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Wilmington School & Residence
Sound Attenuation Program

Report #3: Noise Contour Development Methodology Report



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Prepared By:



Landrum & Brown

27812 El Lazo Road
Laguna Niguel, CA 92677
Fred Greve P.E.
Matthew B. Jones P.E.

Prepared for:



Harbor Community Benefit Foundation

150 W. 6th Street, Suite 100B
San Pedro, CA 90731

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1.0 INTRODUCTION

This is the third report produced for the Harbor Community Benefit Foundation's (HCBF) Wilmington School and Residence Sound Attenuation Program. This report documents the methodology and assumptions used to generate the noise contour maps that are being delivered concurrently with this report.

2.0 NOISE LEVEL CALCULATION METHODOLOGY

The measurement survey showed that there are two primary sources of noise that are related to port activity and impact residences or schools; trucks and trains. The sections below present the methodologies used to calculate noise levels from these two sources. Section 2.1 discusses train noise and Section 2.2 discusses truck noise.

2.1 Rail Lines

Trains can be separated into three distinct noise sources, the locomotive, the cars, and the warning horn. The locomotive causes the maximum pass-by noise level when the warning horn is not being sounded. The warning horn is much louder than the locomotive and generates the maximum train noise level when sounded. The noise from the rail cars is considerably less than the warning horn and the locomotive but contribute to the Leq noise level generated by the train passes.

Rail lines generate considerably higher noise levels along rail sections where warning horns must be sounded. The Federal Rail Agency (FRA) train horn rule requires locomotive operators to sound their horn four times in the 15 or 20 seconds before crossing a roadway at-grade. In the Wilmington Area, this results in locomotives sounding their warning horns within 1,000 feet of an at-grade rail crossing. Outside of these areas the locomotive engines are the dominant source of noise causing the Lmax noise level. The methodology to used to calculate the maximum noise levels in horn zones is discussed in Section 2.1.1 and the methodology used to calculate the maximum noise levels from locomotives is discussed in Section 2.1.2. The Federal Rail Agency rail noise model was used to estimate Leq noise levels from the rail lines. This is discussed in Section 2.1.3

2.1.1 Locomotive Warning Horn Maximum Noise Levels

Locomotive horn Lmax contours were developed based on measurement data performed by Volpe Laboratories for the Federal Railroad Administration (FRA) during their development of the Train Horn Quiet Zone rules (Rapoza & Fleming, 2002). These measurements were performed to document the differences in the sound radiation patterns from locomotive warning horns of different models and mounting locations.

Five different models of warning horns typically in use were tested. These horns had between three and five "chimes" (i.e., horns with different fundamental frequencies) and included three with all chimes facing forward and two with forward facing and rear facing chimes. The horns were mounted in one of four typical locations, on the cab roof near the front of the locomotive, on the roof near the center of the locomotive, on the front hood of the locomotive in front of the cab, and above the coupler at the front of the locomotive. Each of the horn models were tested at each of the mounting locations on two locomotives. This was done to assess the effect of the type of locomotive on the sound radiation patterns.

The roof mounting locations are 16 feet above the ground while the front hood and coupler installations were 12 feet and 3 feet above the ground. The analysis found that the roof mounted horns generated higher noise levels because the lower mounting points resulted in more ground attenuation resulting in lower noise levels around the locomotive. Additionally, the

noise reduction provided by noise barriers along the rail line will be greater for the lower mounting locations than the roof locations. Therefore, the roof location noise levels, front and center were used to generate a composite noise level representing the maximum noise levels from either mounting location.

For the FRA study, horn noise levels were measured in 45° increments around the locomotives at distances of 100 feet and 200 feet from the horn. The results of the measurements are presented in a polar plot (sound level versus direction on a polar chart) in the report and this graphic was used to determine the horn sound levels in 15° increments for the two horn locations and two measurement distances. This data was normalized to set the maximum noise level 100 feet from the horn to 110 dBA which is the maximum level allowed by the FRA's regulations. The average of the normalized sound levels based on the 100 foot and 200 foot measurement distances were calculated for each mounting location. The measurements were nearly but not exactly symmetrical along the length of the locomotive. Therefore, the average of the symmetrically located points on either side of the locomotive was used to make the horn sound levels symmetrical.

