Report

Noise Study
Bristol Park Redevelopment Area

Project I.D.: 13C018.00

City of Champaign, Illinois

April 2013

Foth

2314 West Altorfer Drive
Peoria, IL 61615
(309) 691-5300 • Fax: (309) 691-1892
www.foth.com

April 15, 2013

Ms. Susan K. Jones
Environmental Coordinator
City of Champaign
102 N. Neil Street
Champaign, IL 61820

Dear Ms. Jones:

RE: Noise Study
Bristol Park Redevelopment Area

Enclosed for your review is a Noise Study for the Bristol Park Redevelopment Area. The study was prepared in accordance with U.S. Department of Housing and Urban Development (HUD) Noise Assessment Guidelines. These guidelines outline specific procedures for assessing potential noise impact from outside noise sources to proposed redevelopment areas.

If you have any questions or comments on the report, please do not hesitate to contact Pat Sloan at (309) 683-1678 or patrick.sloan@foth.com.

Sincerely,

Foth Infrastructure & Environment, LLC

Curtis E. Dungey, CHMM, CIH
Lead Environmental Scientist

Patrick G. Sloan, P.E.
Client Director

Noise Study
Bristol Park Redevelopment Area

Distribution

No. of Copies	Sent To
3	Ms. Susan K. Jones Environmental Coordinator City of Champaign 102 N. Neil Street Champaign, IL 61820

Noise Study
Bristol Park Redevelopment Area

Project ID: 13C018.00

Prepared for

City of Champaign

102 N. Neil Street
Champaign, IL 61820

Prepared by

Foth Infrastructure & Environment, LLC

April 2013

2314 West Altorfer Drive • Peoria, IL 61615 • (309) 691-5300 • Fax: (309) 691-1892 • www.foth.com

Noise Study
Bristol Park Redevelopment Area

Contents

Tables

Contents

Figures

Appendices

Noise Study
Bristol Park Redevelopment Area

Executive Summary

The City of Champaign, Illinois (City) is in the process of considering redevelopment of an area known as the Bristol Park Redevelopment Area (Proposed Development) for use as low income housing construction. As currently conceived, the City would work with the federal U.S. Department of Housing and Urban Development (HUD) for funding to redevelop this area. As part of planning for this process, Foth Infrastructure & Environment, LLC (Foth) was asked to assess the impact of outside noise sources on the proposed redevelopment area in accordance with noise assessment guidelines developed by the HUD.

HUD Noise Assessment Guidelines were used to estimate the impact of noise from a nearby rail line to the area. Overall noise impact was expressed in terms of the day-night average sound level, or DNL. This is the degree of acceptability of the calculated noise level. The DNL takes into account distance from the source and certain operational factors associated with the railway operations. A DNL was calculated for three different distances from the noise source, including 160 feet, 400 feet, and 600 feet. The 160-foot distance was selected because it was determined this would be the closest a structure could be built to the noise source, based on the current street configuration.

Results of the noise assessment indicate that the DNL for the distance of 160 feet from the noise source would be 73.7, which would be in the “Normally Unacceptable” range of 65 to 75. The DNL decreases with distance, and approaches levels in the “Acceptable” level at about 600 feet. It was determined the DNL could be reduced with use of a noise barrier placed along the east side of North Chestnut Street. Use of a 20-foot-high noise barrier would bring the DNL for most locations reviewed for this assessment within the “Acceptable” range for the scenario where only one-story houses would be constructed. The one exception may be locations near the south edge of the noise barrier, where the DNL was slightly above the “Acceptable” level of 65. However, if two-story structures were built, it appears that the “Acceptable” level could not be achieved at locations near the noise barrier, except for houses constructed beyond the 400-foot distance. While a higher noise barrier, at perhaps 25 feet, may achieve this, this height was not evaluated as part of this study. According to HUD guidelines, the acceptability of noise at levels in the “Normally Unacceptable” range can be further enhanced by using special building construction in the design of housing units to ensure people occupying the units are sufficiently protected from outdoor noise.

Additional considerations are also discussed in the report. One of these considerations includes a discussion of certain exceptions that the City may be able to take advantage of that would raise the HUD acceptable DNL level from 65 to 70. In order to use an exception, the City would need to demonstrate it meets all of the conditions. Another consideration would involve conducting actual field measurements using a sound level meter. Field measurements may provide a more accurate assessment of estimates that were calculated using a relatively basic approach set forth by the HUD noise assessment guidelines.

List of Abbreviations, Acronyms, and Symbols

City	City of Champaign, Illinois
CFR	Code of Federal Regulations
CN	Canadian National Railway
dB	decibels
DNL	Outdoor Day-Night Average Sound Level
DOT	U.S. Department of Transportation
Foth	Foth Infrastructure & Environment, LLC
HUD	U.S. Department of Housing and Urban Development
mph	miles per hour
NAL	Noise Assessment Location
Proposed Development	Bristol Park Redevelopment Area
™	Trademark

1 Introduction

The City of Champaign, Illinois (City) is in the process of considering redevelopment of an area known as the Bristol Park Redevelopment Area (Proposed Development) for use as low income housing construction. As currently conceived, the City would work with the federal U.S. Department of Housing and Urban Development (HUD) for funding to redevelop this area. The proposed area is bordered on the west side by North Market Street and the east by North Chestnut Street. The northern border of the development would be the northern boundary of lots located along East Roper Street and on the south end by East Bradley Street. The main line of the Canadian National Railway (CN) is located on the east side of the Proposed Development. Figure 1 provides a site location map indicating the general location of this area within the City. A map showing boundaries of the Proposed Development is provided as Figure 2.

1.1 Purpose

As part of planning for this process, Foth Infrastructure & Environment, LLC (Foth) was asked to assess the impact of outside noise sources on the proposed redevelopment area in accordance with noise assessment guidelines developed by HUD. These guidelines are located in a document entitled *The Noise Guidebook* (HUD, No Date). This document provides guidance for evaluating the impact of nearby sources of noise from airports, roadway traffic from major thoroughfares, and rail traffic. Chapter 5 of the document outlines noise assessment procedures that should be followed to evaluate these noise sources with respect to identified Noise Assessment Locations (NAL) within the proposed area. The purpose of this report will be to examine identified noise sources in accordance with guidelines in this document.

1.2 Scope of Work

In accordance with the HUD guidelines, Foth has specifically been asked to evaluate the impact of noise to this neighborhood from operations at the nearby CN rail line and from interstate road traffic on I-74 to the north of the site. There are no airports near the site. As part of this scope of work, Foth focused on regular scheduled rail traffic that passes through the crossing at East Bradley near the intersection of North Chestnut Street. It should be noted that a rail yard exists to the northeast of the neighborhood. Several tracks to the east of the main rail line move lines of rail cars periodically through this area as well. While it is anticipated there may also be noise associated with these sources, it is considered to be sporadic and will not be evaluated as part of this report.

1.3 Regulatory Requirements

Noise at the Bristol Park Redevelopment Area was evaluated in accordance with *The Noise Guidebook*, as prepared by HUD. Foth relied on procedures, figures, work charts, and work sheets included in Chapter 5 of the document, entitled Noise Assessment Guidelines for this evaluation. This guidebook is based on HUD noise regulations at 24 Code of Federal Regulations (CFR) Part 51. The purpose of the guidelines is to provide a process for evaluating the acceptability of anticipated noise from identified noise sources in the area. No actual field measurements were made as part of this process. Foth is also aware that the City has a noise ordinance and the state of Illinois has a noise regulation. These regulatory requirements were not considered as part of this evaluation.

2 Background Information

The following subsections will provide background information on sources of noise to be evaluated for this report. This information will provide the basis for the evaluation in the remainder of the report.

2.1 CN Rail Line

As noted in Section 1, the main CN rail line is located along the east side of the Proposed Development. The closest existing structures in this area are located approximately 160 feet from the centerline of the main rail track. These are structures that are located just immediately to the west of North Chestnut Street. The main rail line is in direct line-of-sight to the Proposed Development and is at the same approximate elevation. Based on projections from Google™ Earth, the main line rail bed is at approximately 740-feet elevation. The housing area is at approximately 7380feet elevation. According to information provided by CN and also by the U.S. Department of Transportation (DOT), approximately 20 scheduled trains pass through the crossing at East Bradley Street in an average day. Included in Table 1 are certain data regarding rail traffic that passes through this crossing. All traffic is in the form of diesel trains. There are no electrified trains traveling through this crossing. This information was obtained directly from the local CN rail office. These data will be used during the noise evaluation for this area.

Table 1

CN Main Rail Line Data

Data Input Need	CN Estimates
Average Diesel Trains Per Day	20
Average Diesel Trains Between 10 PM and 7 AM	4
Average Number of Locomotives Per Train	2
Average Railway Cars Per Train	167
Average Train Speed (mph)	40 [1]
Track Construction	Continuous Welded Rail
Whistle or Horn	Use Starts at 1,360 feet from Crossing in Both Directions

[1]Typical speeds range from 5 to 60 mph; 40 mph is assumed to be average.

Prepared by: CED1
Checked by: PGS

2.2 I-74 Interstate Highway

The I-74 interstate highway is located approximately 1,500-feet north of the closest structure in the Proposed Development. Based on information in *The Noise Guidebook*, roads further than 1,000 feet from an NAL do not need to be included in the noise evaluation. Therefore, the I-74 highway was not be evaluated for noise impact as part of this report.

3 Methods

As noted previously, Foth used Noise Assessment Guidelines in Chapter 5 of *The Noise Guidebook* developed by HUD for evaluating noise impacts to the Proposed Development. The guidelines provide a straightforward method for evaluating prospective sites in a consistent manner without actually visiting the site or conducting field measurements. The procedures can be used for existing or prospective buildings located on the site. The guidelines indicate that site assessments should be made at representative locations around the site where significant noise is expected. Locations are designated as NALs. A complete copy of Chapter 5 from *The Noise Guidebook* is provided as Appendix A. The Noise Assessment Guidelines include instructions, various examples, and forms that can be used for the analysis.

The degree of acceptability of the noise environment at a NAL is determined from the calculated outdoor day-night average sound level (DNL) in decibels (dB). Work sheets are provided with the guideline to develop the evaluation for each NAL. Results from the evaluation will be categorized into one of three categories, as noted in Table 2.

Table 2

HUD Noise Acceptability Criteria

DNL Category	Level	Comments
Acceptable	Less than or at 65	Levels at 65 may be of some concern, but common building construction will make indoor environment acceptable.
Normally Unacceptable	Between 65 and 75	Noise exposure more severe; barriers may be necessary between site and prominent noise sources. Special building construction may be necessary for buildings.
Unacceptable	Greater than 75	Noise at site so severe that construction cost to make the indoor environment acceptable may be prohibitive.

Prepared by: CED1
Checked by: PGS

3.1 Rail Line Noise Evaluation Process

As noted in Section 2, the closest existing structures in the Proposed Development are located approximately 160 feet from the centerline of the main rail line. These are structures located along North Chestnut Street. Given these are the closest locations to the rail line, this distance was evaluated first. This first distance is referred to as NAL 1. To provide further information regarding the impact of distance from the noise source, two additional NALs were established at distances of 400 and 600 feet from the main rail line. These are referred to as NALs 2 and 3, respectively. These are also located in the general vicinity of current housing locations. These three NALs are shown on Figure 2 and identified as NALs 1 through 3. For illustrative purposes, they are placed in the middle of the development. Using the criteria provided in Table 1, noise estimates in terms of DNL were developed using work sheets provided in the HUD guidance document.

