Environmental Noise Analysis

Automated Railroad Warning Horn Systems

City of Roseville, California
Bollard & Brennnan Job # 99-156

Prepared For:

City of Roseville
Department of Housing and Redevelopment
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EXECUTIVE SUMMARY

Bollard & Brennan Inc. has completed an analysis of the relative noise emissions of conventional locomotive-mounted railroad warning horns versus the noise emissions of the Automated Horn System (AHS). The analysis was based on extensive noise measurement surveys of both existing ambient conditions and the AHS system in operation. The results of the analysis indicate that a substantial reduction in warning horn noise exposure could be realized in the residential neighborhoods in the immediate vicinity of the Yosemite and Center railroad crossings if the AHS were implemented at those locations. This conclusion is based on the fact that the AHS focuses the warning sound at the affected locations, rather than spread it along the entire corridor as do conventional locomotive warning horns.

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, the build to the highest levels at the train passes. With the AHS, the warning noise exposure at the nearest residences would be uniformly and continuously high throughout the train approach and entry into the grade crossing. Therefore, if the AHS system is implemented at these crossings, Bollard & Brennan recommends that an attitudinal study be conducted during a probationary period to assess the acceptance of the system by residences in the nearby community, both close to and somewhat removed from the grade crossings.

INTRODUCTION

The acoustical consulting firm of Bollard & Brennan, Inc. was retained by the City of Roseville to conduct a noise assessment for an automated railroad warning horn system at the Yosemite and Center Street railroad grade crossings in the City of Roseville, California.

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. A description of AHS is provided in a subsequent section of this report. The City of Roseville commissioned this study to determine if the use of the AHS could reduce overall railroad warning horn usage noise exposure within the neighborhoods located nearest to the Yosemite and Center Street railroad grade crossings.

Information cited in this report pertaining to the AHS system features and operation was obtained from field observations and noise measurements conducted by Bollard & Brennan, Inc. in Roseville on the afternoon of June 4, 1999, as well as from the Automated Horn Systems Internet Web Page (http://members.home.net/merrilla).

DESCRIPTION OF EXISTING RAILROAD WARNING HORN OPERATIONS

Existing railroad warning horn usage in Roseville typically consists of the train engineer sounding the locomotive mounted warning horn for various durations as it approaches within 1/4 mile of a grade crossing until it enters the crossing. Because the distance between the Yosemite and Center Street crossings is approximately ½ mile, warning horns are currently used along the entire study corridor from 1/4 mile east of the Center Street crossing to 1/4 mile west of the Yosemite Street Crossing. The locations west of those crossings are affected by eastbound train horn usage, whereas the locations east of those crossings are affected by westbound trains sounding their horns as they approach the crossings.