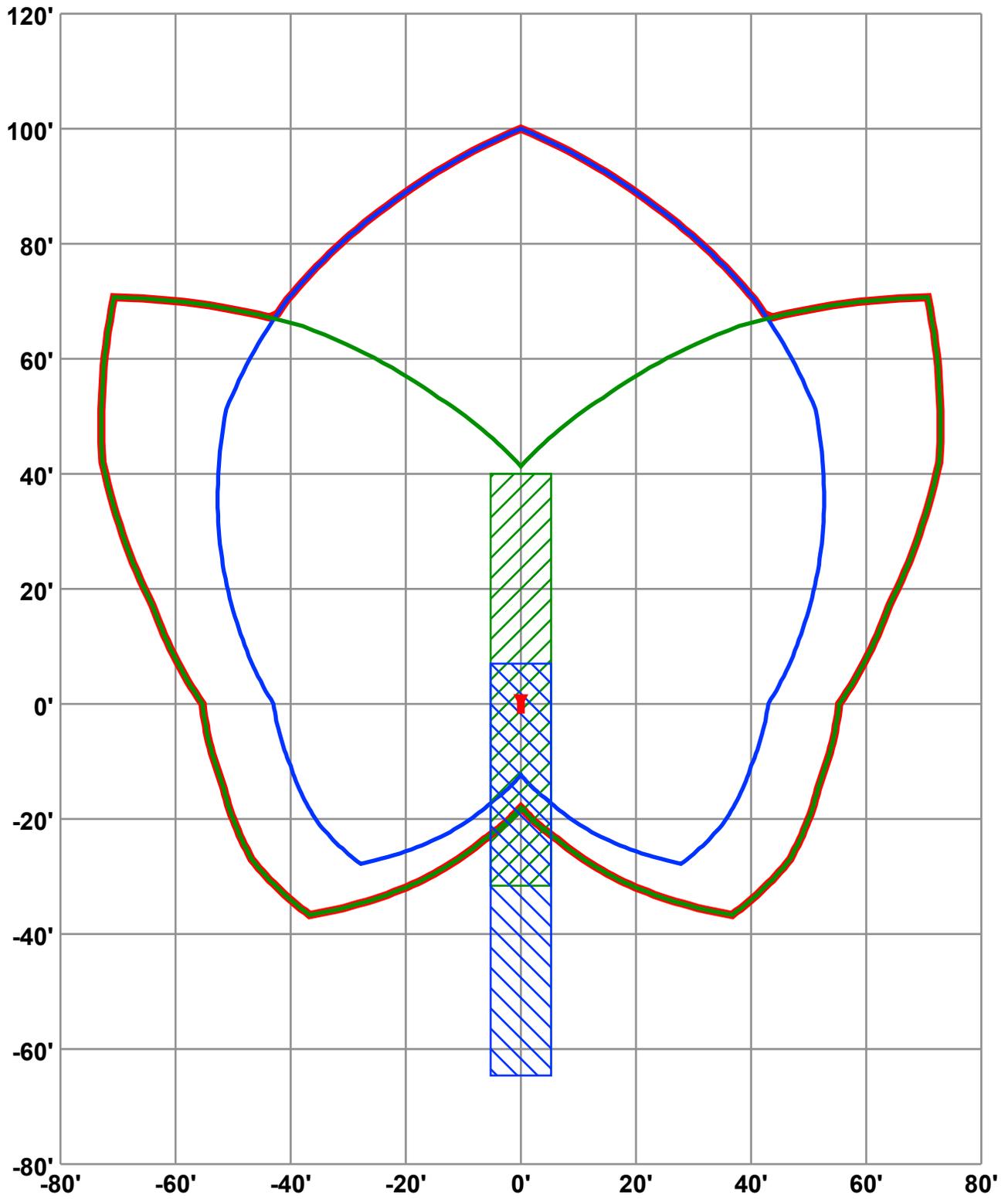
Figure 1 presents the 110 dB contours for the front and center mounted horn locations developed from the FRA measurement data as discussed above. This graphic shows that the center mounted horn results in a considerably lower noise level directly in front of the locomotive, about 8 dB, but the noise levels at $\pm 45^\circ$ are higher, by about 3 dB. A composite contour, consisting of the higher noise level in each direction, as shown in Figure 1, was used to map the train horn Lmax contours.

Train horn noise levels estimated using the FRA measurement data were compared to the noise levels measured during the noise measurements performed in the first task of this project. The FRA data was found to provide a worst-case estimate of the maximum train horn noise levels experienced in the project area. This analysis was also used in the development of the noise contour maps to estimate drop off rates and barrier effects.

The FRA train horn rule requires locomotive operators to sound their horn four times as they approach an at-grade rail crossing. The soundings are to occur in the 15 to 20 seconds prior to the arrival at the intersection. During the noise measurements performed for this program the trains were observed operating at relatively slow speeds on the order of 25 mph or less. At a speed of 25 mph the train travels 733 feet in 20 seconds. To account for variations in timing of the soundings as they are performed when the conductor estimates that they are 20 seconds from the intersection, the contour maps were developed assuming that the train horns would begin sounding 1,000 feet from each crossing. The contours represent conditions where the horn is sounded the entire distance because the soundings can take place at any point within this distance. Therefore, the contours represent the maximum sound levels experienced from a large number of train passes. For each individual train pass there would be contours from four locations similar to those shown in Figure 1 but lengthened depending on the length of the blast and the speed of the train.

