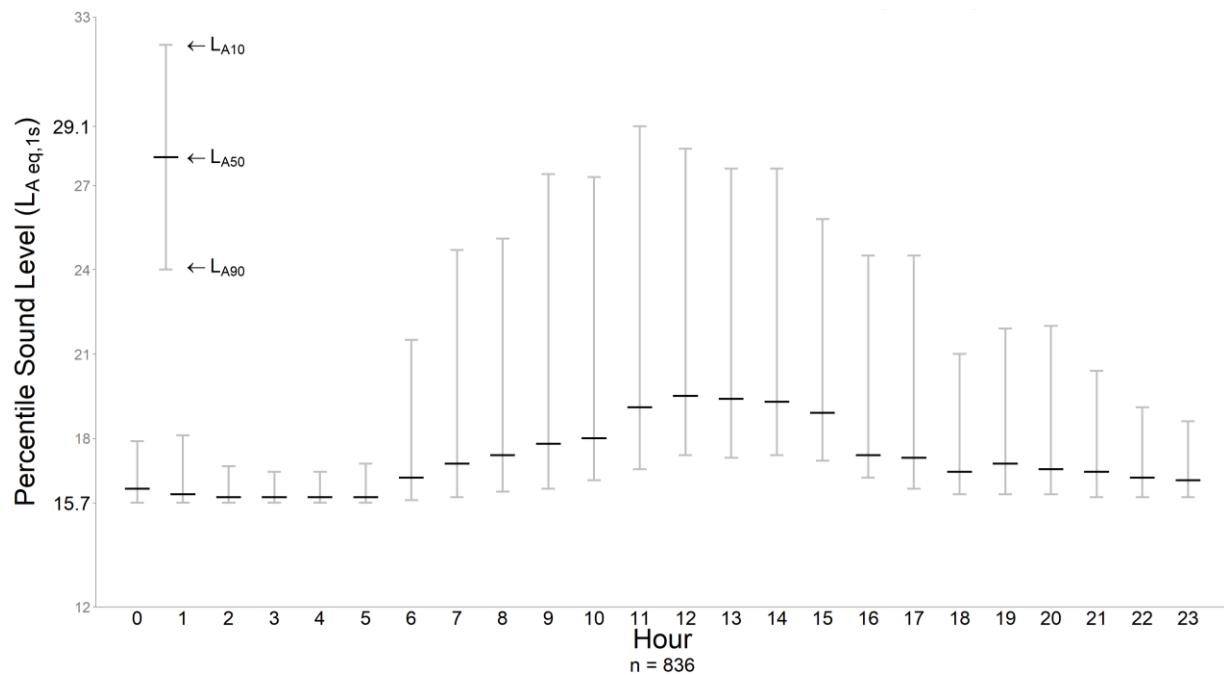


Figure 17. Hourly percentile sound levels ($L_{Aeq,1s}$), in dB re 20 μ Pa, at CANY020 in winter, 2026. L_{nat} is not included in this graph since off-site listening has not yet been completed.

Preliminary Conclusions

This snapshot acoustic monitoring effort provides an initial characterization of the soundscape along the Green and Colorado River corridors in Canyonlands National Park, in support of the park's ongoing river management planning process. Across the four seasons and four monitoring sites sampled between 2024 and 2026, existing ambient sound levels (L_{A50}) ranged widely, from a low of 16.3 dB (CANY020, winter night) to a high of 48.0 dB (CANY016, summer night), reflecting substantial seasonal and site-level variability in the acoustic environment.

The clearest contrast in the dataset is between the winter sampling (CANY019, CANY020) and the summer/fall/spring sampling (CANY015, CANY016). Winter ambient levels were consistently the lowest recorded (L_{A50} 16.3–20.4 dB, day and night), and the percent of time that sound levels exceeded all four functional thresholds (35, 45, 52, 60 dB) stayed below 3.5% at both winter sites, day and night. This likely reflects the near absence of river recreation traffic and reduced aircraft activity outside the primary visitor season. CANY019 and CANY020 are different physical locations than CANY015 and CANY016, however, this seasonal pattern should not be treated as a direct site-to-site comparison.

CANY016 stood out among the river sites for unusually high percent-time-above-threshold values at night in summer (73.84% of nighttime hours exceeded 45 dB, full frequency range) and, to a lesser extent, fall (14.81%). These exceedances nearly disappeared when the same thresholds were evaluated using the ANS frequency range (20–1,250 Hz), which excludes most biological and other high-frequency sound (0.01% in both seasons). This strongly suggests the elevated nighttime sound levels at CANY016 are dominated by high-frequency biophony (e.g., insect chorus) rather than low-frequency mechanical or vehicle noise. This distinction is a useful reminder of why frequency-weighted comparisons matter when interpreting raw sound level thresholds at river corridor sites.

