Environmental Noise Analysis

Automated Railroad Warning Horn System Follow-Up Test Revised

City of Roseville, California

Bollard & Brennan Job # 2003-174

Prepared For:

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INTRODUCTION

Bollard & Brennan Inc. has conducted followup noise levels surveys of the new Automated Horn System (AHS) located at the Yosemite and Center Street grade crossings of the Union Pacific Railroad tracks. The follow-up noise level tests were commissioned by the City of Roseville to quantify the extent by which the local ambient noise environment has been affected by the conversion from manual horn usage from the locomotives to the new automated system which generates horn sounds from fixed positions near these two grade crossings. This report contains the results of the AHS noise testing, and presents conclusions regarding the effects of the AHS on the local noise environment.

BACKGROUND

This report is prepared as a follow-up to the August 1999 report entitled: *Environmental Noise Analysis: Automated Railroad Warning Horn Systems*, prepared by Bollard & Brennan, Inc. under contract to the City of Roseville. In that report, noise level measurements were conducted of both conventional horn usage, as well as of a prototype AHS which was suspended from a boom near the railroad tracks and operated specifically for that noise testing. This analysis contains excerpts from that report where necessary to provide background information.

A conclusion of the 1999 study was that the AHS was predicted to result in a considerable decrease in ambient noise levels in the communities nearest to the Berry and Yosemite Street grade crossings. That conclusion was based on a comparison of noise generation of conventional versus simulated railroad warning horns, and the fact that the AHS focused the sound energy where it was needed; at the crossings, rather than spreading the sound up and down the tracks as occurs with conventional horn usage.

It was noted in the 1999 analysis, however, that a possible drawback of the AHS would be that persons living nearest to the grade crossings could be subject to repetitive AHS noise emissions which are consistently louder than most of the warning horn noise currently received at those locations. This is because the highest noise levels currently received at those locations occur when the train sounds its warning horn immediately prior to entering the grade crossing (closest location in proximity to the residences near the crossing). Therefore, warning horn exposure at the nearest residences currently starts with lower levels as the trains are more distant, then build to the highest levels as the train passes. With the AHS, the warning noise exposure at the nearest residences are uniformly and continuously high throughout the train approach and entry into the grade crossing.

AHS OPERATION

The automated horn system (AHS), which is the subject of this study, was developed by Automated Horn Systems, Inc. for the purpose of providing an alternative audible warning system at railroad crossings. The AHS installed at the Berry and Yosemite Street crossing consist of horns mounted in cases on poles in close proximity to the railroad crossings. The AHS is activated automatically with the railroad crossing arms as trains approach the grade crossings. The following specific information is provided regarding the AHS.

> Once activated by an approaching train, the AHS provides a full 30 to 35 seconds of audible warning in the sequence of two long blasts, a short blast, and then another long blast. The sequence is repeated until the train reaches the crossing.