2.1.2 Locomotive Maximum Noise Levels

The Federal Rail Administration has developed a railroad noise model. The FRA Rail Noise Model (Carl E. Hanson, 2006) does not calculate maximum noise levels and the source noise level used to calculate Leq for a locomotive is in terms of the Single Event Noise Level (SEL) which is a measure of the total noise energy from a locomotive pass by. Generally, the Lmax noise level from a pass at constant speed is approximately 10 dB lower than the SEL level. This results in the estimate that a locomotive passing by at approximately 25 miles per hour will generate an Lmax noise level of 88 dBA. This assumption matched well with the noise measurements performed previously.



110 dBA Lmax Contour	Locomotive Position	Horn Location
<ul style="list-style-type: none"> — Front Mounted Horn — Center Mounted Horn — Composite 	<ul style="list-style-type: none"> Front Mounted Horn Center Mounted Horn 	

**Figure 1 - Locomotive Horn
110 dB Lmax Contour**

Table 1 presents the distance to the Locomotive Lmax Contours. Note that these distances are based on direct line-of-sight with no intervening barriers.

Table 1
Distance To Locomotive Lmax Noise Contours*

Lmax	Distance (ft.)
95	22
90	40
85	71
80	125
75	223
70	397
65	705
60	1,254

* Feet from centerline of rail with no intervening barriers.

2.1.3 Train Leq (H) Noise Levels

The train Leq contours were developed using FRA Rail Noise Model (Carl E. Hanson, 2006). This methodology calculates the Leq noise levels from the locomotive, rail cars, and warning horns. The model calculates Leq noise levels for three areas; (1) outside the horn zone, (2) within horn zone and more than 500 feet from the crossing, and (3) at the crossing. Between 500 feet from a crossing and the crossing itself, the noise level changes linearly with distance from the 2nd to the 3rd areas.

Based on our measurements and observations the maximum number of trains passing by any one location in an hour during the day is four. There were often two locomotives per train and 40 cars. This data was used to calculate the distances to daytime Leq (H) contours which are presented below in Table 2. One fewer train per hour would lower the Leq (H) by approximately 1 dB and one additional train per hour would raise the Leq (H) by approximately 1 dB. The noise levels presented in Table 2 were found to agree well with the noise levels measured in Task 1 of the project.

Table 2
Distance to Daytime Train Leq (H) Noise Contours*

Leq (H)	Outside Horn Zone	Within Horn Zone	
		>500' from Crossing	At Crossing
85	--	19	37
80	--	61	116
75	19	193	367
70	60	611	1,159
65	191	1,933	3,666
60	603	6,112	11,594
55	1,908	19,327	36,664
50	6,033	61,118	115,941

* Feet from centerline of rail with no intervening barriers.
 -- Noise level not exceeded outside of tracks.

During the nighttime hours up to two trains per hour were observed passing at any one rail segment adjacent to a residential area. This results in the nighttime Leq (H) noise level being 3 dB lower than the daytime level. Table 3 presents the distances to the noise contours for two trains passing in an hour.

Table 3
Distance to Nighttime Train Leq (H) Noise Contours*

Leq (H)	Outside Horn Zone	Within Horn Zone	
		>500' from Crossing	At Crossing
85	--	18	10
80	--	58	31
75	10	183	97
70	30	580	306
65	95	1,833	966
60	302	5,797	3,056
55	954	18,332	9,664
50	3,017	57,971	30,559

* Feet from centerline of rail with no intervening barriers.
 -- Noise level not exceeded outside of tracks.

2.2 Trucks

Truck noise levels were calculated using the Federal Highway Administration's (FHWA) Traffic Noise Model (TNM) version 2.5 (Menge & Rossano, 1998). Unlike the FRA's rail noise model, TNM uses maximum noise levels by vehicle type as the basis calculate Leq (H) noise levels. Maximum truck noise levels are discussed in Section 2.2.1 and Leq (H) noise levels are discussed in Section 2.2.2.

2.2.1 Maximum Noise Levels

As discussed above, FHWA's TNM calculates Leq (H) noise levels. However, this calculation is based on Reference Mean Emission Levels (ReMELs) for various vehicle types, operating conditions, and speed. These ReMELs are actually the maximum pass-by noise level at a distance of 50 feet. The vehicle types included in TNM are automobiles, medium trucks, heavy trucks, busses, and motorcycles. The heavy truck vehicle type represents noise levels generated by container trucks. TNM includes heavy truck ReMELs for two operating conditions; accelerating and cruise. Because most of the areas with residential uses adjacent to truck routes have frequent stops the accelerating condition was used. Between 0 and 20 mph the accelerating heavy truck ReMEL is 80 dBA and it rises to 81 dBA at 30 mph.

Table 4 presents the distance to the Lmax noise contours for a container truck pass by based on the TNM ReMELs. This estimate was compared with the container truck pass-by maximum noise levels measured in the first task of this project. The noise levels presented in Table 4 were found to correlate well with the measured noise levels.