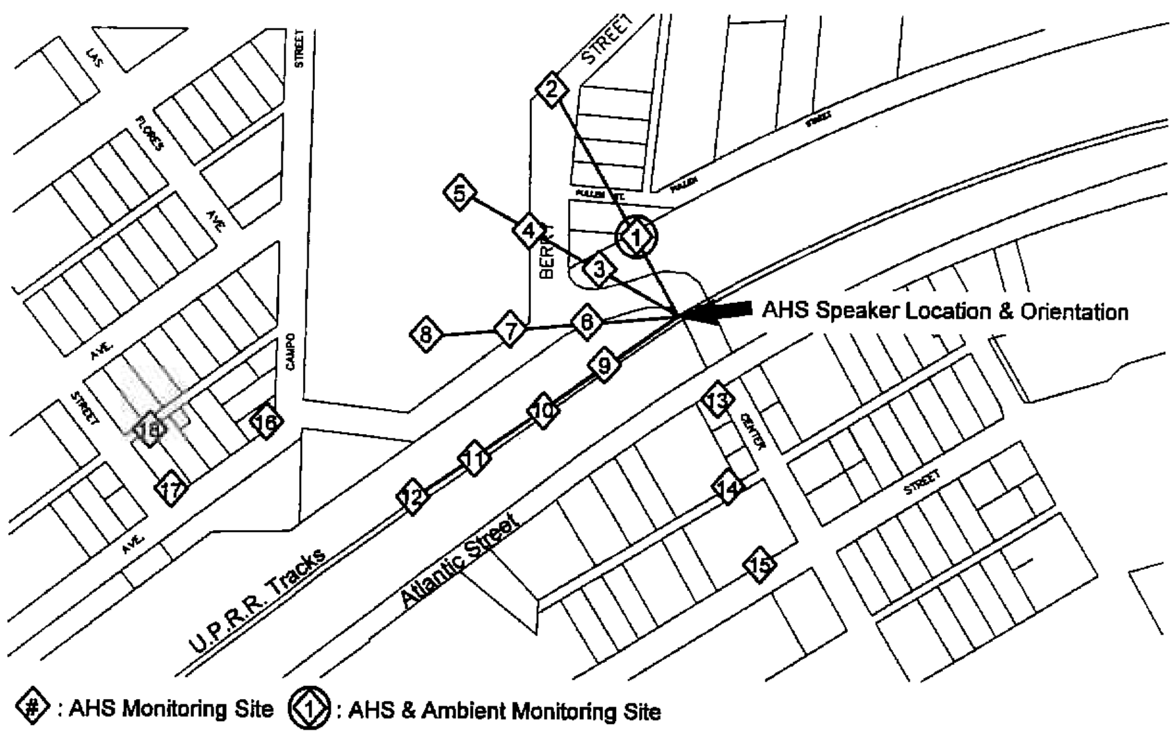
The sound intensity generated by locomotive-mounted railroad warning horns was observed by Bollard & Brennan, Inc. to be a function of the duration of horn usage. That is, longer horn soundings are louder than relatively short soundings. Further observations indicated that locomotive-mounted warning horn usage was not uniform from one train to the next. Some engineers sound the warning horns at these crossings for several short bursts while others use fewer but longer soundings as the trains approach the intersections. Existing railroad warning horn noise levels are discussed in a later section of this report.

EXISTING AMBIENT AND WARNING HORN NOISE LEVELS

In order to assess the degree by which the AHS may reduce overall noise exposure along the project study corridor, it is necessary to quantify existing ambient noise conditions. To that end, ambient noise monitoring was conducted at two locations for a continuous period of 92 hours at each site. The objective of the ambient noise measurement program was to quantify ambient noise levels in general, as well as specific railroad warning horn noise emissions.

The ambient noise measurement sites represent two of the nearest existing residences to the Yosemite and Center Street grade crossings. Specifically, the back yard of the residence located at 100 Berry Street was selected due to its proximity to the Center Street crossing, and the front patio of the residence located at 255 Tahoe Avenue was selected due to its proximity to the Yosemite Street crossing. The continuous noise measurement locations are shown on Figures 1 and 2.

Figure 1
Center Street Crossing Test Noise Measurement Locations



Larson Davis Laboratories (LDL) Model 820 precision integrating sound level meters were used for the noise level measurement survey. 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).

The meters were programmed to log hourly interval data consisting of the maximum, average and background noise levels in each hour, in addition to other statistical data. The meters were also programmed to record individual loud events when thresholds for loudness and duration of noise levels were exceeded. The intent of the exceedance monitoring was to extract railroad noise from the overall ambient noise measurement results.