After completion of the analysis at the three NAL distances from the rail line, additional NALs were established at locations near the south end and north end of the Proposed Development. These NALs were used in conjunction with the first set of NALs to evaluate noise at these locations if a noise barrier were placed near the rail line to shield noise from the residential area. These additional NALs are depicted on Figure 3, along with the location of a possible noise barrier.

3.2 Methods of Data Analysis

Railway noise was evaluated in a step-wise fashion, using the HUD guidelines. Basic information regarding railway traffic is first entered into Work Sheet D. This work sheet incorporates rail line data from Table 1 and uses a series of simple calculations for both the diesel locomotive and rail cars to arrive at a value that is labeled as the "Average Daily Number of Operations." This value, along with the effective distance from the noise source, is entered into Work Chart No. 3 to determine the DNL. The resulting DNL is compared against the levels shown in Table 2 to assess acceptability.

If the DNL is determined to be "Normally Unacceptable," it can be further evaluated with respect to installation of a noise barrier. Evaluation of a prospective noise barrier involves additional computations that are carried out first using Work Chart Nos. 5 and No. 6. Work Chart No. 5 takes into account the elevations of the source, the NAL (observer), and barrier height. The steps in the evaluation lead the evaluator through a series of computations to arrive at additional factors that can be used in Work Chart No. 6. Work Chart No. 6 uses the distance (h) between the barrier top and line-of-sight from the source to the observer in combination with a ratio of the distance between the source and barrier and NAL and barrier to arrive at an estimate of the noise barrier performance. An adjustment must also be made if the NAL is at a given distance from the barrier when compared to the distance from the barrier to the source. This is termed "loss of ground attenuation." This adjustment is made to the estimated noise reduction from the noise barrier to take into account the implication that a certain amount of noise will be re-directed over the top of the noise barrier, thus reducing the sound reduction gained through the barrier design. This factor is subtracted from the calculated noise barrier performance value.

During the noise barrier evaluation, Foth evaluated two scenarios: one situation where all of the homes would be constructed as one-story houses. The second scenario would be if all the houses were two-story homes. HUD guidelines require one to assume the line-of-sight to the NAL (observer) is at five feet below the overall height of the structure (the effective height). For one-story houses, Foth assumed the overall height would be 15 feet, with the effective height being 10 feet. If the houses were two-story structures, Foth assumed the overall height would be 25 feet, with the effective height at 20 feet as line-of-sight to the source. In addition to the above, Foth used 15 feet as the height of the locomotive and railroad cars. This latter value was in conformance with HUD guidelines. All structures, including those at NALs, the barrier and noise source on the railway line were evaluated with respect to given actual elevations. Elevations were taken from projections at Google ™ Earth.

Finally, given the barrier will always be finite, the effective noise reduction will also need to be evaluated using Work Chart No. 7. This final work chart accounts for NAL locations being at certain locations along the barrier, including points near the end of the barrier. NALs located near the end of the barrier may be more exposed to noise radiating around the edge of the wall. The Work Chart is used to determine the angle subtended by the barrier at the NAL, or observer location.

4 Discussion

Following is a discussion of the noise assessment for the Proposed Development using the HUD Noise Assessment Guidelines that were summarized in Section 3.

4.1 Results of Initial NAL Review

The DNL for each of the NALs 1 through 3 was determined using the methodology described in Section 3. Computations were completed using the Railway Noise Data Sheet and Computations and Findings Work Sheet. These are the revised work sheets that were included in an “Errata” section of *The Noise Guidebook*. They are also included in Appendix A. Results from this evaluation are provided in Table 3. Results indicate that the DNL for an NAL located 160 feet from the rail line would be at 73.7 dB. If the NAL were moved further from the source of noise to a location 400 feet away, the DNL would be 67.8 dB. If the NAL were moved even further from the noise source at 600 feet, the DNL is calculated to be 65.3 dB. From these calculations, only development that occurs at 600 feet from the main rail line would meet the “Acceptable” criterion of 65. Results of the computational analysis are provided in Table 3. Work sheets showing the computations at different distances from the noise source are provided in Appendix B.

Table 3

DNL Levels at Specified Distances from the Source

Distance from the Centerline of the Main Rail Line (Feet)	DNL Calculation (dB)
160	73.7
400	67.8
600	65.3

Prepared by: CED1
Checked by: PGS

4.2 Use of a Noise Barrier

The HUD Noise Assessment Guidelines allow for use of a noise barrier to shield sensitive locations from railway noise sources if the DNL falls into the category “Normally Unacceptable.” Given the calculated DNLs at two closer distances fall into this category, Foth evaluated use of a noise barrier to bring noise levels within acceptable levels. It was determined that CN will use a horn or whistle as a safety precaution when approaching the rail crossing at East Bradley Street. A sign is located along the tracks at approximately 1,360-feet north and south of the crossing. Trains will activate their horns starting at this distance and continue up to the crossing. It is anticipated that impact to the Proposed Development will be particularly noticeable for those trains approaching from the north. In the HUD Noise Assessment Guideline, the whistle/horn factor figures significantly in the final adjustment for operations. To reduce the DNL in the Proposed Development, a 20-foot-high noise barrier could be placed approximately 100 feet from the main line railway. Given the railway owns the property strip between North Chestnut Street and the rail line, it is anticipated the barrier could be placed on the east side of North Chestnut Street. The noise barrier could begin just north of East Bradley and the railroad crossing and continue along the rail line to the southern end of the electrical substation located just northeast of the area. Work Chart No. 5 was completed for three distances described above and shown in Table 3. From Work

Chart No. 5, several factors (h, R and D) are used to evaluate overall noise barrier performance using Work Chart No. 6. The noise barrier was first evaluated assuming all housing would be one-story structures. With one-story structures, it will be assumed the typical height of the house is 15 feet. From the HUD guidelines, the impact of noise to the structure is from a point five feet from the top of the structure, or 10 feet. The results of the assessment using Work Chart No. 6 for a one-story structure are shown in Table 4.

Table 4

One-Story Structure
Potential Noise Barrier Performance Based on Distance

Distance from Source (Feet)	Barrier Performance using Work Chart 6	Adjustment for Loss of Ground Attenuation from Work Chart 6	Potential Barrier Performance (dB)	Resulting DNL with Noise Barrier at Infinite Length (dB)
160	10.8	- 0	10.8	62.9
400	7.8	- 2	5.8	62.0
600	7.2	- 3	4.2	61.1

Prepared by: CED1
Checked by: PGS

At the distance 160 feet from the source, the potential barrier performance prior to adjustment would have a reduction of 10.8 dB, with the reduction decreasing at increasing distances. This is primarily due to the height of the barrier between the source and the observer line-of-sight decreasing at increasing distances. In addition, the methodology requires this estimate to be reduced for loss of ground attenuation. As explained previously, the calculated noise reduction is adjusted by this latter factor in that it is believed that a portion of the radiated sound will be redirected over the barrier. While there is no reduction for this factor at the closest distance, the adjustment increases to -3 at 600 feet. Results indicate the potential barrier performance could reduce the DNL to acceptable levels at all three distances.

The potential noise barrier performance was also evaluated for the possibility of two-story structures being built in this area. In this scenario, it was assumed that all two-story structures would be 25 feet in height. Therefore, from HUD guidelines, the effective impact point would be five feet less at 20 feet. The results of the assessment using Work Chart No. 6 for two-story structures throughout the Proposed Development are shown in Table 5.

Table 5

Two-Story Structure
Potential Noise Barrier Performance Based on Distance

Distance from Source (Feet)	Barrier Performance using Work Chart 6	Adjustment for Loss of Ground Attenuation from Work Chart 6	Potential Barrier Performance (dB)	Resulting DNL with Noise Barrier at Infinite Length (dB)
160	4.5	- 0	4.5	69.2
400	5.3	- 2	3.3	65.5
600	5.8	- 3	2.8	62.5

Prepared by: CED1
Checked by: PGS

With the increased height of the two-story structures, the height of the barrier between the source and the effective height of the observer at a given NAL is less than that for the one-story structures. Therefore, the potential noise barrier performance in terms of noise reduction in dB will be less. With the adjustment for loss of ground attenuation included, the potential noise performance indicates that the DNL could only be reduced to "Acceptable" levels at about the 400-foot distance. While a higher noise barrier will probably improve this evaluation, it is assumed that at this point most of the structures will be one-story and that the higher noise barrier would not be needed.

The effectiveness of the noise barrier as calculated above for both one-story and two-story structures assumes an infinite noise barrier with respect to each NAL. As noted previously, if a noise barrier were installed along North Chestnut Street, the closest it could be installed with respect to the rail bed would be approximately 100 feet. Assuming the finite length of the barrier would be from the south point at East Bradley Street near the railroad crossing and continue to the southeast corner of the electrical substation, the length of the barrier would be approximately 1,300 feet.

The actual performance of the noise barrier can be further evaluated using Work Chart No. 7. This Work Chart allows one to take into account the length of the barrier with respect to the NAL and the angle formed by drawing lines between the NAL and each end of the barrier. This was evaluated by placing three NALs at the three distances along the length of the barrier. One NAL would be in the middle, with the other two NALs placed near each end of the barrier. The approximate location of the NALs along the barrier for each of the distances is depicted on Figure 3. Table 6 presents the estimated actual noise barrier performance for one-story structures when placed at three different locations and distances along the barrier.

Table 6

One-Story Structure
Actual Noise Barrier Performance
Based on Proximity to Edge of Barrier

NAL Distance (feet)	Location Along Barrier	Angle Formed using Work Chart 7 (Degrees)	Original DNL Calculation for this Distance (dB)	Potential Barrier Performance (dB)	Actual Barrier Performance (dB)	Predicted Actual DNL Using 20-Foot-High Noise Barrier (dB)
160	South End	142	73.7	10.8	7.5	66.2
	Middle	168	73.7	10.8	9.8	63.9
	North End	165	73.7	10.8	9.2	64.5
400	South End	85	67.8	5.8	2.3	65.5
	Middle	120	67.8	5.8	3.5	64.3
	North End	105	67.8	5.8	2.5	65.3
600	South End	73	65.3	4.2	1.8	63.5
	Middle	98	65.3	4.2	2.2	63.1
	North End	87	65.3	4.2	1.8	63.5

Prepared by: CED1
Checked by: PGS

As a result of the analysis using Work Chart No. 7, one can see the actual predicted noise reductions for one-story houses due to use of a 20-foot-high noise barrier along the North Chestnut Street. Use of the HUD Noise Assessment Guidelines predicts that the noise barrier would offer a 9.8 dB reduction near the middle of the structure for a 160-foot distance, with this dropping off to 7.5 dB reduction near the south end of the barrier. This reduction is due to potential noise radiating around the edge of the barrier. While it appears a structure at this location may be slightly above the “Acceptable” DNL, other NALs at this distance near the barrier would be within the “Acceptable” category. Additional considerations to reduce the DNL further would be to incorporate sound reduction materials into the proposed housing construction design at locations where the DNL is slightly above the “Acceptable” criterion.

The above analysis can also be completed for two-story structures using Work Chart No. 7. In this scenario, the noise barrier remains at the same location along North Chestnut Street and the NALs are at the same locations along the barrier as depicted in Figure 3. However, with the height of the structures increased to 25 feet and the effective height of the observer at 20 feet, the line-of-sight between the noise source and the observer are essentially at the same level at the 160-foot distance. The effective height of the barrier increases slightly with increasing distance from the barrier due to a change in angle for the line-of-sight. Completed computations using Work Sheet No. 5 for the two-story scenario are provided in Appendix B show the calculated factors that go into the noise performance estimate. Results are shown in Table 7.