Table 4
Distance To Truck Lmax Noise Contours*

Lmax	Distance (ft.)
90	18
85	32
80	56
75	100
70	177
65	315
60	561

* Feet from centerline of truck travel path with no intervening barriers.

2.2.2 Leq Noise Levels

Leq Noise levels from container trucks were calculated using the FHWA's TNM. This model calculates Leq (H) noise levels based on the hourly number of truck passes and the speed of the trucks. The number of truck passes that were used to model Leq (H) levels are based on the maximum number of trucks per hour observed passing during the noise measurement survey. The posted speed limit on each roadway was used for the speed. Container truck noise impacts were identified at five noise measurement sites; 2, 3, 15, 22 and 25. Table 5 presents the streets adjacent to these sites, the number of hourly truck passes during the daytime and nighttime and speed to used to calculate container truck Leq (H) noise levels at these sites. The last two columns show the daytime and nighttime Leq (H) noise levels at a distance of 15 meters (approximately 50 feet) from the centerline of the roadway. This is the basic output of the TNM Model.

Table 5
Data Used to Calculate Truck Leq (H) Noise levels

Site	Street	No of Trucks		Speed (mph)	Leq (H)* dBA	
		Day	Night		Day	Night
2	Drumm	100	30	30	69.0	63.7
22	Opp	15	5	25	60.0	55.2
25	Sanford	40	20	25	64.2	61.2
3	Alameda S ¹	120	50	45	69.9	66.1
3	Alameda N ²	280	200	45	73.5	72.1

* 15 meters from roadway centerline with no intervening barriers.

1. Alameda Blvd South of Henry Ford Ave.

2. Alameda Blvd. North of Henry Ford Ave.

Table 6 presents the distance from the centerline to Leq (H) noise levels in 5 dB increments between 50 and 70 dBA during the daytime and Table 7 presents the same data for the nighttime. It should be noted that these are "direct line-of-sight" noise levels that do not account for any noise barriers or structures or topography that act as noise barriers. The calculated noise levels were compared with the noise measurements performed previously and were found to agree. In addition, data gathered during the noise measurements was used in the development of the contour maps to estimate drop off rates and barrier effects.

Table 6
Distance to Daytime Truck Leq (H) Noise Contours

Site	Street	Distance to Leq (H) Contour (ft.)*				
		70 dBA	65 dBA	60 dBA	55 dBA	50 dBA
2	Drumm	42	90	195	419	903
22	Opp	11	23	49	106	228
25	Sanford	20	44	94	203	438
3	Alameda S	48	104	224	482	1,039
3	Alameda N	85	183	394	848	1,827

* Feet from roadway centerline with no intervening barriers.

1. Alameda Blvd South of Henry Ford Ave.
2. Alameda Blvd. North of Henry Ford Ave.

Table 7
Distance to Nighttime Truck Leq (H) Noise Contours

Site	Street	Distance to Leq (H) Contour (ft.)*				
		70 dBA	65 dBA	60 dBA	55 dBA	50 dBA
2	Drumm	19	40	87	188	405
22	Opp	5	11	24	51	110
25	Sanford	13	28	59	128	276
3	Alameda S	27	58	125	269	579
3	Alameda N	68	146	315	678	1,460

* Feet from roadway centerline with no intervening barriers.

1. Alameda Blvd South of Henry Ford Ave.
2. Alameda Blvd. North of Henry Ford Ave.

3.0 CONTOUR MAP DEVELOPMENT

Using the source noise levels presented above, “raw” noise contours that do not account for barrier effects were drawn for each noise source overlaid on an aerial photograph of the project area. The contours were then adjusted to account for the effects of noise barriers, structures and topography that act as noise barriers and affect the propagation of noise from the sources. This was done using Google Street View to determine the locations and sizes of noise barriers and structures along with Google Earth Pro to determine where and by how much topography affects the propagation of noise.

In most cases, homes and other buildings had the greatest effect on the noise contours. Unlike a continuous noise barrier that results in 5 dB of noise reduction when it breaks the line-of-sight between a source and a receiver, homes and buildings are not continuous and have gaps through which a portion of sound energy can penetrate. The amount of noise reduction provided by rows of buildings is reduced based on the fraction of the gaps in the row of buildings. A 20% gap reduces the noise reduction relative to a continuous barrier by 1 dB while a 50% gap reduces the noise reduction by 3 dB and an 80% gap reduces the by 7 dB.

The contours were developed to determine the highest noise levels impacting schools and residences in the vicinity of the noise sources of concern. Therefore, in areas with two story homes the contours represent noise levels impacting the second floors of the homes. Noise levels impacting the first floor are considerably lower than at the second floor. However, bedrooms, the most noise sensitive rooms, are typically located on the second floor of two story homes.

