National Park Service
U.S. Department of the Interior

Natural Resource Program Center
Natural Sounds Program

Walnut Canyon National Monument
Preliminary results of shooting range tests
September 2010

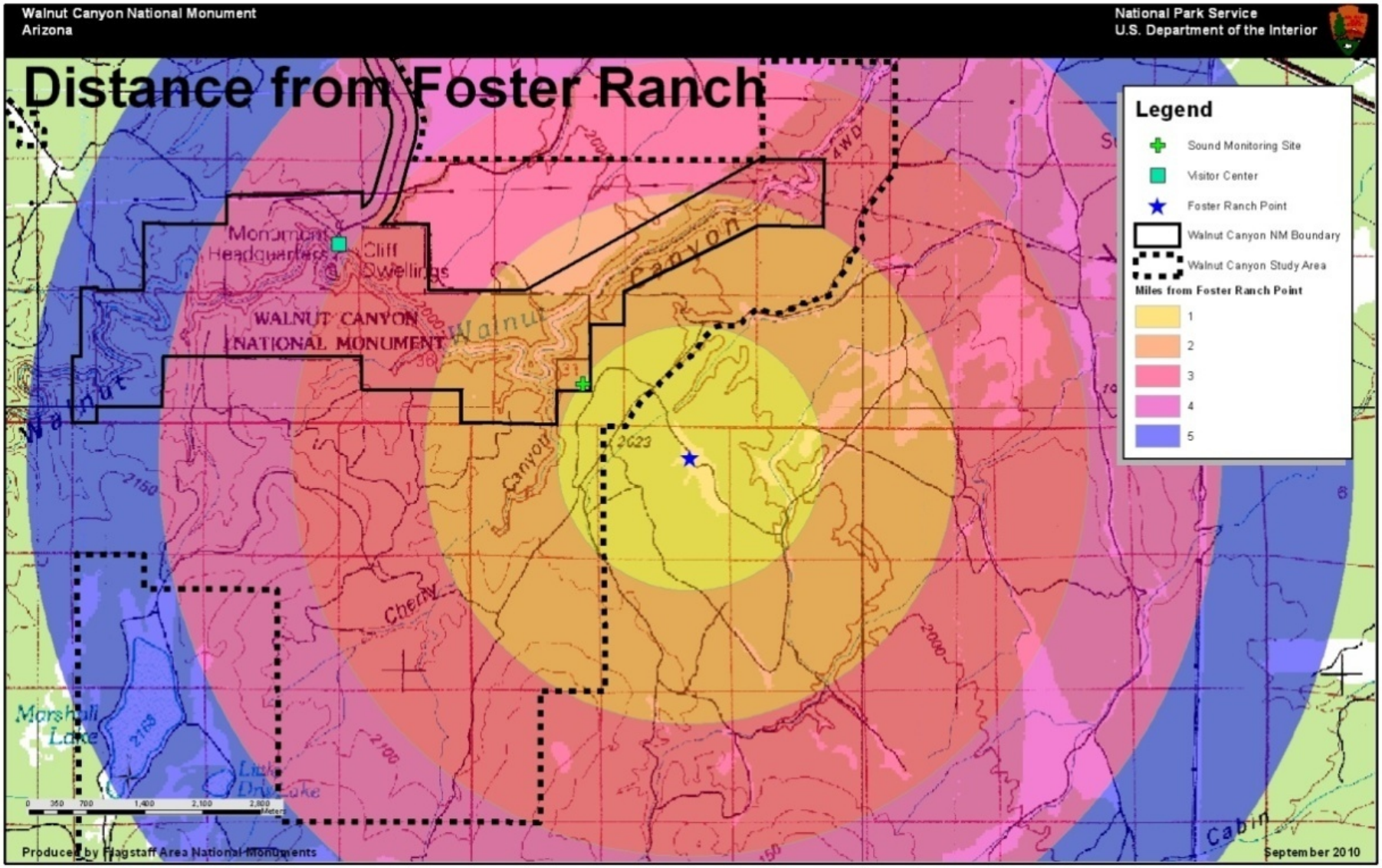
Background Information

In order to determine the possible impacts of a shooting range proposed by the State of Arizona, staff at Walnut Canyon National Monument (WACA) collected 22 days of acoustical monitoring data from August 5, 2010 through August 27, 2010. WACA staff deployed the acoustical monitoring system within WACA boundaries, as close as possible to the proposed shooting range. Table 1 below provides information about the location and name of the study area. To test audibility of gunshots fired from the proposed range at Foster Ranch, a series of tests was performed there on August 26, 2010. Shots were fired at 0700h, 1200h, and 1700h on the site of the proposed range. Following collection by WACA staff, the National Park Service Natural Sounds Program (NSP) was contacted. WACA staff requested that NSP analyze the acoustical data. See
Figure 1 on the following page for the location of the proposed shooting range in relationship to significant features at the monument such as the visitor center, monument boundary, and study area boundary.