Where off-site listening analysis has been completed (CANY015, fall 2024 and spring 2025), aircraft overflights were the single largest identified contributor to audible noise, accounting for 40.8% of time audible in fall and 37.4% in spring, exceeding all other identified sources combined in both seasons. Watercraft and vehicle sources (reported together pending reanalysis; see QA/QC discussion in Appendix A) accounted for a smaller but still meaningful share of audible noise (11.5% fall, 5.3% spring), with higher mean event counts and durations in fall than spring, consistent with greater river-based motorized use during that season. Because the distinction between watercraft and vehicle events is still being reanalyzed, any management conclusions specific to motorized watercraft impacts on the soundscape should be treated as provisional until that reanalysis is complete and the final comprehensive report is issued.

Off-site listening analysis has not yet been completed for CANY016, CANY019, or CANY020; L_{Anat} and source-specific audibility could not be calculated for these sites in this snapshot report, and L_{A90} was used as the best available proxy for natural ambient conditions. Completing listening analysis for all four sites, together with the ongoing watercraft/vehicle reanalysis, are priority next steps toward the final report. This work will enable a more direct, source-resolved comparison of river-, road- and

aircraft-related noise across all monitoring locations. This information will be directly useful to decisions under the river management plan regarding the timing, volume, and type of permitted river use.

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Appendix A: Off-Site Listening and Spectrogram Analysis

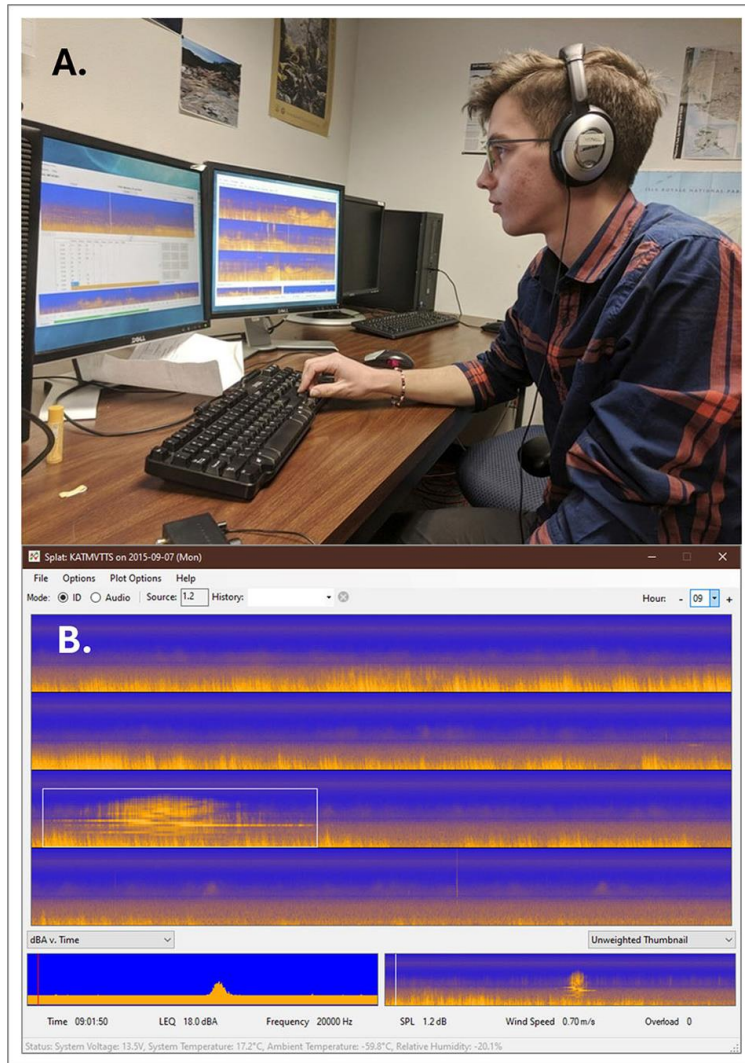


Figure 18. Depictions of auditory analysis by trained technicians. The top image (A) shows a Colorado State University student identifying sound sources using Listening Center software (NPS). The bottom image (B) is a screen shot of NPS Sound Pressure Level Annotation Tool (SPLAT) software with an annotated noise event.