4.0 CAVIATS

The noise contours are representative of existing noise sources under calm conditions without a temperature inversion (i.e., where temperature increases with altitude—normally it decreases with altitude). Below, in Section 4.1, we discuss how weather can affect the noise propagation and considerably increase noise levels. These effects are minimal near the source and can be large away from the source.

Future changes to port associated operations will result in noise exposure changes. Pending projects from the Port that will affect noise exposures in the project area are discussed in Section 4.2.

4.1 Weather Effects

The noise contours represent typical weather conditions with calm to light winds and no temperature inversions. Wind and temperature inversions can cause the noise to diffract (bend) over the tops of barriers and structures negating their noise reducing barrier effects. In the case of wind, this occurs downwind from the noise source (up wind noise levels can be greatly reduced because the sound is refracted upwards). With temperature inversions, the increase occurs in all directions. The potential for increased noise levels due to weather effects increases with distance from the source and the noise reduction provided by intervening structures and topography. Noise levels near the source are generally not significantly affected. However, away from the noise source, noise levels can approach the direct line of sight noise levels presented above under certain weather conditions.

The noise level increases from weather effects can be quite localized. These weather effects will result in the sound from a source bending over the tops of all barriers and structures and resulting in a noise level that is only reduced from the direct line-of-sight noise level by the additional distance the sound must travel in specific areas determined by the specific weather conditions. In some cases, the effect can be quite focused causing a large increase at some distance from a source while the noise levels just short of this distance and just beyond this distance are not substantially increased from calm and non-inversion conditions. The distance to and the focus of the increase are determined by the specific weather conditions.

4.2 Changes in Future Noise Levels

The Port of Los Angeles has three projects in the planning stages that will affect noise levels in the Wilmington Area. The first is the reconfiguration of the main TraPac truck entrance at the intersection of Figueroa St. and John S Gibson Blvd./W Harry Bridges Blvd along with realigning Figueroa Street between C Street and the freeway ramps and this intersection. The primary impact of this project will be to remove the existing at-grade rail crossing which will eliminate the requirement for trains to sound their warning horns as they approach this crossing. This will eliminate the impact from this noise source to the homes north of C Street near this intersection. Because the project involved the freeway off-ramps it was required prepare a Traffic Noise Study Report per Caltrans/FHWA Guidelines to ensure that the realignment of the freeway ramps and Figueroa Street would not result in traffic noise levels exceeding their Noise Abatement Criteria (67 dBA Leq (H)) and implement feasible noise abatement where this level is exceeded. The largest noise related impact of this project would be the removal of the train horn noise source that can occur at any hour of the day and night. During our measurements, residents that we spoke to in this area identified the train horns, especially late at night, as the primary source of noise annoyance.

The Port is also implementing two grade separation projects that will eliminate at-grade crossings and required train warning horn soundings. However, these projects are located well away from any residential areas or schools. These projects will create roadway overpasses on

Fries Ave. and Avalon Boulevard south of A-Street within the Port. However, as train horn soundings are audible throughout the community any reduction of soundings is beneficial.

The City and Port have also begun a project to upgrade the at-grade crossing of the McFarland Rail line where it crosses Anaheim St. This at-grade crossing will be upgraded to comply with the requirements for a Train Horn Quiet Zone. The FRA has developed the Train Horn Quiet Zone program to eliminate the need for train warning horn soundings in an area. In order for a Quiet Zone to be established all of the at-grade crossings must implement specific safety devices. After this project is completed, the Anaheim St. crossing will comply with these requirements. For the establishment of a quiet zone, which is likely the most efficient way of reducing the most serious noise impacts from port operations, will require that all at-grade crossings in an area meet these requirements.

5.0 NOISE CONTOUR MAPS

5.1 Train Noise Contour Maps

Figure 2 presents the L_{max} noise contours and 0 presents the daytime Leq(H) noise contours. These figures are also presented in the large format (48" x 36") maps included with this document.

Nighttime Leq(H) noise levels are 3 dB lower than the daytime levels. These figures show that the residences that are most impacted by train noise are the homes along the McFarland Rail Line south of the Watson Rail Yard. There are many at grade crossings in this area that result in trains sounding their horns for the entire track length between L Street and Anaheim Street. Homes just west of Alameda Boulevard and the rail line that runs alongside north of Anaheim Street and south of Rubidoux Street are also subject to considerable train noise levels. Homes in the northern finger of the community between Wilmington Ave and Just west of Avalon Boulevard are also subject to considerable noise levels from trains and the horns sounded at at-grade roadway crossings.

5.2 Container Truck Noise Contour Maps

Figures 0, 5, and 6 present container truck noise contours. 0 shows the L_{max} noise contours. Figure 5 shows the daytime Leq(H) contours and Figure 6 shows the nighttime Leq(H) contours. These figures are also presented in the large format (48" x 36") maps included with this document.