Table 1. Study area

Site ID	Site Name	Dates Deployed	UTM E	UTM N	Zone
WACA003	Shooting Range	8/5-8/27	045696	3890472	12

Figure 1. Location of proposed shooting range and Walnut Canyon National Monument.



Data and Results

At the monitoring site, sound pressure level (SPL) measurements were taken, along with digital audio recordings. The acoustical monitoring equipment used for this study makes 33 SPL measurements every second for a set of frequency bands that span the range of human hearing (12.5 - 20,000 Hz). These 33 measurements approximate the capacity of human listeners to independently sense signals in different parts of the audible spectrum. The SPL is measured in decibels (dB), a logarithmic scale where 0 dB represents the threshold of human hearing. The logarithmic scale is a useful way to express the wide range of sound pressure levels over which the auditory system functions. Microphone measurements can be adjusted according to a weighted scale (A-weighting) such that they resemble the response of the human ear (Harris, 1998, p. 116).

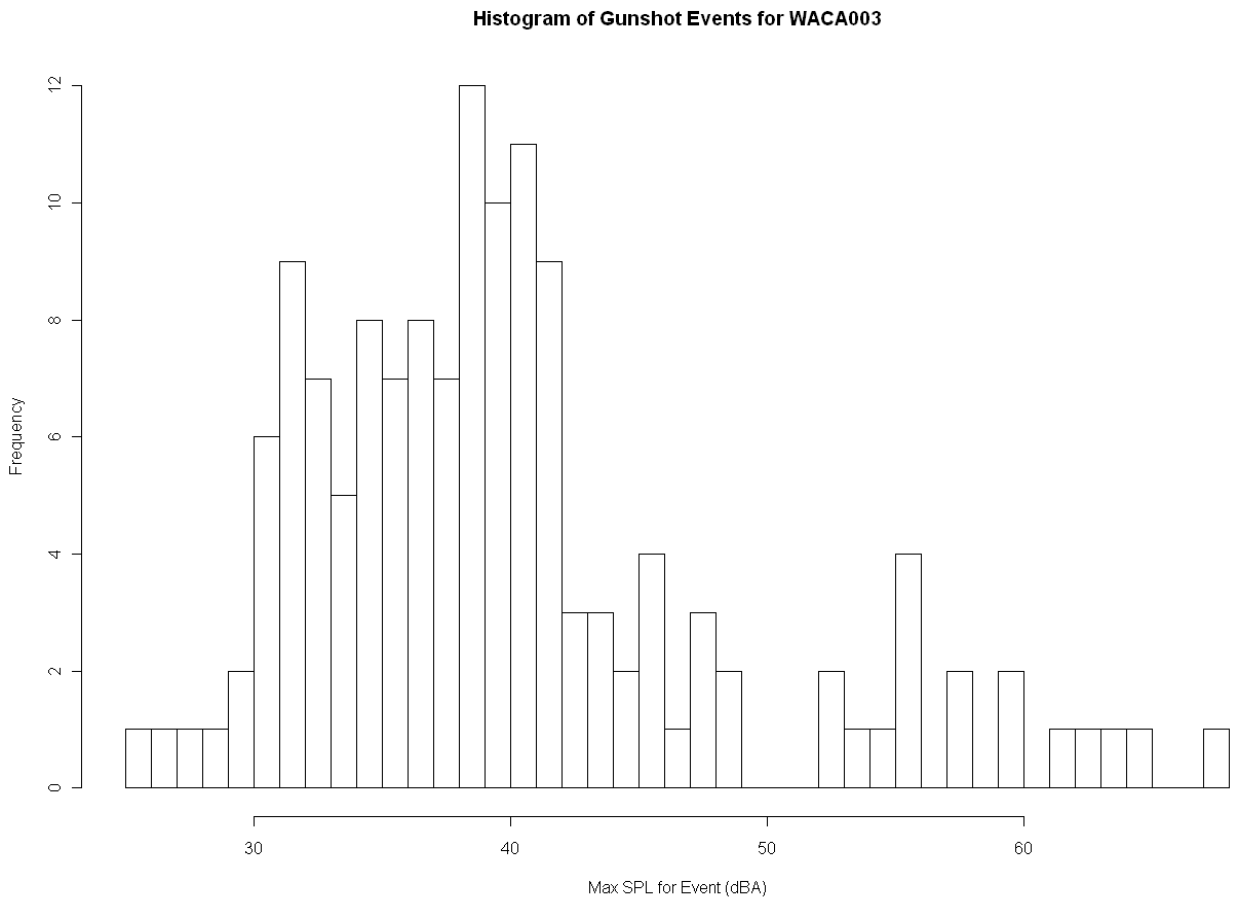
The logarithmic dB scale can be difficult to interpret, and the effect of a seemingly small change in SPL can be greater than anticipated. When noise interferes with hearing natural sounds, the noise is said to *mask* the natural sounds, and this affects the extent of the listening area. For example, if the ambient SPL is 30 dB, and transportation noise raises the ambient to 33 dB (a 3 dB increase), the listening area or auditory horizon for humans (and many birds and mammals) would be reduced by 50%. Increasing the ambient SPL an additional 3 dB (to 36 dB) would reduce the listening area by half again, to 25% of the initial area. Note however, that changes in SPL do not proportionately translate to changes in perceived loudness. The rate of change of loudness is complex and dependent on the stimulus itself (SPL, frequency, bandwidth, duration, background, etc.). At a minimum, each 10 dB increase in SPL causes a doubling of perceived loudness (Crocker, 1997, p.1481). Table 2 presents park sound sources and common sound sources with their corresponding A-weighted decibel values (dBA).