Figure 2
Yosemite Street Crossing Test Noise Measurement Locations

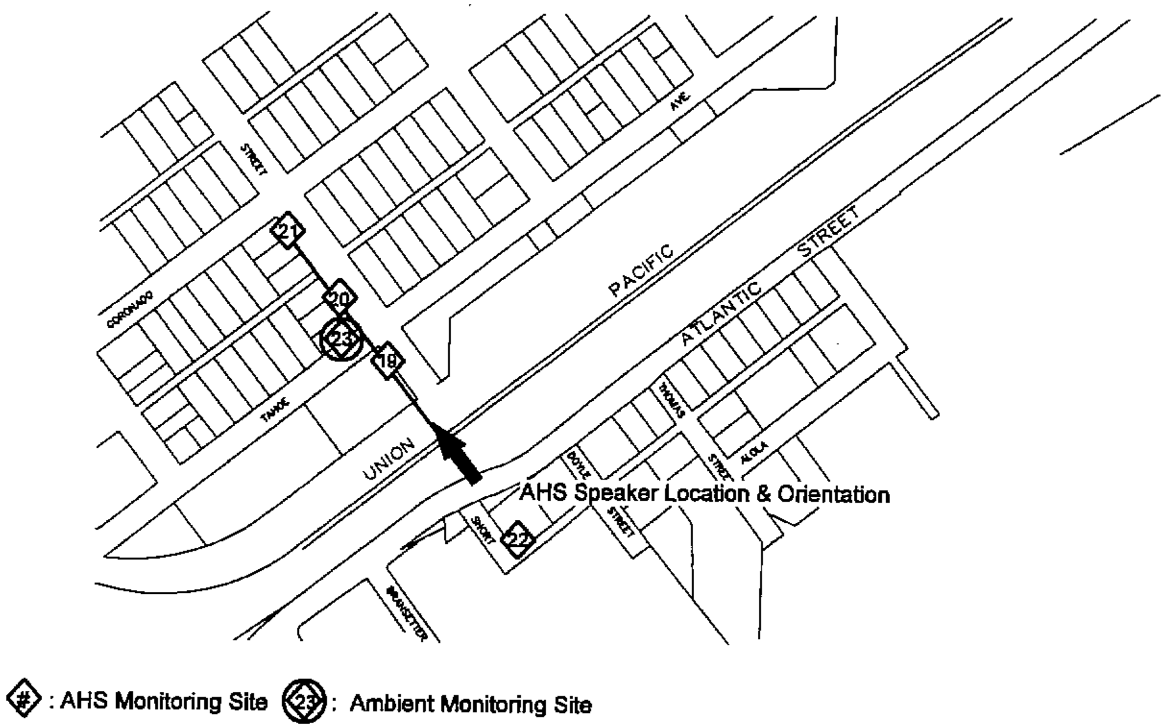


Table 1 shows a summary of the continuous ambient noise measurement results. Figures 3 and 4 show a graphical depiction of the changes in maximum and background noise levels over the 4-day monitoring period. In general, maximum noise levels shown in Figures 3 and 4 are representative of railroad warning horn usage, whereas the background noise levels represent the quietest 10% of the hour (generally excludes railroad events).

Table 1
Ambient Noise Measurement Results
Nearest Residents to Yosemite and Center Street Railroad Crossings
Roseville, California

Location	Date	Maximum Levels (Lmax) Day	Maximum Levels (Lmax) Night	Background Levels (L90) Day	Background Levels (L90) Night
100 Berry Street	June 5	87	83	48	47
	June 6	87	78	45	45
	June 7	88	85	48	47
255 Tahoe Street	June 5	88	87	52	50
	June 6	87	83	50	46
	June 7	90	86	54	52

Source: Bollard & Brennan, Inc.
Data represent mean values for the indicated day and nighttime periods.
Daytime hours are 7 am to 10 pm.
Nighttime hours are 10 pm to 7 am.

The Table 1 data indicate that existing maximum noise levels at the two nearest residences to the railroad tracks are relatively high, averaging in the mid to upper 80's during both day and nighttime periods. The reported maximum noise levels are believed to be caused primarily by railroad warning horn usage, although it is possible that particularly loud vehicles may, in some cases, have generated the hourly maximums.