Sound Pressure Level Annotation Tool

Sound pressure level data were annotated visually across 10 days of spectrograms at CANY015 in the fall and spring using the NPS-developed software, Sound Pressure Level Annotation Tool (SPLAT). Trained technicians used SPLAT to draw bounding boxes at the beginning and end of noise events using visual cues from the sound pressure energy, time, and frequency of a spectrogram. From the drawn bounding boxes, noise event counts (i.e., the number of boxes), frequency range, and event duration (i.e., the length of each box) were obtained. In addition, the noise-free interval (NFI) metric was generated. The NFI represents the length of time that passes between the end of one noise

event and the beginning of the next. Over a longer sampling period, the median of NFI can describe how a typical opportunity for solitude has been fragmented by noise (Poling and Betchkal 2023). Like the Listening Center software, the total percent time noise was audible was then used to calculate the natural ambient sound level (L_{Anat}) for each hour.

Sound Pressure Level Annotation Tool Results

During quality assurance/quality control (QA/QC) review, spectrogram-based annotation was found to periodically misidentify motorized watercraft and vehicle sources (e.g. motorcycles, autos, UTVs/ATVs) due to overlapping acoustic signatures on spectrograms. As a result, event counts and durations attributed to Watercraft and Vehicle source categories are undergoing reanalysis and should be considered preliminary. This data quality issue does not affect total noise metrics (e.g. L_{Anat} and noise-free interval) or the audibility results for other sound sources, which are derived independently of individual source classification and remain reliable. The findings from the initial QA/QC review are presented below.

Overall, mean time audible of noise was higher at CANY015 in fall (54.8%) than in spring (43.2%), driven primarily by a greater contribution from aircraft (40.8% vs. 37.4%) and from Watercraft + Vehicles events (11.5% vs. 5.3%; Tables 11–12). Existing ambient sound levels (L_{A50}) were lower in fall than in spring during the day (24.0 vs. 33.9 dB) but comparable at night (36.0 vs. 34.8 dB); these seasonal differences may also reflect natural factors such as wind, hydrology, and avian activity. The gap between existing and natural ambient levels ($L_{A50} - L_{Anat}$) was similar during the day across seasons (2.8 dB fall, 3.0 dB spring) but larger at night in fall (2.7 dB) than in spring (1.6 dB), consistent with the higher nighttime Watercraft + Vehicles event count observed in fall (7.4 events vs. 1.8 events per night; Tables 13–14).

Mean hourly audibility of noise events was obtained for each hour of the day over the sampling period (Tables 13–14). The noise-free interval (NFI), which is the length of time between the end of one noise event and the beginning of the next, was also calculated for each hour of the day (Figure 19 – Figure 20). In fall 2024, the median NFI across all hours of the day was approximately 1:28 (mm:ss). The lowest hourly median NFI occurred at 08:00 h (0:49), coinciding with increased daytime aircraft and river traffic, and the highest hourly median NFI occurred at 05:00 h (20:15), during the early morning hours before daily activity began. In spring 2025, the median NFI across all hours of the day was approximately 2:25 (mm:ss), with the lowest hourly median NFI again occurring at 08:00 h (0:59) and the highest at 05:00 h (21:12).

Table 11. Summary of fall noise sources and sound levels at Canyonlands National Park (CANY) in 2024. Included for each site are mean percent time audible for all human-caused noise, including the top known noise sources, and existing (L_{A50}) and natural (L_{Anat}) ambient sound levels (dB re 20 μ Pa, A-weighted broadband, 12.5 Hz–20 kHz) during the day (0700–1900) and night (1900–0700). The difference between the natural and existing ambient sound levels indicates the deviation from the natural condition. L_{Anat} is

calculated based on sound source identification from audio recordings. Watercraft and vehicle events are combined pending reanalysis, as source identification between these two categories is being revisited.

	a) Mean time audible for noise (% of 24-hour time period)				b) Median Existing Ambient (L~A50~) in dB		Median Natural Ambient (L~Anat~) in dB	
Site Name	Noise	Aircraft	People	Watercraft+ Vehicles	Day	Night	Day	Night
CANY015	54.8	40.8	11.0	11.5	24.0	36.0	21.2	33.3
CANY016	N/A	N/A	N/A	N/A	25.7	37.1	N/A	N/A