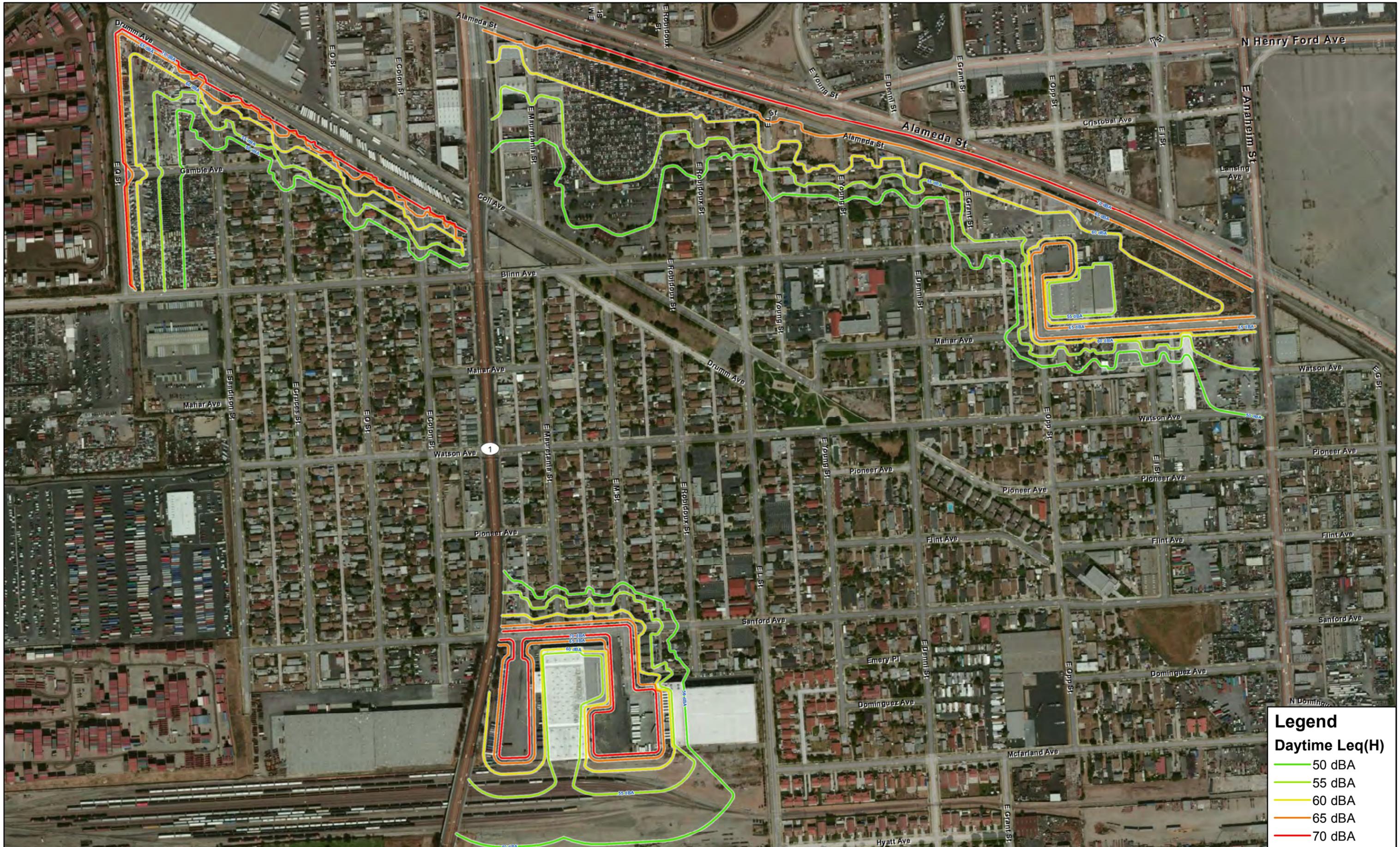
These figures show that the homes along Drumm Avenue are most impacted by container truck noise levels. There are more trucks on Alameda Street traveling at a higher speed and generating more noise. However, the homes along Alameda Street, located on the south side between Rubidoux Street and Grant Street, are located further from the road than the homes along Drumm Avenue and exposed to lower truck noise levels. Nevertheless, the homes along Alameda Street are exposed to train noise and warning horns from activity on the rail line located between Alameda Street and the homes.

The two other areas where container truck noise impacts residences are along Stanford Avenue/M Street and along Opp Street/Mahar Avenue. Container trucks have use these residential streets to access distribution facilities located adjacent to residential areas. There are two larger distribution facilities adjacent to Stanford Avenue that result in more trucks, and higher noise levels impacting the residences than along Opp Street. In both cases, trucks were observed accessing the facilities during the nighttime hours.