Figure 3
Measured Ambient Noise Levels
Site 1 - 100 Berry Street - June 4-8, 1999
(Shaded areas represent nighttime hours)

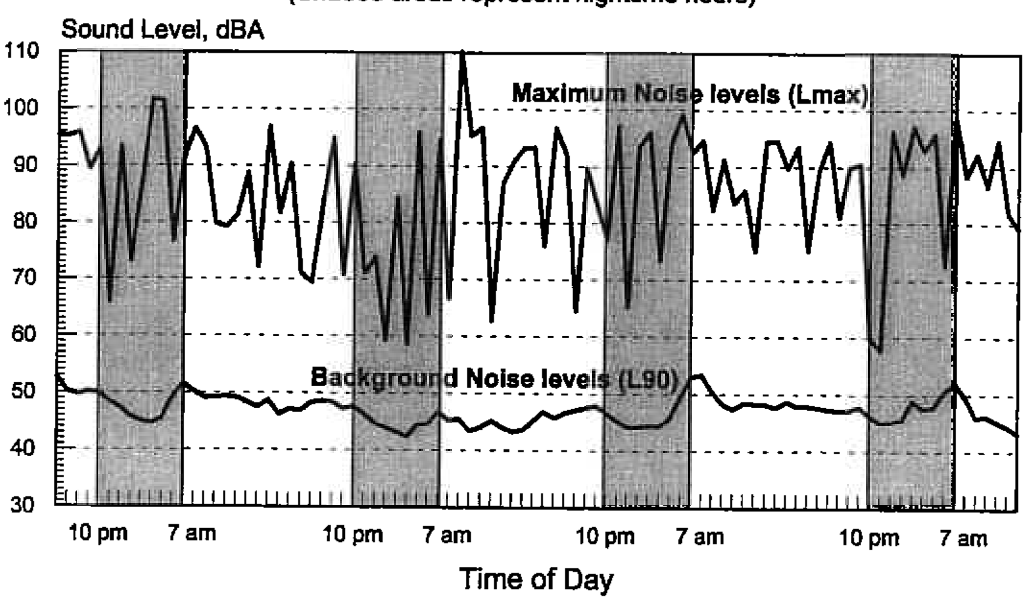
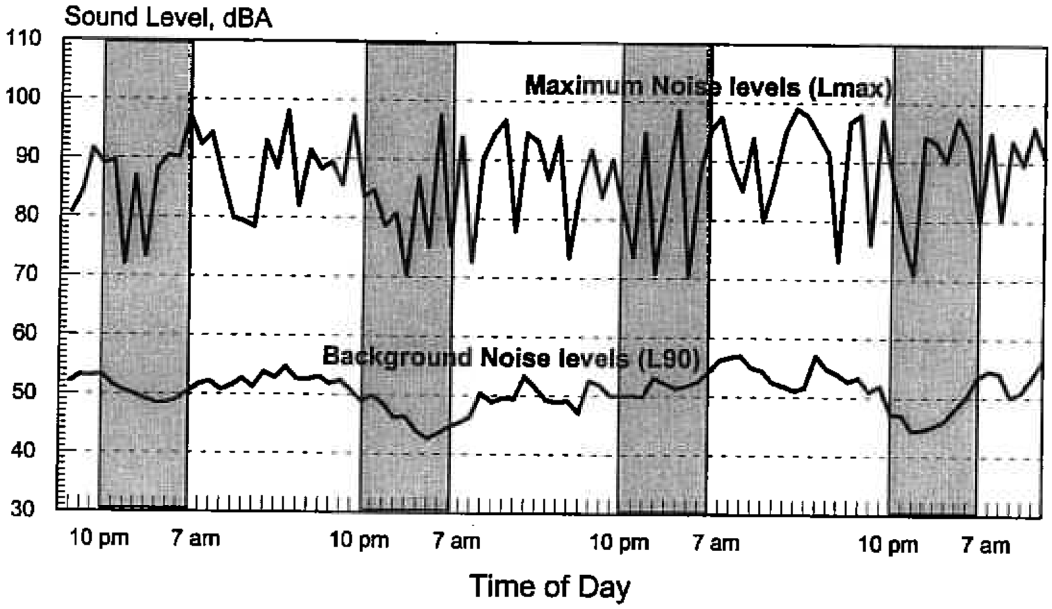


