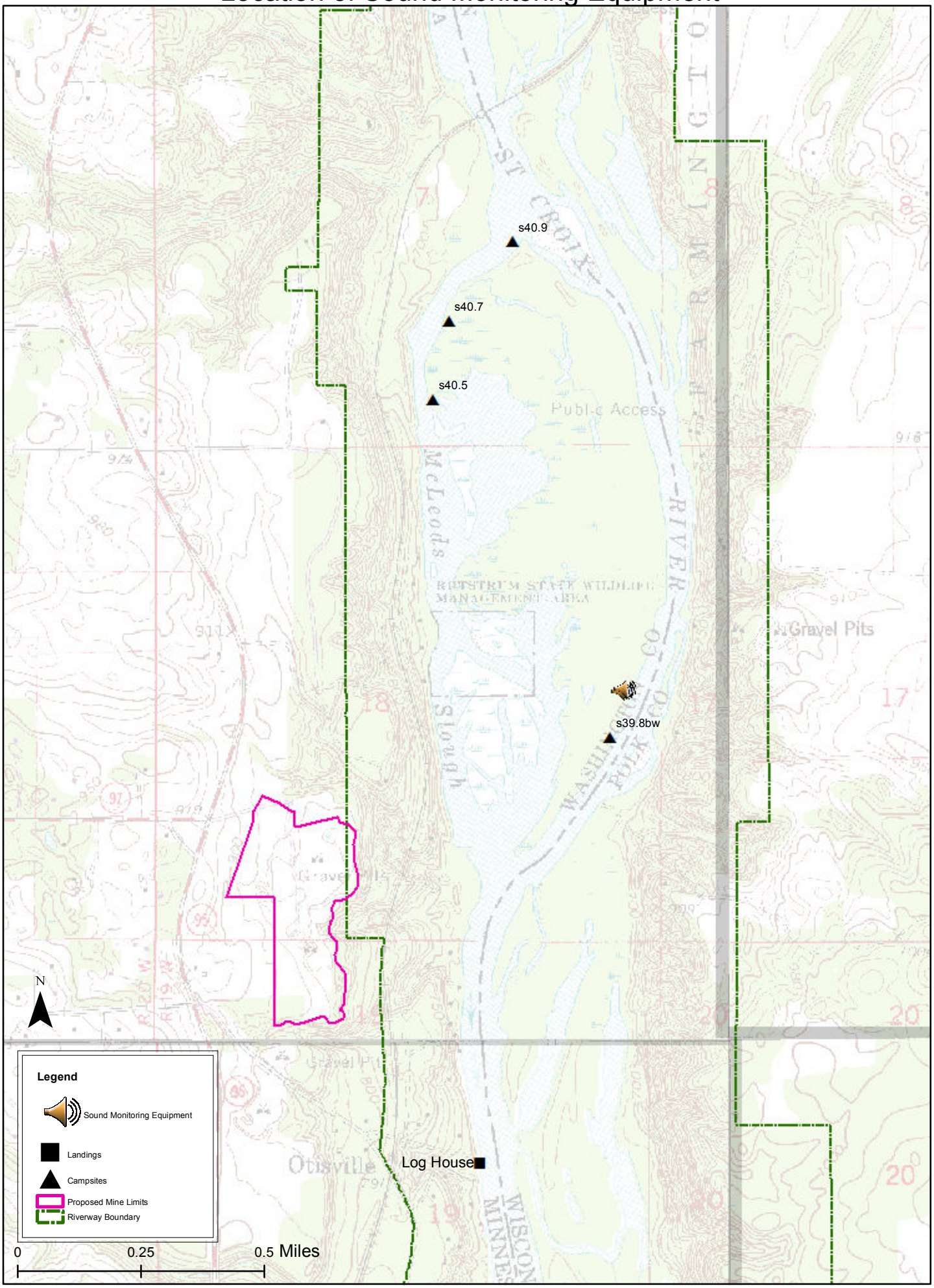
Location of Sound Monitoring Equipment



National Park Service
U.S. Department of the Interior

Natural Resource Program Center
Natural Sounds Program

Saint Croix National Scenic Riverway
Acoustical Monitoring Snapshot

August 2011

Background Information

In 2011, the Natural Sounds and Night Skies Division received a technical assistance request to collect baseline acoustical data at Saint Croix National Scenic Riverway (SACN). During the months of June and July, 2011, one acoustical monitoring system was deployed for 38 days. The baseline data collected during this period will help park managers, and planners quantify existing acoustical conditions. While the park is subject to the effects of many external noise sources (such as highways, paper plants, and motor boats), at present, the most controversial noise issue the park faces is an EIS for the reopening of the nearby Zavoral Gravel Mine. The selected monitoring site is proximal to the location of the Zavoral Mine, and thus will provide the best available information about the baseline acoustical conditions, and insight into the potential impacts of the mining operation.