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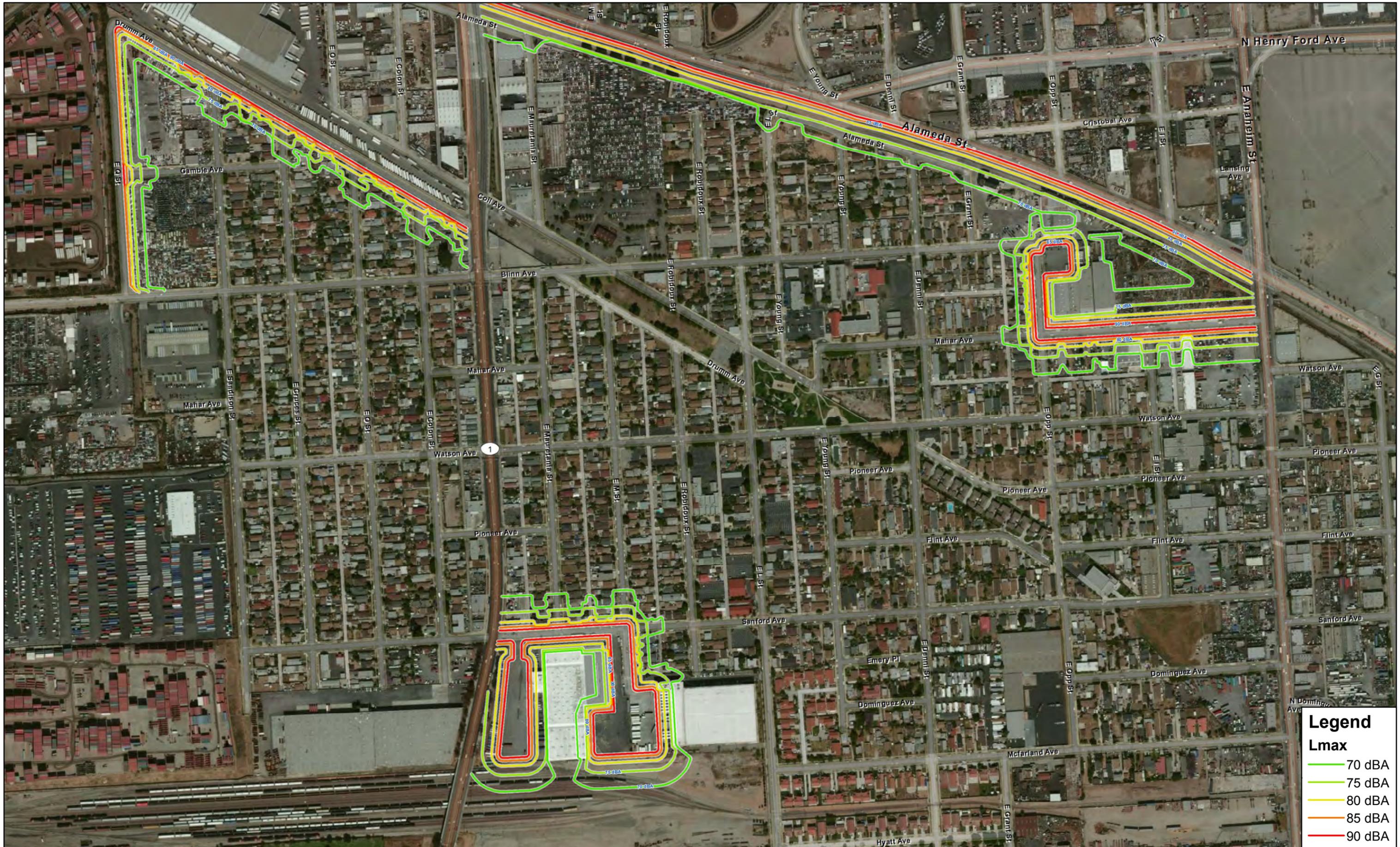
Figure 6 - Container Truck Nighttime Leq(H) Noise Contours



Legend
Daytime Leq(H)