Table 7

Two-Story Structure
Actual Noise Barrier Performance
Based on Proximity to Edge of Barrier

NAL Distance (feet)	Location Along Barrier	Angle Formed using Work Chart 7 (Degrees)	Original DNL Calculation for this Distance (dB)	Potential Barrier Performance (dB)	Actual Barrier Performance (dB)	Predicted Actual DNL Using 20-Foot-High Noise Barrier (dB)
160	South End	142	73.7	4.5	3.8	69.9
	Middle	168	73.7	4.5	4.2	69.5
	North End	165	73.7	4.5	4.0	69.7
400	South End	85	67.8	3.2	2.3	65.5
	Middle	120	67.8	3.2	3.3	64.5
	North End	105	67.8	3.2	3.0	64.8
600	South End	73	65.3	2.8	1.3	64.0
	Middle	98	65.3	2.8	1.7	63.6
	North End	87	65.3	2.8	1.5	63.8

Prepared by: CED1
Checked by: PGS

Table 7 indicates that for two-story structures, the predicted actual DNL at 160 feet would be in the "Normally Unacceptable" range for all locations that were evaluated. DNL levels beginning at about 400 feet would be in the "Acceptable" range. From this analysis, it appears that homes constructed up to 400 feet would need to be limited to one-story homes. It is possible the noise barrier could also be increased to meet the HUD "Acceptable" limit.

It should also be noted that while the calculated DNLs were developed based on HUD noise assessment guidelines, predicted noise from the rail line would not be continuous throughout a given day. As noted previously, current CN records indicate that an average of 20 trains pass through this area with an average of 167 cars each. However, if each train passing lasted approximately 10 minutes each, this would amount to train noise during about 200 minutes each day, or 3.3 hours. This would be approximately 14% of each day.

Additional noise may come from occasional locomotive engine noise from car switching in the rail yard located east and north of the rail crossing and car traffic along East Bradley Street. These sources of noise were not factored into this analysis.

4.3 Other Considerations

In addition to the above analysis, the City may want to evaluate this project using alternative approaches. Two examples of this are discussed below.

4.3.1 Exceptions

The noise assessment evaluation indicates that the DNL for some locations within the Proposed Development may be in the "Normally Unacceptable" range, especially at locations less than 400 feet to the noise source, if a noise barrier is not installed. The HUD noise regulation allows for exceptions in certain instances and may allow the "Acceptable" range to be raised from 65 to 70 dB as a DNL. If this is allowed, all of the following conditions must be met:

- The project does not require an Environmental Impact Statement under 24 CFR 51.104 (b) (1) and noise is the only environmental issue.
- The project has received a Special Environmental Clearance and has received the concurrence of the Environmental Clearance Officer.
- The project meets other program goals to provide housing in proximity to employment, public facilities, and transportation.
- The project is in conformance with local goals and maintains the character of the neighborhood.
- The project sponsor has set forth reasons, acceptable to HUD, as to why the noise attenuation measures that would normally be required for new construction in the 65 to 70 DNL range cannot be met.
- Other sites which are not exposed to noise above 65 DNL and which meet program objectives are generally not available.

If the City wishes to pursue qualification for an exception under this portion of the rule, further research will need to be made to determine if the project qualifies for all of these conditions.

4.3.2 Use of Field Noise Measurements

The HUD rules also allow one to assess noise for the project by use of actual noise measurements. This is outlined in 24 CFR 51. 106. Given the HUD Noise Assessment Guidelines use a relatively structured approach to the assessment; therefore, some of the assumptions made in the computations may not be borne out when conducting actual field measurements. For example, the use of a whistle/horn by the train may vary along the approach leading up the rail crossing. Chapter 7 of HUD's *The Noise Guidebook* outlines the process for collecting noise measurements in the field. Essentially, noise measurements can be obtained at the same NALs evaluated in the report using a sound level meter. This can be done by setting up an instrument with logging capabilities at a specified location and programming it to obtain day and night noise data over one or several days. These data can be expressed in terms of the DNL and compared against the HUD criteria.

Such measurements may be helpful in either verifying the computational analysis conducted for this study or provide data that may refute this information. In this way, the field data may assist the City in making a more informed decision about moving forward with the project.

5 Conclusions

The impact of noise from a nearby rail line was evaluated with respect to HUD Noise Assessment Guidelines for a proposed low income housing development that may occur in the Bristol Park Redevelopment Area in Champaign, Illinois. Overall noise impact was expressed in terms of a DNL, which is the degree of acceptability of the calculated noise level. The DNL takes into account distance from the source and certain operational factors associated with the railway operations. A DNL was calculated for NALs located at three different distances from the noise source, including 160 feet, 400 feet, and 600 feet. The 160-foot distance was selected because it was determined this would be the closest a structure could be built relative to the noise source, based on the current street configuration.

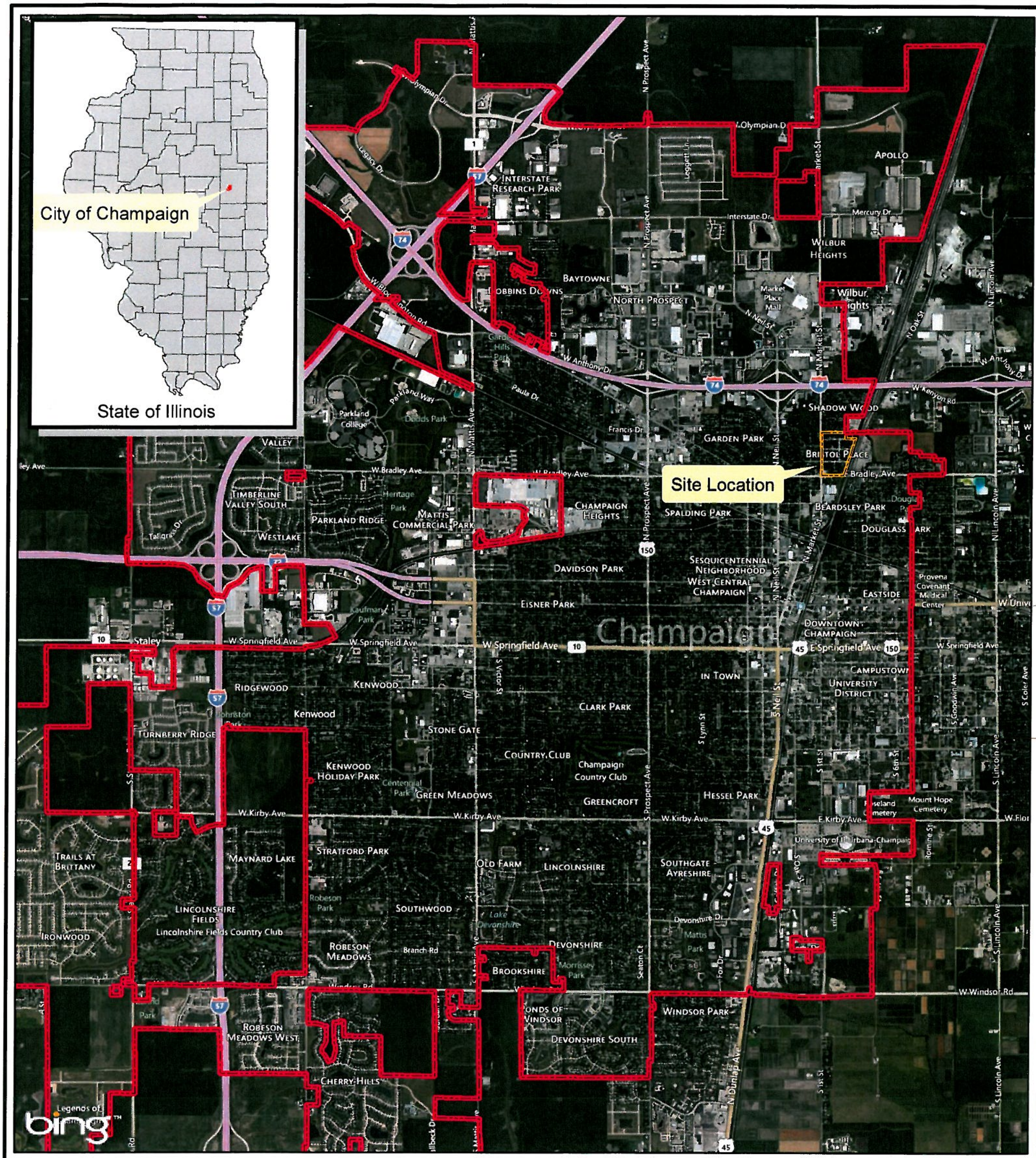
Results of the noise assessment indicates that the DNL for a NAL located at a distance of 160 feet from the noise source would be 73.7 dB, which would be in the “Normally Unacceptable” range of 65 to 75. The DNL decreases with distance, and approaches levels in the “Acceptable” level at about 600 feet. It was determined the DNL could be reduced with use of a noise barrier placed along the east side of North Chestnut Street. Use of a 20-foot-high noise barrier would bring the DNL for most locations reviewed for this assessment within the “Acceptable” range for the scenario where only one-story houses would be constructed. The one exception may be locations near the south edge of the noise barrier, where the DNL was slightly above the “Acceptable” level of 65. However, if two-story structures were built, it appears that the “Acceptable” level could not be achieved at locations near the noise barrier, except for houses constructed beyond the 400-foot distance. While a higher noise barrier, at perhaps 25 feet, may achieve this, this height was not evaluated as part of this study.

In addition to the above, two suggestions were made for additional consideration in evaluation of noise data at this location. The first suggestion may allow the City to qualify for an exception that would allow the “Acceptable” range to be raised from 65 to 70 DNL. To qualify for this exception, the City would need to be able to demonstrate it meets all conditions set forth at 24 CFR 51.105. The second suggestion would involve conducting actual field measurements of noise using a sound level meter with logging capabilities. Actual measurements may assist the City in either verifying or refuting data that has been calculated using the straightforward approach set forth by HUD Noise Assessment Guidelines.

6 References

U.S. Department of Housing and Urban Development (HUD), *The Noise Guidebook*, Chapter 5 – Noise Assessment Guidelines and Errata Sheets, No Date. http://portal.hud.gov/hudportal/HUD?src=/program_offices/comm_planning/environment/training/guidebooks/noise.

Figures



NOTES:

1. Base map from Esri.com and its data suppliers.

LEGEND

City of Champaign

Bristol Neighborhood Boundary

This drawing is neither a legally recorded map nor a survey and is ot intended to be used as one. This drawing is a compilation of records, information and data used for reference purposes only.