> The AHS generates the warning from 3 fixed locations at each crossing, so the warning is focused in the locations and directions of oncoming vehicles and pedestrians. Since trains currently sound their horns within 1/4 mile of the crossings, the placement of the AHS right at the crossing significantly reduces the area along the railroad tracks exposed to elevated warning horn noise levels.
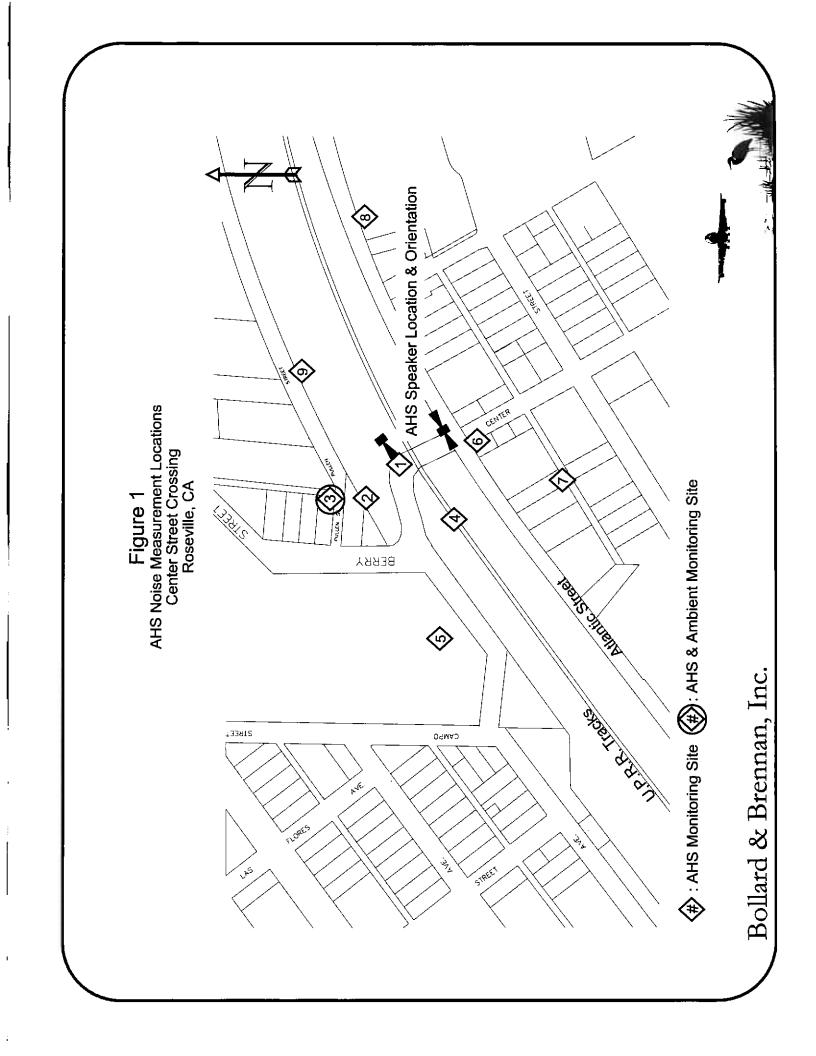
> The AHS warning was developed to generally "sound" like a locomotive warning horn.

> Since the implementation of the AHS at the Berry and Yosemite Street crossings, adjustments to the AHS have been made to better focus and adjust the intensity of the AHS output in response to system objectives and feedback from the local community.

AHS NOISE GENERATION

To quantify the noise emissions of the AHS, a series of noise level measurements were conducted on November 19 & 21, 2003 and on January 13, 2004 while the AHS was in operation. The measurements were conducted at the locations shown on Figures 1 and 2 using Larson Davis Laboratories (LDL) Model 820 precision integrating sound level meters. The meters were calibrated before and after use with an LDL Model CA200 acoustical calibrator to ensure the accuracy of the measurements. The equipment used meets all pertinent specifications of the American National Standards Institute for Type 1 sound level meters (ANSI S1.4).

At sites 3 and 15, monitoring was conducted for a continuous 48 hour period spanning November 19 & 20, 2003. The intent of the continuous monitoring was to quantify noise levels at these residential locations during both daytime and nighttime periods. The numerical results of the continuous noise monitoring conducted at sites 3 and 15 is shown in Appendix B, and is presented graphically in Figures 3 & 4 for the 24-hour period of November 19, 2003.

Figure 1
AHS Noise Measurement Locations
Center Street Crossing
Roseville, CA

AHS Speaker Location & Orientation

BERRY STREET

PULLEN ST.

N

U.P.R.R. Tracks

Atlantic Street

CENTER STREET

FLORES AVE.

CAMPO AVE.

LAS AVE.