Table 2. Sound pressure level examples

Park Sound Sources	Common Sound Sources	dBA
Volcano crater	Human breathing at 3m	10
Leaves rustling	Whispering	20
Crickets at 5m	Residential area at night	40
Conversation at 5m	Busy restaurant	60
Snowcoach at 30m	Curbside of busy street	80
Thunder	Jackhammer at 2m	100
Military jet at 100m AGL	Train horn at 1m	120

NSP staff reviewed data from August 26, 2010 and examined each instance of gunshot. They determined that sound pressure measurements for these events were typically centered around either 38 dBA or 55 dBA (the highest peaks in Figure 2). The histogram below displays the sound levels (dBA) for all gunshots during the three time periods of interest (0700, 1200, 1700) with the number of gunshots reflected in the Frequency axis of this chart.

Figure 2. Histogram showing frequency of occurrence at given sound levels (in dBA) for all gunshot events on 8/26/2010 at WACA003



In order to estimate the impact that the potential shooting range might have on the acoustical environment in WACA, NSP staff calculated the amount of time (in seconds), within each hour of interest, that median sound levels exceeded 38 dBA and 55 dBA on all days other than August 26th within the monitoring period. NSP also converted those same results into percentages (Table 4). In essence, the values in **Error! Reference source not found.** and Table 4 indicate how often sound levels similar to those of the gunshots occur in the existing acoustical environment. The results show that sound levels of this magnitude are uncommon, particularly during the 0700 and 1700 hours.

Table 3. Mean number of seconds above 38 dBA and 55 dBA over 21 day monitoring period, in each hour of interest.

Hour	Mean number of seconds above 38 dBA	Mean number of seconds above 55 dBA
700	109.7 (1:49)[1]	0.5 (0:00)
1200	568.9 (9:28)	14.6 (0:14)
1700	213.8 (3:33)	2.0 (0:02)

Table 4. Mean percent time above 38 dBA and 55 dBA over 21 day monitoring period, in each hour of interest.

Hour	Percent time above 38 dBA	Percent time above 55 dBA
700	3.0 (0:00)	0.0 (0.00)
1200	15.8 (0:15)	0.4 (0:00)
1700	5.9 (0:05)	0.1 (0:00)

In the interest of providing a reference point, NSP staff calculated what the median sound pressure level (L_{50}) was for the hours of interest, across all days in the monitoring period. The results of these calculations are presented in Table 5. As one might guess, the SPL levels during the 1200 hour were greater than the morning and evening hours. This is a common trend in parks because human activity is at its height during the middle of the day, and meteorological effects (such as wind) are more likely to occur.

Table 5. Median (L_{50}) dBA for hours of interest during the full monitoring period at WACA003.

Hour	Median L50
700	22.7
1200	28.0
1700	24.4

[1]Number of seconds above 38 and 55 dBA, translated into minutes:seconds.

Literature Cited

Crocker, M. J. (1997). *Encyclopedia of Acoustics*. John Wiley and Sons, New York.

Harris, C. M. (1998). *Handbook of Acoustical Measurements and Noise Control*, 3rd ed. McGraw-Hill, New York.

Natural Resource Program Center
Natural Sounds Program
1201 Oakridge Drive, Suite 100
Fort Collins, CO 80525
(970)267-2104
http://www.nature.nps.gov/naturalsounds/

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