This briefing is a preliminary snapshot of the acoustical conditions at the site. A full acoustical monitoring report will follow, pending further data analysis. The metrics presented in this snapshot are calculated solely from sound pressure level data, and do not distinguish between intrinsic and extrinsic sound sources. Sound source identification, an estimate of the natural ambient condition, and the summary of attended listening sessions will be included in the full report after analysis of the digital audio recordings is complete. Table 1 describes the location and characteristics of the monitoring site.

Table 1. Monitoring site information

Site	Site Name	Dates Deployed	Vegetation	Elevation	Latitude	Longitude
SACN001	Swing Bridge Island	6/22/11 - 7/27/11	Riparian area, deciduous forest	227m	45.26050	092.75419

Data & Metrics

At each site, sound pressure level (SPL) measurements were taken, along with digital audio recordings and meteorological data. Natural Sounds Program equipment makes 33 SPL measurements each 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. 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 natural ambient SPL is 30 dB, and transportation noise raises the ambient to 33 dB (a 3 dB increase), the listening area 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 other 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 (HALE)	Human breathing at 3m	10
Leaves rustling (CANY)	Whispering	20
Crickets at 5m (ZION)	Residential area at night	40
Conversation at 5m (WHMI)	Busy restaurant	60
Snowcoach at 30m (YELL)	Curbside of busy street	80
Thunder (ARCH)	Jackhammer at 2m	100
Military jet at 100m AGL(YUCH)	Train horn at 1m	120

Table 3 summarizes sound pressure levels that relate to human health and speech, as documented in the scientific literature. Human responses can serve as a proxy for potential impacts to other vertebrates because humans have more sensitive hearing at low frequencies than most species (Dooling and Popper, 2007, p. 5). To help interpret the acoustic data collected within the park, and to better understand the implications of the data, it may be helpful to consider sound pressure levels in relation to the functional effects listed in Table 3.

Table 3. Effects of sound pressure levels on humans

SPL (dBA)	Relevance
35	Blood pressure and heart rate increase in sleeping humans (Haralabidis et al., 2008)
45	World Health Organization's recommendation for maximum noise levels inside bedrooms (Berglund, Lindvall, and Schwela, 1999)
52	Speech interference for interpretive programs (U.S. Environmental Protection Agency, 1974)
60	Speech interruption for normal conversation (U.S. Environmental Protection Agency, 1974)

For a given frequency range, the *time above* metric indicates the amount of time that the SPL exceeds a specified decibel value. By comparing the amount of time that sound pressure levels are above certain values, variations in levels can be observed over time (or between sites). Table 4 reports the percent of time that measured levels were above the values in Table 3. These values are useful for making comparisons, but should not be construed as thresholds of impact. The top value in each split-cell of Table 4 reports the *percent time above* for the 20 – 1,250 Hz range. It is useful to look at this low-frequency range because it includes transportation noise while excluding higher-frequency bird and insect sounds. Transportation is often a major contributor of low frequency sound, but the 20 – 1,250 Hz range does not correspond to a specific vehicle or type of transportation. Note that natural sources such as flowing water also produce low

frequency sounds. The bottom *percent time above* value in each split-cell is calculated from the full 12.5-20,000 Hz range.