: AHS Monitoring Site

⊕ : AHS & Ambient Monitoring Site

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Figure 2
AHS Noise Measurement Locations
Yosemite Street Crossing
Roseville, CA

AHS Speaker Location & Orientation

◈ : AHS Monitoring Site   ◉ : Ambient Monitoring Site

◈ : AHS Monitoring Site   ◉ : Ambient Monitoring Site

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Figure 3
Measured Ambient Noise Levels
116 Berry Street (Site #3)
Wednesday November 19, 2003

Sound Level, dBA

Hour of Day

Lmax Leq
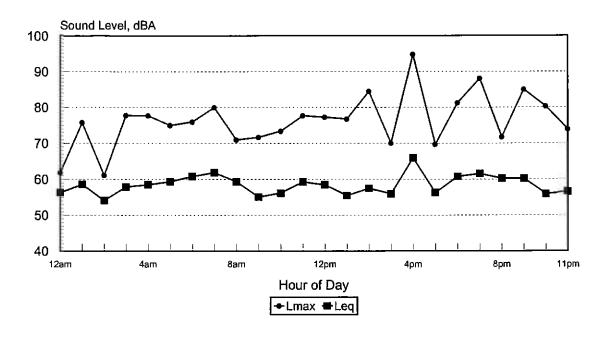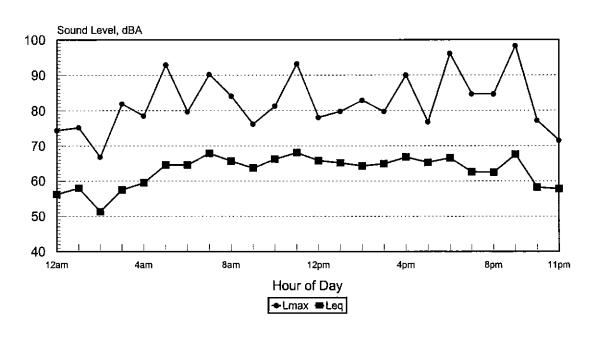
Figure 4
Measured Ambient Noise Levels
604 Atlanic Street (Site #15)
Wednesday November 19, 2003

Sound Level, dBA

Hour of Day

Lmax Leq

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The intent of the AHS noise measurement program was to quantify AHS noise emissions in terms of maximum noise levels to allow direct comparison to both maximum noise levels generated by conventional locomotive-mounted warning horns. The results of the AHS system noise tests are shown in Table 1.

Table 1
Noise Level Measurement Results
Berry and Yosemite Street Railroad Crossing Vicinity
November, 1999 - Roseville, California

Location	Measured AHS Maximum Noise Level
1	107
2	85
3	78
4	83
5	69
6	84
7	75
8	70[1]
9	70
10	97
11	74
12	66
13	N/A
14	72
15	75
16	N/A
17	72
18	58

Notes: Source - Bollard & Brennan, Inc.
N/A: Background noise levels were so high as to interfere with the measurement of the AHS.
[1]AHS sound levels barely exceeded background traffic noise levels at this location.

The Table 1 data indicate that the AHS generates its highest noise output directly beneath and in line with the AHS speaker. In general, it was not difficult to obtain noise readings of the AHS at the nearest locations. However, due to the presence of construction activities and local traffic it was not possible to quantify the AHS noise emissions at more distant locations without contamination of the sample from these sources.

The Table 1 data was used to develop noise contours for the AHS. Although measured background levels varied, the continuous data collected at sites 3 and 15 indicated that background maximum

noise levels seldom dipped below 70 dB during passages of local vehicles. As a result, the noise contours developed for this assessment were the 70 dB Lmax noise levels generated by the AHS. Those contours are shown on Figure 5.