Figure 4
Measured Ambient Noise Levels
Site 23 - 255 Tahoe Street - June 4-8, 1999
(Shaded areas represent nighttime hours)

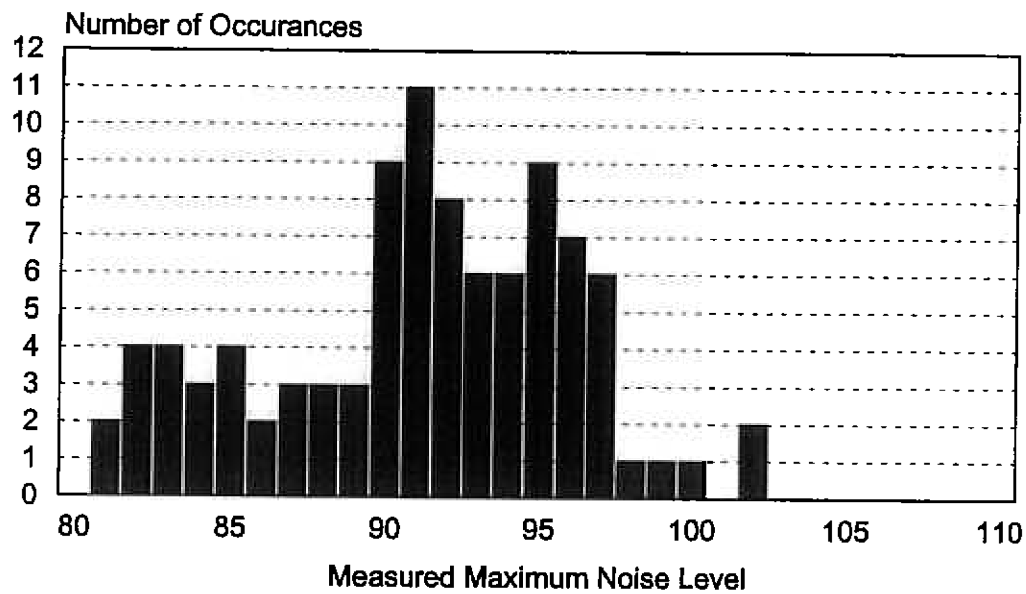


The background noise levels reported in Table 1 and shown on Figures 3 and 4 generally represent the levels in the residential community nearest the railroad tracks when no trains or significant traffic volumes are present. although considerably lower than the maximum values, are nonetheless relatively high as compared to typical residential areas. The background levels are reported primarily to establish a baseline conditions against which the comparison of conventional versus AHS warning noise levels can be compared.

An analysis of the noise level exceedance data collected at both locations indicates that there were approximately 80-90 events which satisfied the exceedance thresholds for identification as a probable railroad noise event. The data which are believed to be likely railroad events were analyzed to determine the range of existing maximum noise levels generated y warning horn usage in the immediate vicinity of the Yosemite and Center Street crossings. The results of the frequency distribution analysis are shown in Figures 5 and 6.