Table 4. Percent time above metrics for day and night

Site	Frequency (Hz)	% Time above sound level: 0700 to 1900				% Time above sound level: 1900 to 0700			
		35dBA	45dBA	52dBA	60dBA	35 dBA	45dBA	52 dBA	60 dBA
SACN001	20-1,250	13.84	1.83	0.31	0.03	5.37	0.64	0.13	0.02
	12.5-20,000	79.4	24.7	9.96	2.63	30.65	10.94	4.57	1.32

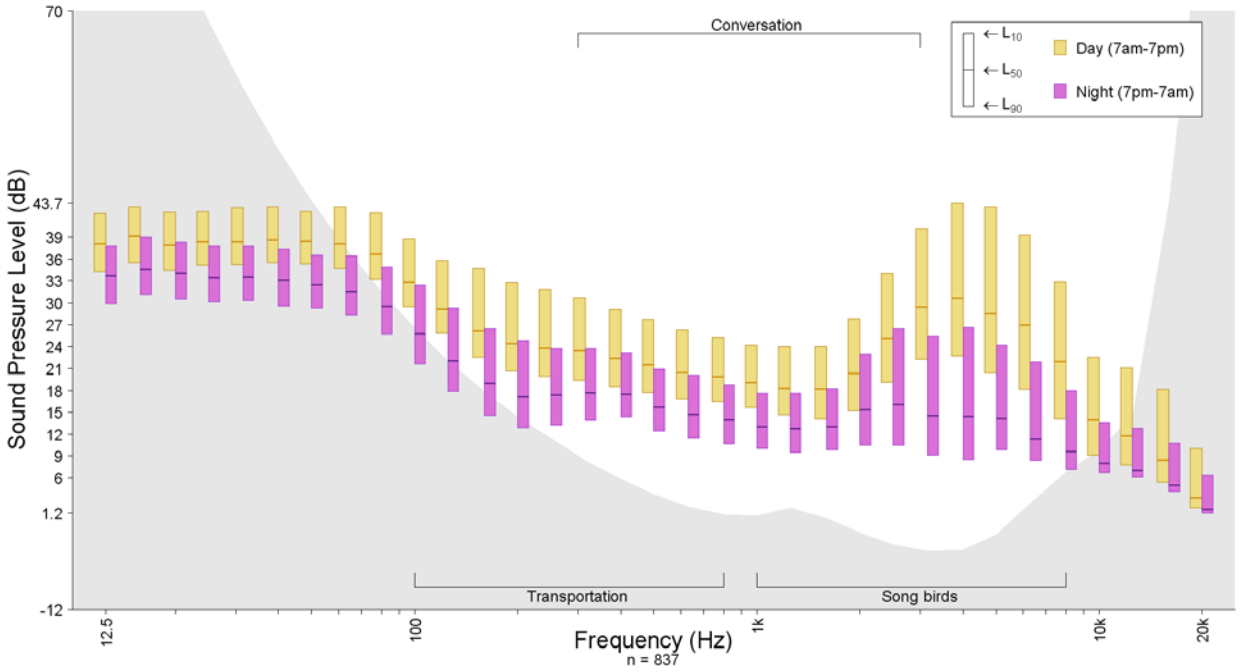
Exceedence levels (L_x) represent the sound pressure levels exceeded **x** percent during the given measurement period (e.g. L_{90} is the SPL that has been exceeded 90% of the time). Table 5 reports the L_{90}, L_{50}, and L_{10} values for both sites. For each split-cell in Table 5, the top value reports the L_x for the 20 – 800 Hz subset of the frequency range, and the bottom L_x value is calculated from the 12.5 – 20,000 Hz spectrum.

Table 5. Exceedence levels for daytime and nighttime existing conditions

Site	Frequency (Hz)	Exceedence levels (dBA): 0700 to 1900			Exceedence levels (dBA): 1900 to 0700		
		L_{90}	L_{50}	L_{10}	L_{90}	L_{50}	L_{10}
SACN001	20-1,250	26.0	29.2	35.5	20.4	23.6	28.5
	12.5-20,000	33.4	39.4	50.5	25.5	29.8	37.5

High frequency sounds (e.g. a cricket chirping) and low frequency sounds (e.g. transportation noise) often occur simultaneously, and do not always occur constantly throughout the day. Figures 1 illustrates these concepts by dividing the full frequency spectrum into 33 smaller frequency bands (each encompassing a one-third octave range), and by plotting the daytime and nighttime SPL range for each band. The grayed area in the background of the graph represents sound pressure levels outside of the typical range of human hearing. The typical frequency ranges 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 1. Day and night dB levels for 33 one-third octave bands at SACN001



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Note: *This is a preliminary snapshot designed to get salient acoustical information back to the park as quickly as possible. This does not replace a full acoustical report, which will follow, pending further data analysis. If there are any questions or concerns about the information in this document, please contact the Natural Sounds and Night Skies Division. Thank you for your interest and participation in acoustical resource monitoring.*

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