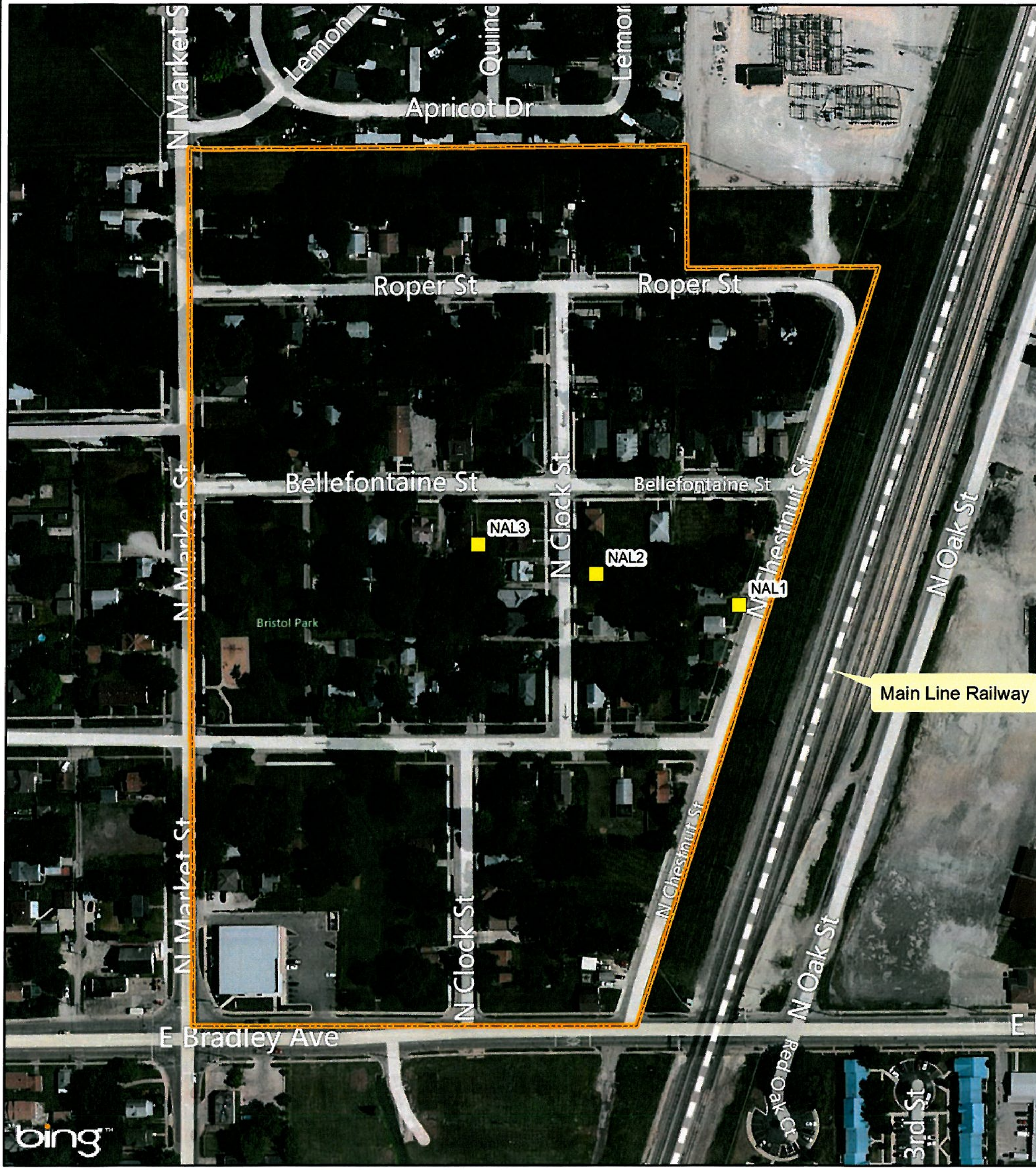
Foth

0 2,000 4,000 Feet

N

CITY OF CHAMPAIGN		
FIGURE 1 SITE LOCATION MAP NOISE ASSESSMENT CHAMPAIGN, ILLINOIS		
Date: MARCH 2013	Revision Date:	
Drawn By: DAT	Checked By: CED	Scope: 13C018

Path: M:\13C018\mxd\NBA\Site_location_map_a-size.mxd Date: 3/28/2013



NOTES:
1. Base map from Esri.com and its data suppliers.

LEGEND

Noise Asessment Location (NAL)

Bristol Neighborhood Boundary

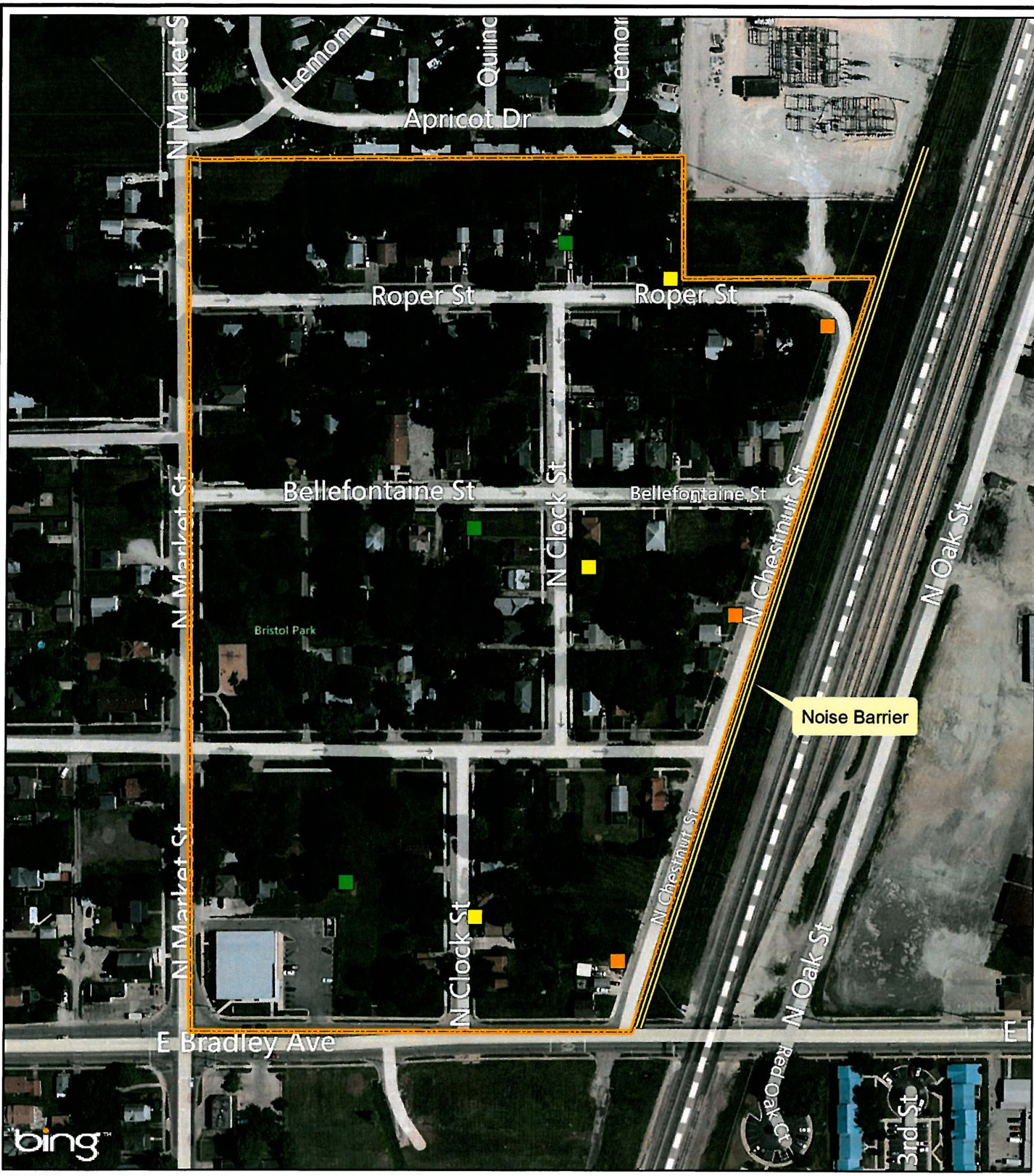
This drawing is neither a legally recorded map nor a survey and is ot intended to be used as one. This drawing is a compilation of records, information and data used for reference purposes only.

0 100 200 Feet

Foth

CITY OF CHAMPAIGN		
FIGURE 2 NOISE ASSESSMENT LOCATIONS CHAMPAIGN, ILLINOIS		
Date: MARCH 2013	Revision Date:	
Drawn By: DAT	Checked By: CED	Scope: 13C018

Path: M:\13C018\mxd\NBA\Noise_assessment_map_a-size.mxd Date: 3/28/2013



NOTES:

1. Base map from Esri.com and its data suppliers.

LEGEND

- NAL for 160 foot distance
- NAL for 400 foot distance
- NAL for 600 foot distance
- Bristol Neighborhood Boundary

This drawing is neither a legally recorded map nor a survey and is ot intended to be used as one. This drawing is a compilation of records, information and data used for reference purposes only.

0 100 200 Feet

Foth

CITY OF CHAMPAIGN

FIGURE 3

NOISE BARRIER EVALUATION
VARYING DISTANCES FROM SOURCE
CHAMPAIGN, ILLINOIS

Date: MARCH 2013	Revision Date:	
Drawn By: DAT	Checked By: CED	Scope: 13C018

Path: M:\13C018\mxd\NBA\Noise_assessment_barrier_map_a-size.mxd Date: 3/28/2013

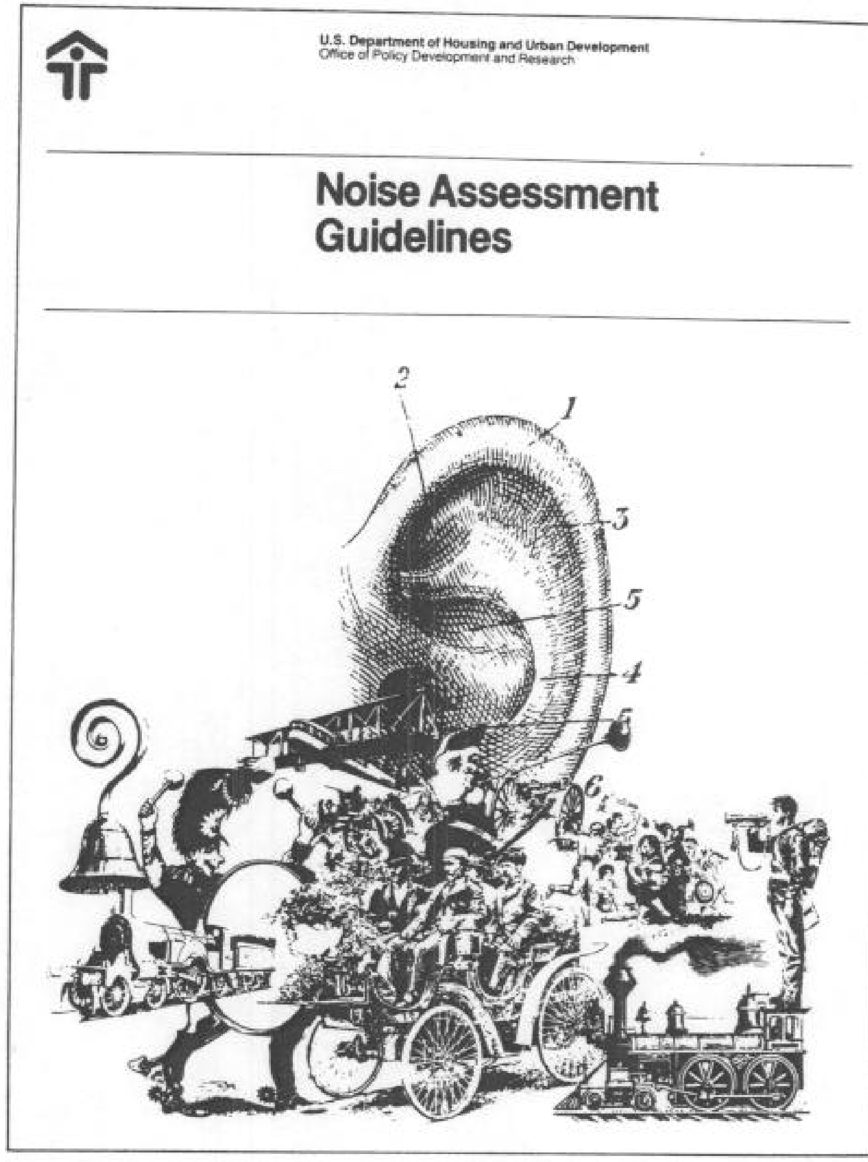
Appendix A

HUD Noise Assessment Guidelines – Chapter 5

and Errata Sheets

Chapter 5

Noise Assessment Guidelines


U.S. Department of Housing and Urban Development
Office of Policy Development and Research

Noise Assessment
Guidelines

Noise Assessment Guidelines

Foreword

In choosing among alternative sites for housing, potential noise problems are prominent among the issues that must be examined. These Noise Assessment Guidelines were developed to provide HUD field staff, interested builders, developers, and local officials with an easy-to-use method of evaluating noise problems with a minimum of time and effort.