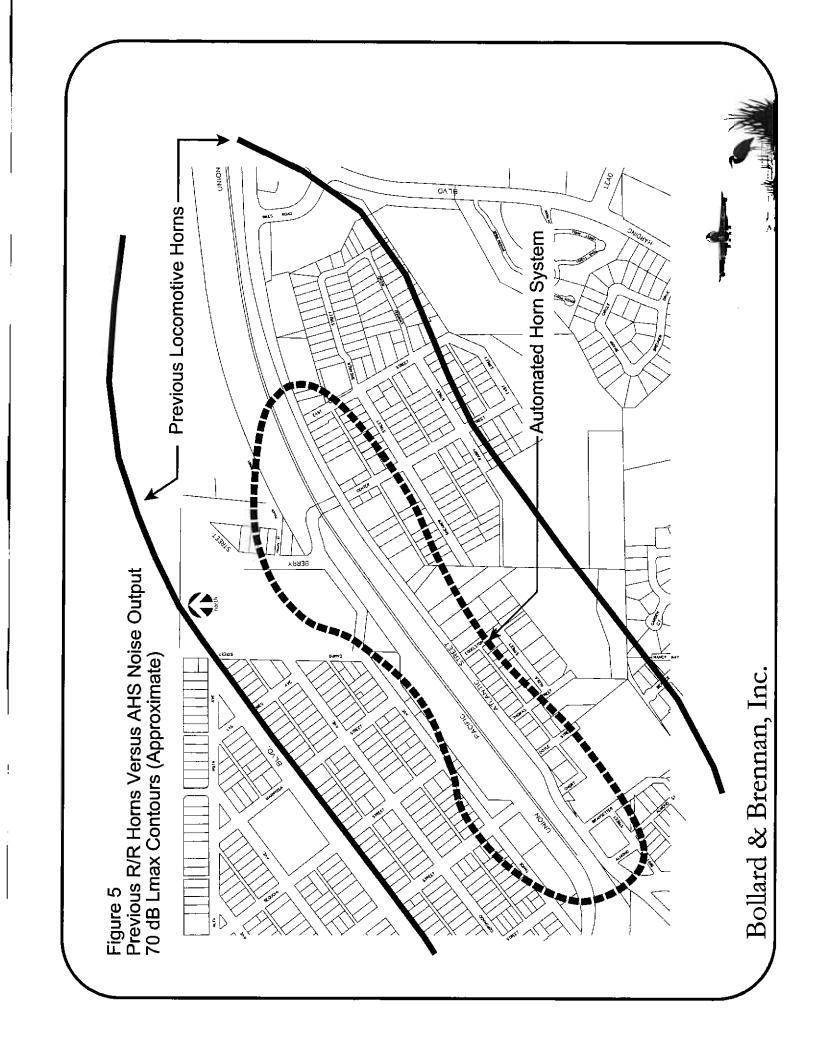**COMPARISON OF PREVIOUS WARNING HORN NOISE LEVELS TO A.H.S. LEVELS**

Figure 5 represents generalized noise contours for the existing warning horn usage along the Atlantic Street corridor, from 1/4 mile east of Center to 1/4 mile west of Yosemite. The Figure 5 contours do not account for all intervening shielding of various locations by existing structures, so the contours should be considered conservative. In addition, the Figure 5 contours apply only to warning horn usage, as locomotive and rail noise would not be affected by the AHS.

CONCLUSIONS

The Figure 5 contours data indicate that the overall noise "footprint" for the AHS is considerably smaller than that generated by the previous locomotive warning horns. It is important to restate, however, that the Figure 5 contours are approximate, since it is not possible to accurately account for all the shielding of railroad warning horn noise provided by intervening commercial, industrial and residential structures, particularly as you move deeper into the neighborhoods. Nonetheless, a conclusion of this study is that a substantial number of residents along the project study corridor have benefitted acoustically from reduced daytime and nighttime warning horn noise since the AHS has been implemented and adjusted at the Yosemite and Center Street crossings.

Compared to maximum noise levels associated with conventional railroad warning horns measured in 1999, the AHS resulted in a net reduction of approximately 15-20 dB at the nearest residences to the grade crossing. This is considered a significant decrease in maximum noise levels.

Bollard & Brennan make these conclusions based solely on the merits of the AHS in reducing warning horn noise levels in the community in the grade crossing vicinity, and on the noise level measurements conducted of the AHS in operation in Roseville, California by Bollard & Brennan, Inc. Staff. Bollard & Brennan Inc. does not make any claims, or offer any conclusions, regarding the ability of the AHS to safely warn pedestrians or motorists of oncoming trains, nor was Bollard & Brennan under contract with the City of Roseville or any other party to do so.

Figure 5
Previous R/R Horns Versus AHS Noise Output
70 dB Lmax Contours (Approximate)

Previous Locomotive Horns

Automated Horn System

north

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Appendix A
Acoustical Terminology

Acoustics   The science of sound.