Table 12. Summary of spring noise sources and sound levels at Canyonlands National Park (CANY) in 2025. Included for each site are mean percent time audible for all human-caused noise, including the top known noise sources, and existing (L_{A50}) and natural (L_{Anat}) ambient sound levels (dB re 20 µPa, A-weighted broadband, 12.5 Hz—20 kHz) during the day (0700-1900) and night (1900-0700). The difference between the natural and existing ambient sound levels indicates the deviation from the natural condition. L_{Anat} is calculated based on sound source identification from audio recordings. Watercraft and vehicle events are combined pending reanalysis, as source identification between these two categories is being revisited.

	a) Mean time audible for noise (% of 24-hour time period)				b) Median Existing Ambient (L~A50~) in dB		Median Natural Ambient (L~Anat~) in dB	
Site Name	Noise	Aircraft	People	Watercraft+ Vehicles	Day	Night	Day	Night
CANY015	43.2	37.4	2.5	5.3	33.9	34.8	30.9	33.2
CANY016	N/A	N/A	N/A	N/A	32.3	33.8	N/A	N/A

Table 13. Results from SPLAT analysis for CANY015 in fall, 2024. Mean event counts and mean event lengths (mm:ss) are shown for each identified sound source, by day and night.

Sound Source	Day		Night	
	Day Mean Event Count	Day Mean Event Length	Night Mean Event Count	Night Mean Event Length
Jet	93.9	03:26	57.7	03:46
Prop	11.6	03:46	1.5	04:02
Helicopter	2.3	03:08	0.3	04:27
Door	0.1	00:06	0.0	00:00
Watercraft + Vehicles*	30.8	04:32	7.4	03:32
People	2.7	02:15	0.6	04:31
Voices	31.5	02:52	16.0	03:03
Portable Audio Devices	0.2	02:02	1.5	06:47
Construction	0.2	57:44	0.0	00:00
Non-natural Other	0.1	00:17	0.4	00:43

*Watercraft and vehicle events are combined pending reanalysis, as source identification between these two categories is being revisited.

Table 14. Results from SPLAT analysis for CANY015 in spring, 2025. Mean event counts and mean event lengths (mm:ss) are shown for each identified sound source, by day and night.

Sound Source	Day		Night	
	Day Mean Event Count	Day Mean Event Length	Night Mean Event Count	Night Mean Event Length
Jet	83.9	03:12	61.8	03:26
Prop	11.3	04:18	1.5	05:15
Helicopter	1.2	04:01	0.2	10:15
Watercraft + Vehicles*	15.5	04:18	1.8	05:19
People	0.3	01:30	0.3	00:44
Voices	5.9	01:55	5.1	04:47
Portable Audio Devices	0.2	02:10	0.0	00:00
Construction	0.2	49:56	0.0	00:00

*Watercraft and vehicle events are combined pending reanalysis, as source identification between these two categories is being revisited.