We believe that this set of tools will simplify the process of balancing the goal of environmental protection with those of efficiency and reduced housing costs. We hope you will find them useful, and invite your comments.

Benjamin F. Bobo
Acting Assistant Secretary for
Policy Development and Research

Stephen J. Bollinger
Assistant Secretary for
Community Planning and
Development

Preface

The Department of Housing and Urban Development, in its efforts to provide decent housing and a suitable living environment, is concerned with noise as a major source of environmental pollution and has issued Subpart B on Noise Abatement and Control to Part 51 of Title 24 of the Code of Federal Regulations.

The policy established by Subpart B embodies HUD objectives to make the assessment of the suitability of the noise environment at a site: (1) easy to perform; (2) uniformly applicable to different noise sources; and (3) as consistent as possible with the assessment policies of other Federal departments and agencies. In furtherance of these objectives, the Office of Policy Development and Research has sponsored research to provide site analysis techniques. These *Noise Assessment Guidelines* do not constitute established policy of the Department but do provide a methodology whose use is encouraged by HUD as being consistent with its objectives. The *Guidelines* provide a means for assessing separately the noise produced by airport, highway, and railroad operations, as well as the means for aggregating their combined effect on the overall noise environment at a site.

This booklet has been prepared by Bolt Beranek and Newman Inc., under Contract No. H-2243R for the U.S. Department of Housing and Urban Development. It is a revision of an earlier edition published in August 1971. With the exception of changes made by the Department, the contractor is solely responsible for the accuracy and completeness of the data and information contained herein.

Contents

Introduction

These guidelines are presented as part of a continuing effort by the Department of Housing and Urban Development to provide decent housing and a suitable living environment for all Americans.

The procedures described here have been developed so that people without technical training will be able to assess the exposure of a housing site to present and future noise conditions. In this context, the site may hold only one small building, in which case the noise assessment is straightforward. Larger sites may hold larger buildings, or many buildings, and the noise level may be different at different parts of the site (or building). Assessments of the noise exposure should be made at representative locations around the site where significant noise is expected. These are designated as "Noise Assessment Locations," abbreviated NAL in the following text.

The only materials required are a map of the area, a ruler (straight edge), a protractor and a pencil. Worksheets and working figures are provided separately.

All of the information you need can be easily obtained – usually by telephone. For convenience, this information is listed at the beginning of each section under headings that indicate the most likely source. While you are obtaining this information, be sure to ask about any approved plans for future changes that may affect noise levels at the site - for example: land-use changes, changes in airport runway traffic, widening of roads, and so forth. In all evaluations, you should assess the condition that will have the most severe or most lasting effect on the use of the site.

Wherever possible, you should try to assess noise environments expected at least ten years in the future.

The degree of acceptability of the noise environment at a site is determined by the outdoor day-night average sound level (DNL) in decibels (dB). The assessment of site acceptability is presented first as an evaluation of the site's exposure to three major sources of noise - aircraft, roadways, and railways. These are then combined to assess the total noise at a site. Worksheets are provided at the back of these Guidelines to use in summarizing your evaluations.

The noise environment at a site will come under one of three categories:

Acceptable (DNL not exceeding 65 decibels) The noise exposure may be of some concern but common building constructions will make the indoor environment acceptable and the outdoor environment will be reasonably pleasant for recreation and play.

Normally Unacceptable (DNL above 65 but not exceeding 75 decibels) The noise exposure is significantly more severe; barriers may be necessary between the site and prominent noise sources to make the outdoor environment acceptable; special building constructions may be necessary to ensure that people indoors are sufficiently protected from outdoor noise.

Unacceptable (DNL above 75 decibels) The noise exposure at the site is so severe that the construction cost to make the indoor noise environment acceptable may be prohibitive and the outdoor environment would still be unacceptable.

When measuring the distance from the site to any noise source, measure from the source to the nearest points on the site where buildings having noise-sensitive uses are located. These points define the Noise Assessment Locations for the site. The relevant measurement location for buildings is a point 2 meters (6.5 feet) from the facade.

If at any point during the assessment the site's exposure to noise is found to be Unacceptable or Normally Unacceptable, every effort should be made to improve the condition, e.g., the location of the proposed dwellings can be changed or some shielding can be provided to block the noise from that source.

Where quiet outdoor space is desired at a site, distances should be measured from the important noise sources to the outdoor area in question and the combined noise exposure should be assessed.

Frequently, the locations of dwellings have not yet been specified at the time the noise assessment of a site is made. In these instances, distances used in the noise assessment should be measured as 2 meters less than the distance from the building setback line to the major sources of noise.

Combining Sound Levels in Decibels

The noise environment at a site is determined by combining the contributions of different noise sources. In these Guidelines, Workcharts are provided to estimate the contribution of aircraft, automobile, truck, and train noise to the total day-night average sound level (DNL) at a site. The DNL contributions from each source are expressed in decibels and entered on Worksheet A. The combined DNL from all the sources is the DNL for the site and is the value used to determine the acceptability of the noise environment.

Sound levels in decibels *are not combined by simple addition!* The following table shows how to combine sound levels:

Table

Difference in Sound Level	Add to Larger Level
0	3.0
1	2.5
2	2.1
3	1.8
4	1.5
5	1.2
6	1.0
7	0.8
8	0.6
9	0.5
10	0.4
12	0.3
14	0.2
16	0.1
greater than 16	0

Use the table by first finding the numerical difference in sound level between two levels being combined. Entering the table with this value, find the value to be added to the larger of the two levels, add this value to the larger level to determine the total. Where more than two levels are to be combined, use the same procedure to combine any two levels; then use this subtotal and combine it with any other level, and so on. Fractional numerical values may be interpolated from the table; however, the final result should be rounded to the nearest whole number.

Example 1: In performing a site evaluation, the separate DNL values for airports, road traffic, and railroads have been listed on Worksheet A as 56, 63, and 61 decibels. In order to complete the final evaluation of the site, these separate DNL values must be combined. The difference between 63 and 56 is 7; from the table you find that 0.8 should be added to 63, for a subtotal of 63.8. The difference between 63.8 and 61 is 2.8; from the table you interpolate that approximately 1.9 should be added to 63.8 for a total of 65.7 or 66 dB when rounded to whole numbers. This example shows how noise from different sources may be Acceptable, individually, at a site, but when combined, the total noise environment may exceed the Acceptable DNL limit of 65 decibels.

Aircraft

Necessary Information

To evaluate a site's exposure to aircraft noise, you will need to consider all airports (civil and military) within 15 miles of the site. The information required for this evaluation is listed below under headings that indicate the most likely source. Before beginning the evaluation, you should record the following information on Worksheet B:

From the FAA Area Office or the Military Agency in charge of the airport:

- Are current DNL or NEF (Noise Exposure Forecast) contours available? Noise contours are available for almost all military airports. These contours have been developed and published as part of the Air Installation Compatible Use Zone (AICUZ) program of the Department of Defense. The contours are published normally as part of an AICUZ report. Noise contours are also available for many civil airports. When available, they are superimposed on a map with an appropriately marked scale (see Figure 1, page 4).
- Any available information about approved plans for runway changes (extensions or new runways).

From the FAA Control Tower or Airport Operations (if DNL or NEF contours are *not* available):

- The number of nighttime jet operations (10 p.m. - 7 a.m.)
- The number of daytime jet operations (7 a.m. - 10 p.m.)
- The flight paths of the major runways.
- Any available information about expected changes in airport traffic, e.g., will the number of operations increase or decrease in the next 10 or 15 years.

In making your evaluation, use the data for the heaviest air traffic condition, whether present or future.

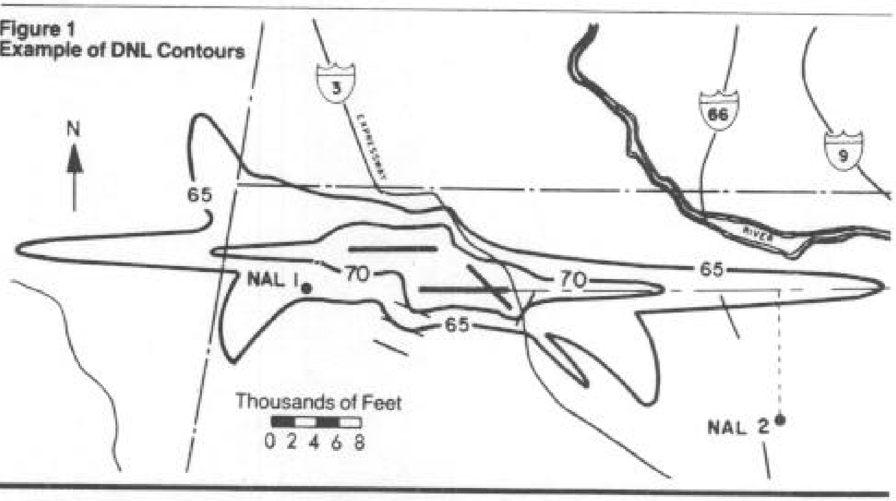
Evaluation of Site Exposure to Aircraft Noise

If current DNL (or NEF) contours are available (as in Figure 1 page 4), locate the site on the map by referring to the marked distance scale. If there are no other noise sources in the area, you do not need to do anything else. If there are other noise sources affecting the site, you will need to find the precise DNL value so you can combine it with the other sources. Obtain the DNL at the appropriate NAL on the site by interpolation between the contours on either side of the NAL. If NEF contours are used, estimate DNL by adding 35 decibels to the NEF values. Note that contours are usually provided in 5 decibel increments. (See Example 2 on page 4.) When supersonic aircraft operations are present, DNL contours are *required* for the assessment.

If DNL or NEF contours are *not* available, the DNL at a site may be estimated in several different ways:

- An FAA Handbook (Reference 1) can be used to estimate DNL contours for sites in general aviation airport vicinities. General aviation airports exclude commercial jet transports but may include business jets.
- A handbook available from EPA (Reference 2 at the back of this Guide) can be used to calculate DNL at individual points.
- A procedure for constructing approximate DNL contours for sites near commercial jet

Figure 1
Example of DNL Contours



Example 2: The illustration in Figure 1 at the top of page 4 shows the NAL's on a map that has DNL contours. We find that NAL number 1 lies between the 65 and 70 dB contours and that NAL number 2 lies outside the 65 dB contour.