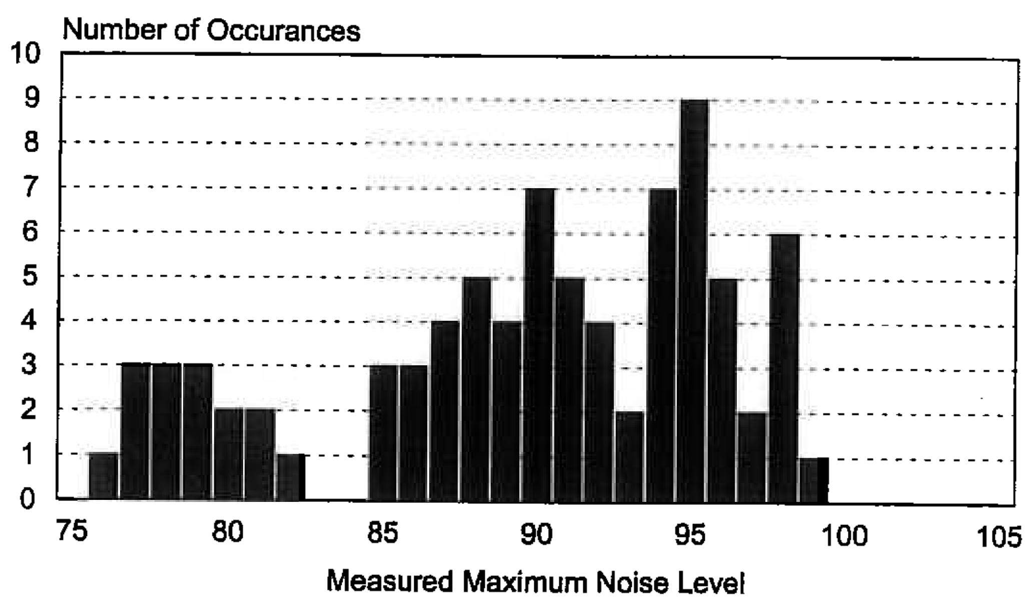
The Figure 5 and 6 data indicate that the maximum warning horn noise levels which occur at the nearest residences to the grade crossings with the greatest frequency are those in the range of 90 to 95 dB Lmax. Therefore, this range of maximum noise levels was used to establish baseline conditions for the existing warning horn usage along the project corridor. The differences in the number of probable railroad events between the two sites is due to local variables such as surface street traffic, distance to the railroad tracks, and shielding of those tracks by intervening structures.

Figure 5
Frequency of Occurance Analysis
Existing Warning Horn Maximum Noise Levels
Site 1 - 100 Berry Street - June 4-8, 1999



Note: This frequency distribution is based on an estimated 95 railroad operations recorded at this location

Figure 6
Frequency of Occurance Analysis
Existing Warning Horn Maximum Noise Levels
Site 23 - 255 Tahoe Avenue - June 4-8, 1999



Note: This frequency distribution is based on an estimated 82 railroad operations recorded at this location

DESCRIPTION OF THE AUTOMATED HORN SYSTEM (AHS) OPERATIONS

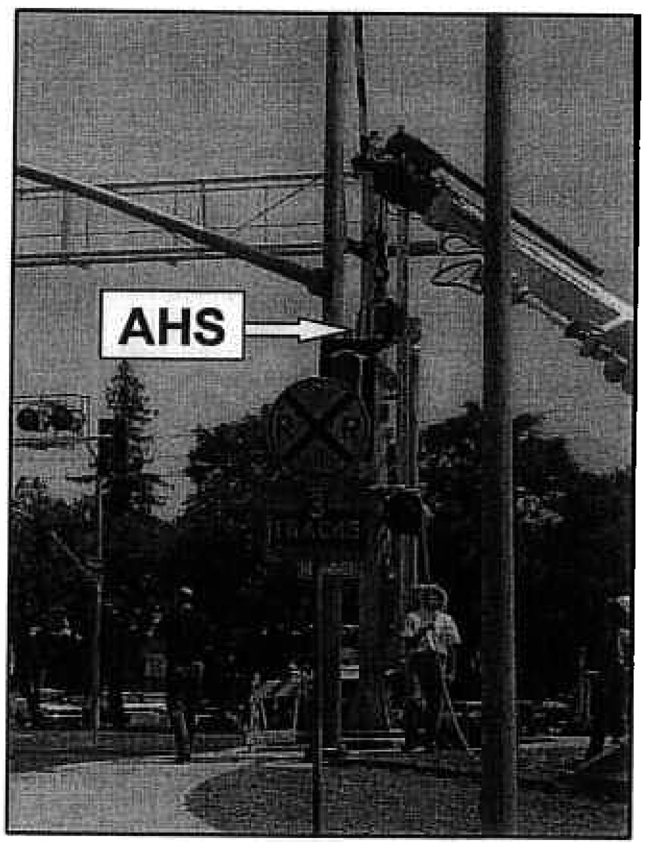
The automated horn system consists of horns mounted in cases on poles in close proximity to railroad grade crossings. The AHS is activated automatically with the railroad crossing arms as trains approach the grade crossings. The following specific information is provided regarding the AHS.