Ambient Noise The distinctive acoustical characteristics of a given space consisting of all noise sources audible at that location. In many cases, the term ambient is used to describe an existing or pre-project condition such as the setting in an environmental noise study.

Attenuation   The reduction of an acoustic signal.

A-Weighting   A frequency-response adjustment of a sound level meter that conditions the output signal to approximate human response.

Decibel or dB Fundamental unit of sound, A Bell is defined as the logarithm of the ratio of the sound pressure squared over the reference pressure squared. A Decibel is one-tenth of a Bell.

CNEL   Community Noise Equivalent Level. Defined as the 24-hour average noise level with noise occurring during evening hours (7 - 10 p.m.) weighted by a factor of three and nighttime hours weighted by a factor of 10 prior to averaging.

Frequency   The measure of the rapidity of alterations of a periodic signal, expressed in cycles per second or hertz.

L_{dn}   Day/Night Average Sound Level. Similar to CNEL but with no evening weighting.

L_{eq}   Equivalent or energy-averaged sound level.

L_{max}   The highest root-mean-square (RMS) sound level measured over a given period of time.

Loudness   A subjective term for the sensation of the magnitude of sound.

Masking   The amount (or the process) by which the threshold of audibility is for one sound is raised by the presence of another (masking) sound.

Noise   Unwanted sound.

Peak Noise   The level corresponding to the highest (not RMS) sound pressure measured over a given period of time. This term is often confused with the "Maximum" level, which is the highest RMS level.

RT_{60}   The time it takes reverberant sound to decay by 60 dB once the source has been removed.

Sabin   The unit of sound absorption. One square foot of material absorbing 100% of incident sound has an absorption of 1 sabin.

Threshold of Hearing The lowest sound that can be perceived by the human auditory system, generally considered to be 0 dB for persons with perfect hearing.

Threshold of Pain   Approximately 120 dB above the threshold of hearing.

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Hour	Leq	Lmax	L50	L90
0	56.3	61.8	56	54
1	58.6	75.8	55	52
2	54.1	61.1	54	52
3	57.9	77.8	54	52
4	58.5	77.7	54	51
5	59.4	75.0	57	55
6	60.8	76.0	60	58
7	61.9	80.0	60	58
8	59.4	71.0	58	54
9	55.1	71.7	52	50
10	56.2	73.4	52	49
11	59.3	77.7	52	49
12	58.5	77.3	53	49
13	55.5	76.8	52	49
14	57.5	84.5	53	49
15	56.0	70.1	54	51
16	66.0	94.8	54	51
17	56.3	69.7	55	52
18	60.8	81.3	58	55
19	61.6	88.1	58	56
20	60.3	71.8	59	57
21	60.3	85.0	58	56
22	56.0	80.3	55	53
23	56.6	73.9	54	52

Statistical Summary

	Daytime (7 a.m. - 10 p.m.)			Nighttime (10 p.m. - 7 a.m.)		
	High	Low	Average	High	Low	Average
Leq (Average)	66.0	55.1	60.1	60.8	54.1	58.0
Lmax (Maximum)	94.8	69.7	78.2	80.3	61.1	73.2
L50 (Median)	60.3	52.0	55.3	59.8	53.6	55.3
L90 (Background)	58.0	48.8	52.3	58.5	51.4	53.3

Computed Ldn, dB	64.8
% Daytime Energy	73%
% Nighttime Energy	27%

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Appendix B
116 Berry Street (Site #3)
Continous 24hr Monitoring
Thursday November 20, 2003

Hour	Leq	Lmax	L50	L90
0	52.4	67.0	52	50
1	51.7	61.5	51	49
2	54.9	72.2	50	47
3	58.8	77.1	51	48
4	56.0	75.3	53	51
5	55.6	63.8	55	54
6	58.4	65.2	58	56
7	63.0	76.4	60	58
8	61.5	78.2	59	56
9	57.8	72.7	56	53
10	61.8	82.1	54	51
11	58.7	77.8	55	52
12	58.7	82.7	55	52
13	59.8	80.6	55	52
14	60.4	80.9	54	52
15	55.6	67.2	55	51
16	61.0	82.4	55	52
17	61.1	80.9	55	51
18	57.2	72.2	56	53
19	57.9	74.9	57	55
20	57.8	68.0	58	56
21	57.0	70.8	55	53
22	54.7	68.3	54	52
23	55.4	74.0	53	50