We find the DNL at NAL number 1 by interpolation from the distances between the NAL and the 65 and 70 dB contours.

By scaling off the map, we find that the distance from the NAL, measured perpendicularly to the contours, is 800 feet to the 65 dB contour and 2400 feet to the 70 dB contour. The distance between the 65 and 70 dB contours is 2400 + 800 =3200 feet. We find the DNL at the NAL number 1 to be 65 decibels plus 800/3200 x 5 decibels = 66.3 decibels.

Example 3: The illustration in Figure 2 at the bottom of page 5 shows an airport for which DNL or NEF contours are not available. The airport has 10 nighttime and 125 daytime jet operations.

To construct the approximate contours, we determine the effective number of operations as follows:

10 (nighttime) x 10 = 100

Add to this the actual number of daytime operations:

100 + 125 (daytime) = 225

To determine the distances A and B in relation to the runway (see Figure 3, page 5), enter the effective number of operations on the horizontal scales of the charts in Figure 3;

airports without supersonic aircraft is as follows:

Determine the "effective" number of jet operations at the airport by first multiplying the number of nighttime jet operations by 10.

Then add the number of daytime jet operations to obtain an effective total (see Example 3, page 4).

On a map of the area showing the principal runways, mark the location of the site and, using the diagram and charts of Figure 3 on page 5, construct approximate DNL contours of 65, 70, and 75 dB for the major runways and flight paths most likely to affect the site. (see Figure 2, page 5.)

Although a site may be Acceptable for exposure to aircraft noise; exposure to other sources of noise, when combined with the aircraft noise, may make the site Unacceptable. Therefore, if necessary, values of aircraft noise exposure less than 65 dB can be estimated from Table 2. Scale the shortest distance D^2 from the NAL to the flight path, as in Figure 2. Scale the distance D^1 from the 65 dB contour to the flight path. Divide D^2 by D^1 and enter this value into the following table to find the approximate DNL at the NAL.

Table 2

D2 / D1	DNL dB
1.00	65
1.12	64
1.26	63
1.41	62
1.58	61
1.78	60
2.00	59
2.24	58
2.51	57
2.82	56
3.16	55

Figure 3
Charts for Estimating DNL for Aircraft Operations

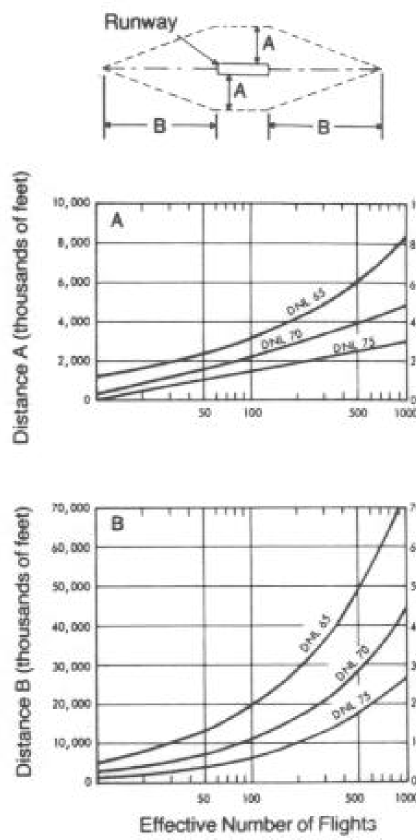
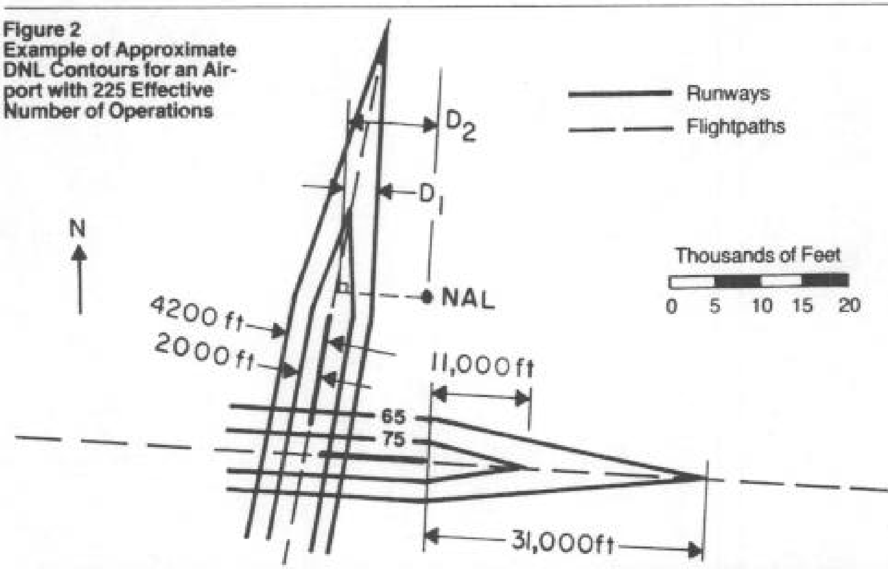


Figure 2
Example of Approximate DNL Contours for an Airport with 225 Effective Number of Operations



read up to the DNL curves; read across the chart to the left to obtain distances A and B from the vertical scales on the charts.

We find from Figure 3, for example, that for 225 effective operations, distance A is 4200 feet for the 65 dB contour and 2000 feet for the 75 dB contour. Distance B is 31,000 feet for the 65 dB contour and 11,000 feet for the 75 dB contour.

Example 4a: The NAL shown in Figure 2 is outside the 65 dB contour. The distance D^2 from the NAL to the flight path is 9700 feet. The distance D^1 from the 65 dB contour to the flight path, measured perpendicularly from the contour, is 3700 feet. The ratio D^2/D^1 is 9700/3700 = 2.62. From Table 2 we find the DNL from the airport to be 56.6 dB. We do not know whether the site is Acceptable or not, however, since we must also assess the contribution of roadway and train noise to the total DNL at the site.

Example 4b: We observe that the perpendicular distance (D^2) from NAL number 2 (Figure 1) to the flight path is more than 3 times the distance (D^1) from the 65 dB contour to the flight path. From Table 2 we find that the contribution of the airport to the DNL at NAL number 2 is less than 55 decibels. We need not consider the airport further in accessing the noise environment at this site.

Roadways

Necessary Information

To evaluate a site's exposure to roadway noise, you will need to consider all roads that might contribute to the site's noise environment; roads farther away than 1000 feet normally may be ignored.

Before beginning the evaluation, determine if roadway noise predictions already exist for roads near the site. Also try to obtain all available information about approved plans for roadway changes (e.g., widening existing roads or building new roads) and about expected changes in road traffic (e.g., will the traffic on this road increase or decrease in the next 10 to 15 years).

If noise predictions have been made, they should be available from the City (County) Highway or Transportation Department. If not, record the following information on page 1 of Worksheet C:

- The distances from the NAL's for the site to the near edge of the nearest lane and the far edge of the farthest lane for each road.
- Distance to stop signs.
- Road gradient, if 2 percent or greater.
- Average speed.
- The total number of automobiles for both directions during an average 24-hour day. Traffic engineers refer to this as ADT, Average Daily Traffic (or sometimes AADT, meaning Annual Average Daily Traffic).
- The number of trucks during an average 24-hour day in each direction.

If possible, separate trucks into "heavy trucks" – those weighing more than 26,000 pounds with three or more axles – and "medium trucks" – those between 10,000 and 26,000 pounds. (Each medium truck is counted as equal to 10 automobiles.) Trucks under 10,000 pounds are counted as automobiles. Count buses capable of carrying more than 15 seated passengers as "heavy" trucks – others, as "medium" trucks. If it is not possible to separate the trucks into those that are heavy and those that are not, treat *all* trucks as though they are "heavy."

Note: If the road has a gradient of 2 percent of more, record the numbers for uphill and downhill traffic separately since these figures will be needed later; otherwise, simply record the total number of trucks. Most often you will have to assume that the uphill and downhill traffic are equally split.

- The fraction of ADT that occurs during nighttime (10 p.m. to 7 a.m.). If this is unknown, assume 0.15 for both trucks and autos.

Evauation of Site Exposure to Roadway Noise

Traffic surveys show that the amount of roadway noise depends on the percentage of trucks in the total traffic volume. To account for this effect, you must evaluate automobile and truck traffic separately and then combine the results.

The noise environment at each site due to traffic noise is determined by utilizing a series of Workcharts to define the contribution of automobiles and trucks from one or more roads at that site. Each noise source yields a separate DNL value.

Workchart 1 provides a graph for assessing a site with respect to the noise from automobiles, light and medium trucks; Workchart 2 provides a similar graph for assessment of heavy truck noise. These values are combined for each road affecting the noise environment at the site to obtain the total contribution of roadway noise. Remember, the noise from aircraft and railways must also be considered before determining the suitability of this site's noise environment.

Effective Distance

Before proceeding with these separate evaluations, however, determine the "effective distance" to each road from the dwelling or outdoor residential activity (the NAL's for the site) by averaging the distances to the nearest edge of the nearest lane and to the farthest edge of the farthest lane of traffic. (See Example 5, page 6, and Figure 4, page 7.)

Note: For roads with the same number of lanes in both directions, the effective distance is the distance to the center of the roadway (or median strip, if present).

Automobile Traffic

Workchart 1 was derived with the following assumptions:

- There is line-of-sight exposure from the site to the road; i.e., there is no barrier which effectively shields the site from the noise of the road.
- There is no stop sign within 600 feet of the site; traffic lights do not count because there is usually traffic moving on one street or the other.
- The average automobile traffic speed is 55 mph.
- The nightime portion of ADT is 0.15.

If each road meets these four conditions, proceed to Workchart 1 for the evaluation. Enter the horizontal axis with the effective distance from the roadway to the NAL; draw a vertical line upward from this point. Enter the vertical axis with the effective automobile ADT; draw a horizontal line across from this point. (The "effective" automobile ADT is the sum of automobiles, light trucks, and 10 times the number of medium trucks in a 24-hour day.) Read the DNL value from Workchart 1 where the vertical and horizontal lines intersect. Record this value in column 16, Worksheet C.

But:

If any of the four conditions is different, make

Example 5: The site shown in Figure 4 is exposed to noise from three major roads: Road No. 1 has four lanes, each 12 feet wide, and a 30-foot wide median strip which accommodates a railroad track. Road No. 2 has four lanes, each 12 feet wide. Road No. 3 has six lanes, each 15 feet wide, and a median strip 30 feet wide.