- 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 a fixed location over the grade crossing, so the warning is focused in the location and direction 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. A photograph of the AHS in the June 4, 1999 test configuration is shown in Figure 7.

Figure 7
AHS System Test Location and Configuration
Cedar Street Crossing - Roseville, California - June 4, 1999



AUTOMATED HORN SYSTEM (AHS) NOISE EMISSIONS

To quantify the noise emissions of the AHS, a series of noise level measurements was conducted on the afternoon of June 4, 1999 while the AHS was in operation. The measurements were conducted at the locations shown on Figures 1 and 2 using similar sound level measurement instrumentation as previously reported for the ambient noise survey.

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 existing maximum noise levels generated by conventional locomotive-mounted warning horns. An additional objective of the noise measurement survey was to determine the directionality of the AHS, as well as the rate at which AHS noise decays with increasing distance from the noise source. The results of the AHS system noise tests are shown in Table 2.

Table 2
Automated Horn System Test Results
June 4, 1999 - Roseville, California

Location	Distance from AHS	Off-Axis Angle (degrees)	Measured Maximum AHS Level
1	150	60	79
2	600	60	58
3	200	30	81
4	400	30	64
5	600	30	61
6	200	0	84
7	400	0	76
8	600	0	75
9	200	30	83
10	400	30	79
11	600	30	—
12	800	30	65
13	200	120	—
14	400	120	—
15	600	120	—
16	900	15	57
17	1100	15	—
18	1200	15	48
19	200	0	—
20	400	0	75
21	600	0	73
22	300	180	69
22	300	0	81