50 dBA
55 dBA
60 dBA
65 dBA
70 dBA

Figure 5 - Container Truck Daytime Leq(H) Noise Contours



Legend

Lmax

- 70 dBA
- 75 dBA
- 80 dBA
- 85 dBA
- 90 dBA



Figure 4 - Container Truck Lmax Noise Contours

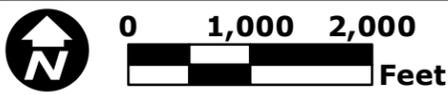
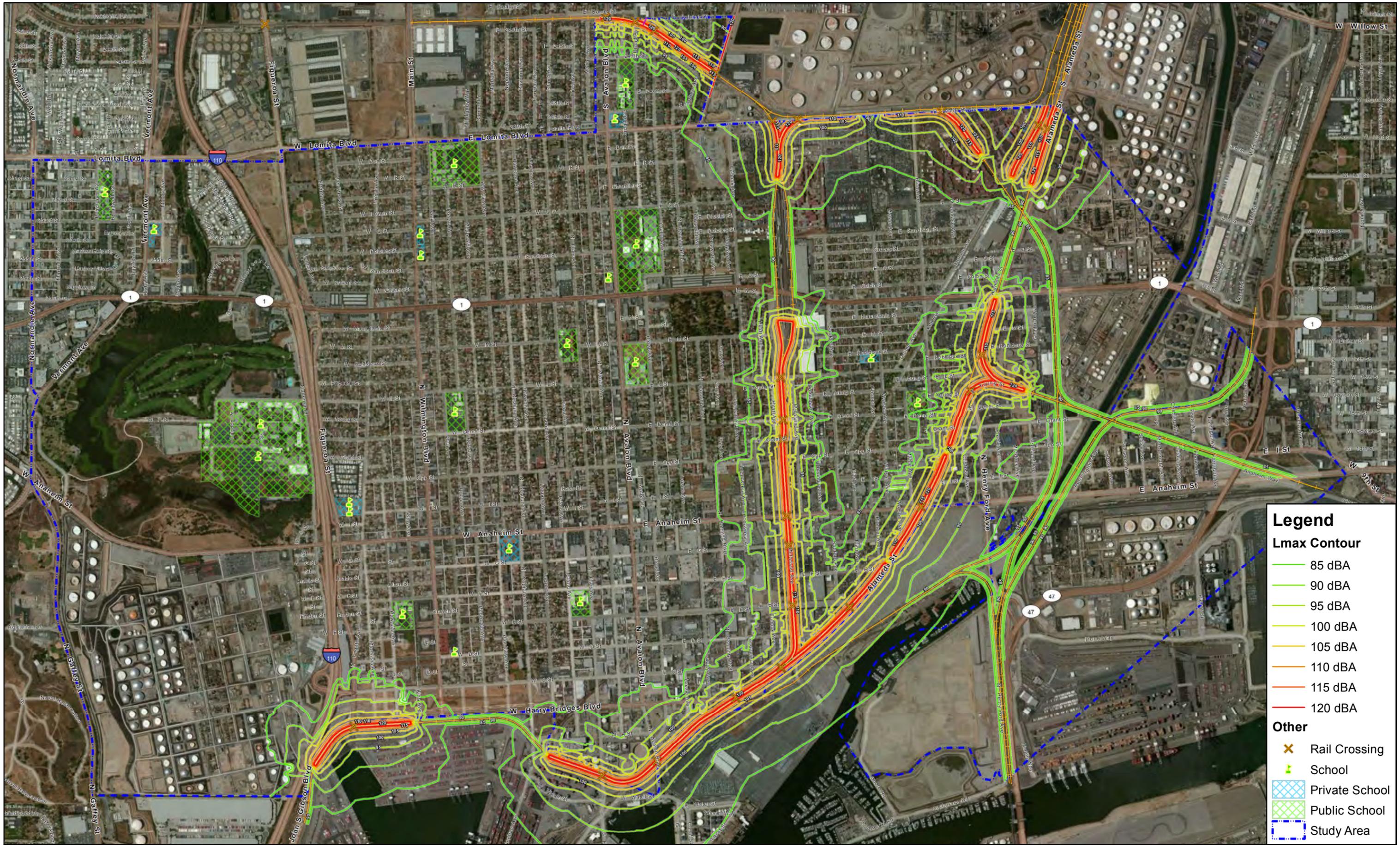


Figure 3 - Train Daytime Leq(H) Noise Contours

- Legend**
- Leq Contour**
- 65 dBA
 - 70 dBA
 - 75 dBA
 - 80 dBA
 - 85 dBA
- Other**
- ✕ Rail Crossing
 - 🏫 School
 - Private School
 - Public School
 - Study Area



Legend

Lmax Contour

- 85 dBA
- 90 dBA
- 95 dBA
- 100 dBA
- 105 dBA
- 110 dBA
- 115 dBA
- 120 dBA

Other

- X Rail Crossing
- 🏠 School
- Private School
- Public School
- Study Area

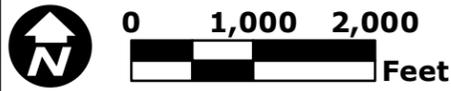


Figure 2 - Train Lmax Noise Contours

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6.0 BIBLIOGRAPHY

Carl E. Hanson, D. A. (2006). *Tansit Noise and Vibration Assessment*. U.S. Department of Transportation, Federal Transit Agency. Washington D.C.: National Technical Information Service.

Menge, C. W., & Rossano, C. F. (1998). *FHWA Traffic Noise Model®*, Version 1.0 Tehchnical Manual (w/ update sheets through Version 2.5). Waltham: Federal Highway Adminisration.

Rapoza, A. S., & Fleming, G. G. (2002). *The Effect of Installation Location on Railroad Hirn Sound Levels*. U.S. Department of Transportation, Federal Railroad Administration. Cambridge: John A. Volpe National Transportation Systems Center.