The distance from NAL No. 1 to the near edge of Road No. 1 is 300 feet. The distance to the far edge of Road No. 1 is 300 feet, plus the number of lanes times the lane width, plus the width of the median strip. Thus, the distance to the farthest edge of the road is:

$300 + (4 \times 12) = 378\ ft$

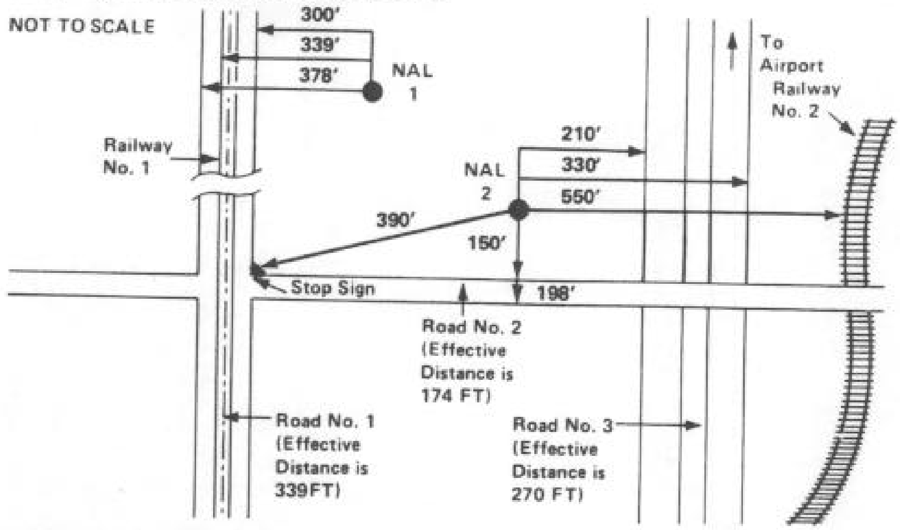
The effective distance is

$$\frac{378 + 300}{2} = 339\ ft$$

This is the value to be entered on line 1c of Worksheet C. The effective distances from the appropriate NAL's to Road No. 2 and Road No. 3 are found by the same method.

The distances shown in Figure 4 will be used for all roadway examples in this booklet.

Figure 4
Plan View of Site showing How Distance Should Be Measured from the Noise Assessment Location (NAL) of the Dwelling Nearest to the Source

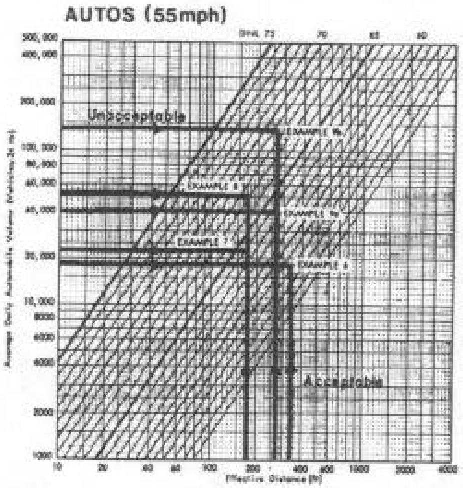


the necessary adjustments (on page 2, Worksheet C) listed below and *then* use Workchart 1 for the final evaluation.

First, a few general words about adjustments as they are applied in these Guidelines. Each Workchart has been derived for a baseline condition which is often found in practical cases. Where conditions differ from the baseline, they are accounted for by a series of one or more adjustment factors.

The adjustment factors are used as multipliers times the average number of vehicles operating during a 24-hour day. If more than one adjustment is required, it is not necessary that each be multiplied times the basic traffic flow separately; all adjustment factors are multiplied together, and them multiplied times the original traffic flow data. This will become clearer as you examine the Worksheets at the back of these Guidelines and work through the examples. After you have become familiar with the Guidelines, you will be able to work examples directly from the worksheets without referring back to the text. To simplify your work, all the adjustment factors are summarized at the back of these Guidelines.

Figure 5
Use of Workchart 1 To Evaluate Automobile Traffic Noise



Adjustments for Automobile Traffic

Stop-and-Go Traffic:

If there is a stop sign (not a traffic signal) within 600 feet of the NAL so that the flow of traffic is completely interrupted on the road under consideration, find the stop-and-go adjustment factor for automobiles from Table 3. Enter this value in column 9 on Worksheet C.

Table 3

Distance from NAL to Stop Sign In Feet	Automobile Stop-and-Go Adjustment Factor
0	0.10
100	0.25
200	0.40
300	0.55
400	0.70
500	0.85
600	1.00

Average Traffic Speed:

If the average automobile speed is other than 55 mph, enter the appropriate adjustment from Table 4 in column 10 of Worksheet C.

Table 4

Average Traffic Speed	Auto Speed Adjustment Factor
20 (mph)	0.13
25	0.21
30	0.30
35	0.40
40	0.53
45	0.67
50	0.83
55	1.00
60	1.19
65	1.40
70	1.62

Example 6: Road No. 1 meets the four conditions that allow for an immediate evaluation. In obtaining the information necessary for this evaluation, it was found that the automobile ADT is 18,000 vehicles (Line 5c of Worksheet C). On Workchart 1 we locate on the vertical scale the point representing 18,000 and on the horizontal scale the point representing 339 feet (see Figure 5). (Note that we must estimate the location of this point.) Using a straight-edge we draw lines to connect these two values and find that the NAL exposure to automobile noise from this road is a DNL of 58 dB, as read from the scale at the top of the graph.

Example 7: Road No. 2 has a stop sign at 390 feet from NAL No. 2. The automobile ADT is reported as being 32,500 vehicles (line 5c of Worksheet C). From Table 3 we interpolate between 300 and 400 feet to find the adjustment factor for stop-and-go traffic to be 0.69. The adjusted traffic ADT is

0.69 × 32,500 = 22,425 vehicles per day

and with an effective distance of 174 feet from NAL No. 2, we find from Workchart 1 that the approximate value of DNL is 64 dB.

Example 8: Suppose that the stop sign on Road No. 2 were replaced by a traffic signal for which no stop-and-go adjustment is made and that the ADT increases to 75,000 vehicles. In addition, assume that the average speed is 45 mph instead of 55 mph. You adjust the new automobile ADT of 75,000 vehicles by the Auto Speed Adjustment Factor from Table 4

0.67 × 75,000 = 50,250 vehicles

and at an effective distance of 174 feet find from Workchart 1 that the approximate value of DNL is 67 dB.

Nightime Adjustment.

DNL values are affected by the proportion of traffic volume that occurs during "daytime" (7 a.m. to 10 p.m.) and "nighttime" (10 p.m. to 7 a.m.). The graph on Workchart 1 assumes that 15 percent of the total ADT occurs during nighttime. If a different proportion of the traffic occurs at night, find the appropriate nighttime adjustment factor from Table 5. Record your answer in column 11 of Worksheet C.

Table 5

Nighttime Fraction of ADT	Nighttime Adjustment Factor
0	0.43
0.01	0.46
0.02	0.50
0.05	0.62
0.10	0.81
0.15	1.00
0.20	1.19
0.25	1.38
0.30	1.57
0.35	1.77
0.40	1.96
0.45	2.15
0.50	2.34

Once you have selected all the appropriate adjustment factors and entered them on page 2 of Worksheet C, multiply all the factors together, then multiply by the automobile ADT (column 12) for 24 hours, found on page 1 of Worksheet C. The resulting adjusted ADT should be entered in column 13. This is the ADT value to be used, in conjunction with the effective distance from the NAL to the road, to find the DNL value from Workchart 1. Enter this DNL value in column 14 of Worksheet C. Remember this is the DNL from automobile (as well as light and medium truck) noise; you must still find the DNL contribution from heavy truck noise in order to obtain the total DNL produced by the roadway you are assessing.

Attenuation of Noise by Barriers:

This adjustment reduces the noise produced by automobiles and trucks on the same road. Instructions for this adjustment appear after the noise assessment for truck traffic below.

Truck Traffic

Wherever possible, separate the average daily volume of trucks into heavy trucks (more than 26,000 pounds vehicle weight and three or more axles); medium trucks (less than 26,000 pounds but greater than 10,000 pounds), light trucks (counted as if they are automobiles). You should already have accounted for medium and light trucks in your automobile evaluation. Do not forget that buses that can carry more than 15 seated passengers are counted as heavy trucks. Heavy trucks (including buses) must be analyzed separately because they have quite different noise characteristics. If it is not possible to separate the trucks into those that are heavy and those that are not, treat *all* trucks as though they are "heavy."

Workchart 2, which is used to evaluate the site's exposure to heavy truck noise, was derived with the following assumptions:

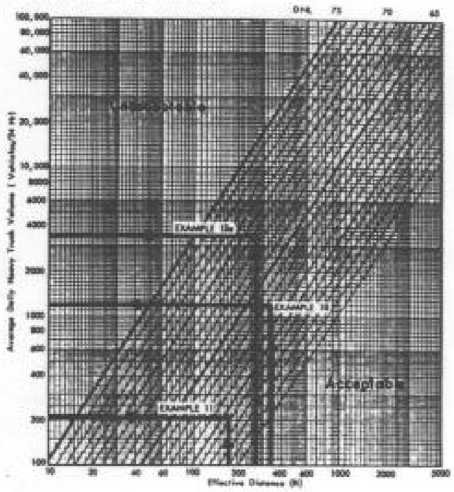
- There is line-of-sight exposure from the site to the road; i.e., there is no barrier which effectively shields the site from the road noise.
- The road gradient is less than 2 percent.
- There is no stop sign (traffic signals are permissible) within 600 feet of the site.
- The average truck traffic speed is 55 mph.
- The nighttime fraction of ADT is 0.15.

If the road meets these five conditions, proceed to Workchart 2 for an immediate evaluation of the site's exposure to heavy truck noise from that road.

But:
If any of the conditions is different, make the necessary adjustment(s) listed below and *then* use Workchart 2 for the evaluation.

Figure 6.
Use of Workchart 2 to Evaluate Heavy Truck Noise

Heavy Trucks (55 mph)



Adjustments for Heavy Trucks

Road Gradient:

If there is a gradient of 2 percent or more, find the appropriate adjustment factor, for heavy trucks going uphill only, as shown in Table 6. List this factor in column 17 of Worksheet C.

Table 6

Percent of Gradient	Adjustment Factor
2	1.4
3	1.7
4	2.0
5	2.3
6 or more	2.5

Example 9a: Road No. 3 is a limited access highway with no stop signs and the average speed is 55 mph. Current traffic data indicate an automobile ADT of 40,000 vehicles of which 15 percent occurs during nighttime hours (10 p.m. to 7 a.m.). With an effective distance of 270 feet to NAL No. 2, Workchart 1 is used to show that the DNL for existing automobile traffic is between 63 and 64 dB. Round off to 64 dB.

Example 9b: However, traffic projections estimate that in 10 years the ADT will increase to 100,000 vehicles at an average speed of 55 mph and nighttime usage will increase to 25 percent. For future traffic, you must adjust the future ADT of 100,000 for the effect of increased nighttime use. From Table 5, you find an adjustment factor of 1.38. The adjusted ADT is

$$1.38 \times 100{,}000 = 138{,}000$$

and at an effective distance of 270 feet you find from Workchart 1 that the DNL will increase to 69 dB; therefore, provision for extra noise control measures should be explored. We will examine in Example 13 the effect of terrain as a shielding barrier that provides sound attenuation.

Example 10: Road No. 1 on Figure 4 meets the four conditions that allow for an immediate evaluation. The ADT for heavy truck flow is 1200 vehicles. Workchart 2 shows that the exposure to truck noise from this road at an effective distance of 339 feet is a DNL of 63 dB at NAL No. 1.

Average Traffic Speed:

Make this adjustment if the average speed differs from 55 mph. If the average truck speed differs with direction, treat the uphill and downhill traffic separately. Select the appropriate adjustment factors from Table 7 below, entering them in column 18 of Worksheet C.