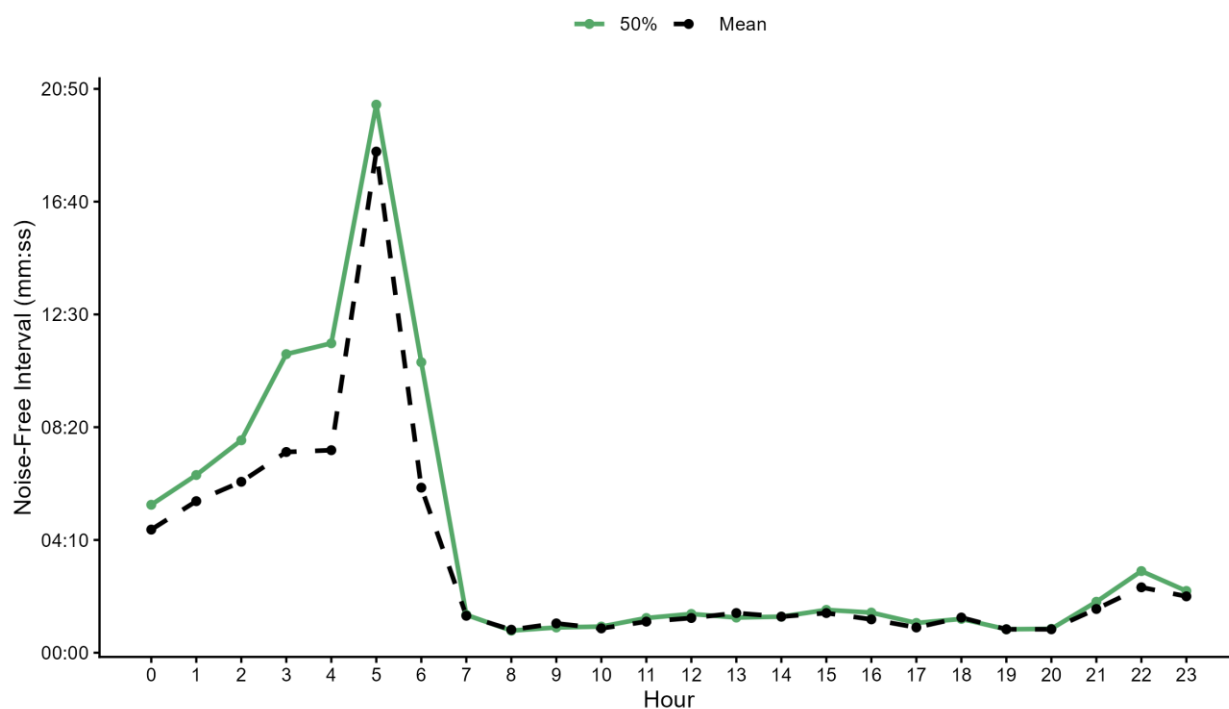


Figure 19. Noise-free interval (NFI) by hour of day at CANY015 in fall. Lines show the median (50th percentile) NFI duration, and the mean NFI duration, for each hour.

NPS/NATURAL SOUNDS AND NIGHT SKIES DIVISION

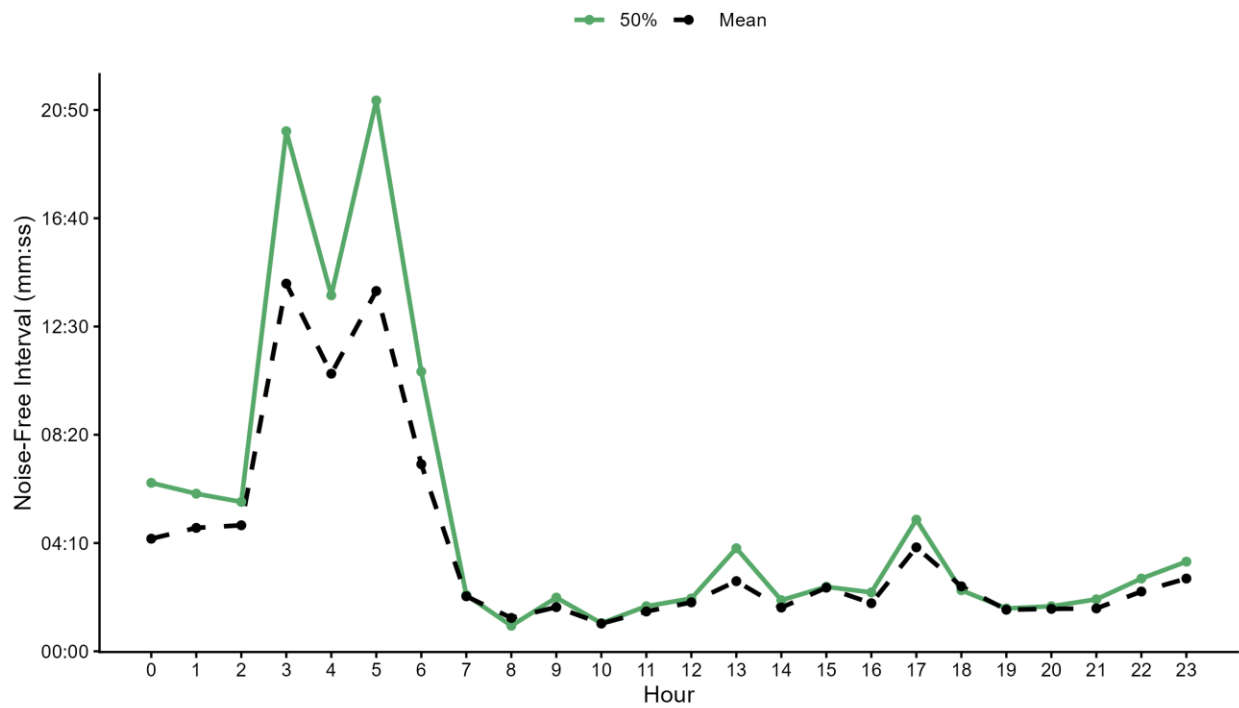


Figure 20. Noise-free interval (NFI) by hour of day at CANY015 in spring. Lines show the median (50th percentile) NFI duration, and the mean NFI duration, for each hour.