Statistical Summary

	Daytime (7 a.m. - 10 p.m.)			Nighttime (10 p.m. - 7 a.m.)		
	High	Low	Average	High	Low	Average
Leq (Average)	63.0	55.6	59.8	58.8	51.7	55.9
Lmax (Maximum)	82.7	67.2	76.5	77.1	61.5	69.4
L50 (Median)	60.1	53.9	55.8	57.8	49.6	52.9
L90 (Background)	58.2	51.0	53.1	55.8	47.1	50.5

Computed Ldn, dB	63.1
% Daytime Energy	80%
% Nighttime Energy	20%

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604 Atlantic Street (Site #15)
Continous 24hr Monitoring
Wednesday November 19, 2003

Hour	Leq	Lmax	L50	L90
0	56.2	74.4	51	47
1	58.0	75.2	50	46
2	51.3	66.8	48	44
3	57.5	81.9	49	46
4	59.5	78.5	50	46
5	64.6	92.9	55	50
6	64.6	79.7	61	54
7	67.9	90.2	66	58
8	65.7	84.1	64	56
9	63.7	76.2	62	51
10	66.3	81.3	62	52
11	68.1	93.2	63	54
12	65.8	78.1	64	55
13	65.2	79.8	64	55
14	64.3	82.9	63	54
15	64.9	79.7	64	55
16	66.8	90.0	65	56
17	65.3	76.8	65	57
18	66.6	96.1	63	56
19	62.6	84.7	60	52
20	62.5	84.7	60	53
21	67.6	98.3	58	52
22	58.2	77.2	54	48
23	57.8	71.6	52	46

Statistical Summary

	Daytime (7 a.m. - 10 p.m.)			Nighttime (10 p.m. - 7 a.m.)		
	High	Low	Average	High	Low	Average
Leq (Average)	68.1	62.5	65.9	64.6	51.3	60.3
Lmax (Maximum)	98.3	76.2	85.1	92.9	66.8	77.6
L50 (Median)	65.5	58.3	62.7	61.4	47.6	52.0
L90 (Background)	57.9	51.3	54.3	54.2	44.5	47.5

Computed Ldn, dB	68.1
% Daytime Energy	86%
% Nighttime Energy	14%

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Appendix B
604 Atlantic Street (Site #15)
Continous 24hr Monitoring
Thursday November 20, 2003

Hour	Leq	Lmax	L50	L90
0	52.9	66.8	46	43
1	52.0	69.6	45	42
2	65.8	96.4	44	40
3	57.2	75.4	46	42
4	55.0	74.3	46	44
5	57.4	72.3	51	47
6	62.5	75.0	59	50
7	66.9	82.3	64	57
8	65.2	77.0	63	57
9	63.7	79.4	61	53
10	64.6	80.2	62	54
11	64.3	80.1	62	54
12	63.8	75.6	62	53
13	64.6	83.4	63	57
14	64.9	82.5	62	54
15	64.0	78.6	63	56
16	65.5	78.9	64	57
17	65.5	78.8	64	57
18	63.4	77.3	62	55
19	61.7	77.7	59	52
20	60.2	73.5	58	50
21	59.1	71.2	57	49
22	58.0	76.6	53	45
23	56.4	74.1	49	43

Statistical Summary

	Daytime (7 a.m. - 10 p.m.)			Nighttime (10 p.m. - 7 a.m.)		
	High	Low	Average	High	Low	Average
Leq (Average)	66.9	59.1	64.2	65.8	52.0	59.7
Lmax (Maximum)	83.4	71.2	78.4	96.4	66.8	75.6
L50 (Median)	64.2	56.6	61.8	59.4	43.8	48.7
L90 (Background)	57.5	49.1	54.3	50.2	40.4	44.0

Computed Ldn, dB	67.1
% Daytime Energy	83%
% Nighttime Energy	17%

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