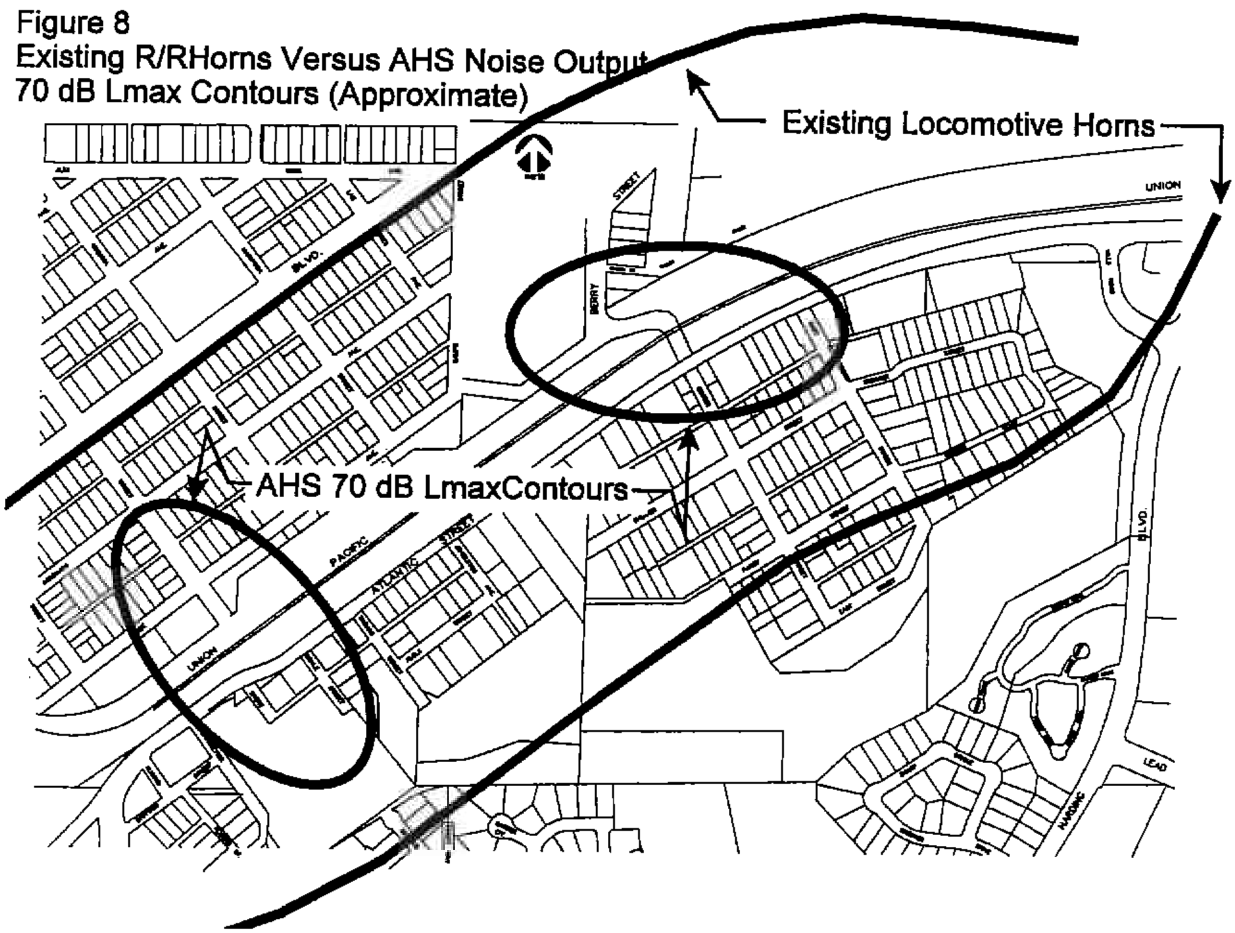
Notes: Source - Bollard & Brennan, Inc.
— means that background noise levels were so high as to interfere with the measurement of the AHS.

As expected, the Table 2 data indicate that the AHS generates its highest noise output perpendicular to, and in front of, the AHS speaker. The data also indicate that the decay rate of the speaker loosely followed a theoretical value of 6 dB per doubling of distance from the source. In addition, the measurement results at location 22 indicate that the difference in noise levels of the AHS when pointed directly towards and 180 degrees away from the receiver was approximately 12 dB. 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 all locations without contamination of the sample from these sources.

COMPARISON OF EXISTING WARNING HORN NOISE LEVELS TO A.H.S. LEVELS

Figure 8 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 8 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 8 contours apply only to warning horn usage, as locomotive and rail noise would not be affected by the AHS.

Figure 8
Existing R/RHorns Versus AHS Noise Output
70 dB Lmax Contours (Approximate)



CONCLUSIONS

The Figure 8 data indicate that the overall noise "footprint" for the AHS is considerably smaller than the existing warning horns. It is important to restate, however, that the Figure 8 contours are very 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 it is likely that a substantial number of residents along the project study corridor would benefit from reduced nighttime warning horn noise if the AHS were successfully implemented at the Yosemite and Center Street crossings.

It should be noted, however, that the sound of the AHS is different than that generated by locomotive warning horns, despite efforts to make them similar. One resident in the immediate vicinity of the Center Street intersection expressed concern about their ability to sleep with the new AHS constantly sounding near their residence at uniform intensity. This concern is legitimate and, if the AHS system is implemented, Bollard & Brennan recommend that an attitudinal study be conducted at various intervals and locations to measure public reaction to the system operation.

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 on the afternoon of June 4, 1999. In so doing, Bollard & Brennan do 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.