Table 7

Average Traffic Speed MPH	Heavy Truck Speed Adjustment Factor
50 or less	0.81
55	1.00
60	1.17
65	1.38

Once you have found the speed adjustment factor, you can combine the uphill and downhill traffic. For uphill traffic, multiply the gradient factor times the speed adjustment factor times uphill traffic volume (truck ADT column 19) (assuming one half the total 24-hour average number of trucks unless specific information to the contrary exists), entering the product in column 20. Multiply the speed adjustment factor for downhill traffic times the downhill traffic volume (truck ADT/2 column 19). Add the values for uphill and downhill traffic, entering this sum in column 21. You may now complete the assessment of heavy truck noise without regard to uphill and downhill traffic separation.

Stop-and-Go Traffic:

If there is a stop sign (remember, not a traffic signal) within 600 feet of an NAL for the site on the road being assessed, find the adjustment factor determined according to Table 8. Enter it in Column 22 of Worksheet C.

Table 8

Heavy Truck Traffic Volume per Day	Heavy Truck Stop-and-Go Adjustment Factor
Less than 1200	1.8
1201 to 2400	2.0
2401 to 4800	2.3
4801 to 9600	2.8
9601 to 19,200	3.8
More than 19,200	4.5

Nighttime Adjustment

After all the above adjustments are made, do not forget to adjust for nighttime operations if they are not 15 percent of the total ADT, using the factors obtained from Table 5 just as for automobiles. Enter this value in column 23 of Worksheet C.

At this point, multiply the adjustment factors for nighttime and stop-and-go traffic times the heavy truck traffic volume in column 21 to find the adjusted heavy truck ADT, entering the product in column 24. Use this value and the effective distance from the NAL to the road to find the truck DNL from Workchart 2, entering your answer in column 25 of Worksheet C. If no shielding barriers are to be considered, combine the DNL from heavy trucks with the DNL from automobiles (column 14). The result is the DNL from the road being assessed and should be entered on Worksheet C.

But:

If a shielding barrier is to be considered for the site, make the analysis described below separately for automobiles and then for heavy trucks *before* combining the DNL values. This step is necessary since barriers are far more effective for automobiles than for heavy trucks. Once you have found the amount of attenuation provided by the barrier for automobiles, enter it in column 15. Find the value of barrier attenuation for heavy trucks and enter it in column 25. Subtract these attenuation values from the DNL values obtained previously (columns 14 and 24), entering the reduced DNL values in columns 16 and 27. Combine the automobile and heavy truck DNL values, reduced by the attenuation provided by the barrier, to find the final DNL produced by the roadway at the site.

Remember to combine the contributions to DNL of *all* roads that affect the noise environment at each NAL for the site to obtain the total DNL from all roadways. Enter this DNL on both Worksheet C and the summary Worksheet A.

Attenuation of Noise by Barriers

Noise barriers are useful for shielding sensitive locations from ground level noise sources. For example, a barrier may be the best way to deal with housing sites at which the noise exposure is not acceptable because of nearby roadway traffic.

A barrier may be formed by the road profile, by a solid wall or embankment, by a continuous row of noise-compatible buildings, or by the terrain itself. To be an *effective* shield, however, the barrier must block all residential levels from line of sight to the road; it must not have any gaps that would allow noise to leak through.

Some Preliminary Matters:

In evaluating noise barrier performance, you will be working with different kinds of "distances" between the sound source, the observer, and the barrier.

Actual Distance – the existing distance that would be measured using a tape measure with no corrections or adjustments. This may mean one of two things, *depending on the application;* either the:

- *slant distance* – the actual distance,

Example 11: Road No. 2 has a stop sign at 390 feet from NAL No. 2. There is also a road gradient of 4 percent. No heavy trucks are allowed on this road, but a schedule shows an average of 12 large buses pass along the road per hour between 7 a.m. and 10 p.m., although no buses are scheduled during the remaining nighttime period. The buses are equally divided in each direction along the road. (Remember large buses, those that carry over 15 seated passengers, count as heavy trucks.)

We find the ADT for the "heavy trucks" (the buses in this case) by multiplying the average number of vehicles per hour by the number of hours between 7 a.m. and 10 p.m. That is, 12 x 15 = 180, or 90 vehicles in each direction. We find from Table 6 that the gradient adjustment factor for uphill traffic is 2.0. We find the truck volume adjusted for gradient is

uphill:	*90 x 2.0 = 180*
downhill:	*= 90*
total (column 21)	*= 270 vehicles*

From Table 8, we find the adjustment factor for stop-and-go traffic to be 1.8.

We also remember that we have no buses in the nighttime period and find the factor in Table 5 on page 8 for zero nighttime operations to be 0.43.

Our final adjusted ADT is (column 24)

1.8 x 0.43 x 270 = 209 Vehicles

From Workchart 2, with an effective distance of 174 feet, we find a DNL of 59 dB.

Example 12a: Road No. 3 is a depressed highway and the profile shields all residential levels of the housing from line of sight to the traffic. The average truck speed is 50 mph. The ADT for heavy trucks is 4400 vehicles. We adjust for average speed (from Table 7)

4400 x 0.81 = 3564

and find from Workchart 2 that, with an effective distance of 270 feet, the DNL from truck noise would be 69 dB if no barrier existed. We proceed to analyze the barrier attenuation.

measured along the line of sight between two points; or the

- *map distance* – the actual distance, measured on a horizontal plane, between the two points, as on a map or on the project plan.

For an observer high in an apartment tower, the slant distance to the road may be much longer than the map distance.

Barrier effectiveness is expressed in terms of noise attenuation in decibels (dB), determined with the aid of Workchart 6. This numerical value is subtracted from the previously calculated DNL in order to find the resultant DNL at the Noise Assessment Location.

Note: A noise barrier can be considered as a means of protecting a site from noise even if it cannot wrap around the site to shield from view practically all of the source of noise at every sensitive location on the site. It must be recognized, however, that such a barrier is much less effective than an ideal barrier. (See Workchart 7 and Step 6 below.)

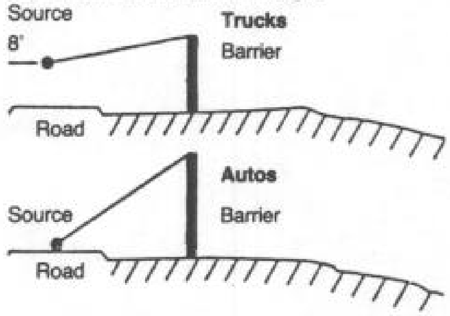
Barriers of reasonable height cannot be expected to protect housing more than a few stories above ground level. Barriers will generally protect the ground and the first two or three floors, but not the higher floors. If there are to be frequently occupied balconies on the upper levels, one solution is to move the building farther from the noise source and face the sensitive areas away from the noise.

Steps to Evaluate a Barrier

1. For the observer's position, use the mid-height of the highest residential level. For the source position, use the following heights (see Figure 7):

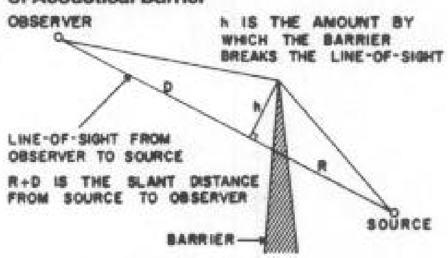
- autos, medium trucks, railway cars – the road or railway surface height
- heavy trucks – 8 feet above the road surface
- diesel locomotives or trains using horns or whistles at grade crossings – 15 feet above the rails.

Figure 7.
Source Heights to Be Used in Roadway Barrier Designs



Get accurate values for the following quantities: h, the shortest distance from the barrier top to the line of sight from source to observer; R and D, the slant distances along the line of sight from the barrier to the source and observer, respectively (see Figure 8).

Figure 8.
Generalized Geometry of Acoustical Barrier



Specifically, R and D are the two segments into which h breaks the line of sight. Note that h is *not* the height of the barrier above the ground but the distance from the barrier top to the line of sight.

2. Enter at the top of Workchart 6 with the value of h on the left-hand scale; move right to intersect the curve corresponding to R (or D, whichever is *smaller*).

3. Move down to intersect the curve corresponding to the value of D/R (or R/D, whichever is *smaller)*.

4. Move right to intersect the vertical scale in order to find the barrier shielding value A in decibels.

5. Interruption of the line of sight with a barrier between the noise source and an observer reduces the amount of sound attenuation provided by the ground. Find the amount of this loss B from the table on Workchart 6 by entering the table with the value of D/R. Find the barrier attenuation value S corresponding to an ideal barrier that completely hides the noise source from view by subtracting B from the value of A obtained in Step 4.

6. If the barrier exists along only a part of the road so that unshielded sections of the road would be visible from the site, the barrier is less effective than an ideal barrier. On a plan view of the site, locate the two ends of the barrier and draw lines from these points to the Noise Assessment Location. Use a protractor to measure the angle formed at the NAL by the two lines. Enter the horizontal scale of Workchart 7 with the values of this angle; read up to the curve having the value of S determined from Step 5 (interpolating if necessary); read left across to the vertical scale labeled "actual barrier performance" to find the value of FS to use for the actual barrier in question.

7. Subtract the barrier attenuation value S (or FS if adjusted for finite barrier length according to Workchart 7) from the value of DNL previously determined to reevaluate the site with the noise barrier in place.

Example 12b: (Refer to Figure 9.) Six stories are planned for the housing where the site has an elevation of 130 feet. The effective elevation for the highest story is found by multiplying the number of stories by 10 feet, adding the site elevation, and subtracting 5 feet.

(6 × 10) + 130 - 5 = 185 feet

The barrier, which in this case is formed by the road profile, has no "height" other than the elevation of the natural terrain above the noise sources traveling on the roadway. The important dimensions are indicated in Figure 9.

Some people with a technical background will be able to fit the geometric diagram to the site situation readily, working from the project drawings and a scratch sheet.

But if you are *not* confident of your geometry, Workchart 5 gets you the values of R, D, and h from the map distances and elevations of the site. We illustrate that procedure in this example.

First, enter the elevations of the source (S), the observer (O), and the top of the barrier (H), as well as the map distances from the barrier to the source (R') and observer (D'), at the top right of Workchart 5. Then, follow the steps on that Workchart to derive the values of h, R, and D that are needed in using Workchart 6.

Entering Workchart 6 at the upper left with the value of h (5.5 feet), we move horizontally

Figure 9.
Detail of Site Showing Measurements Necessary for a Barrier Adjustment

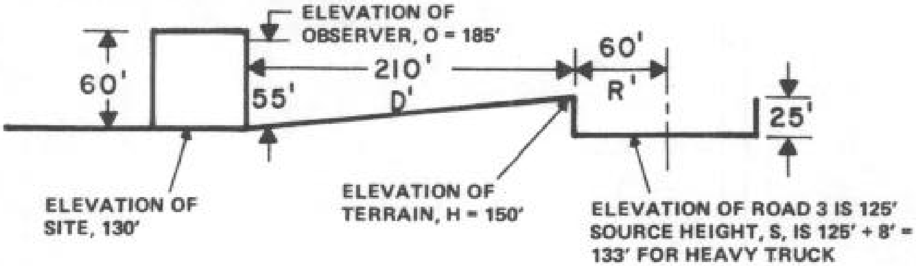
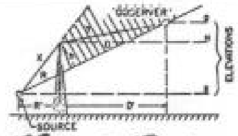


Figure 10.
Use of Workchart 5 to Determine Barrier Dimensions in Example 12b

Workchart 5
Noise Barrier
To find R, D and h from Site Elevations and Distances

Enter the values for:
H= 150 R'= 60
S= 133 D'= 210
O= 185

Fill out the following worksheet (all quantities are in feet):



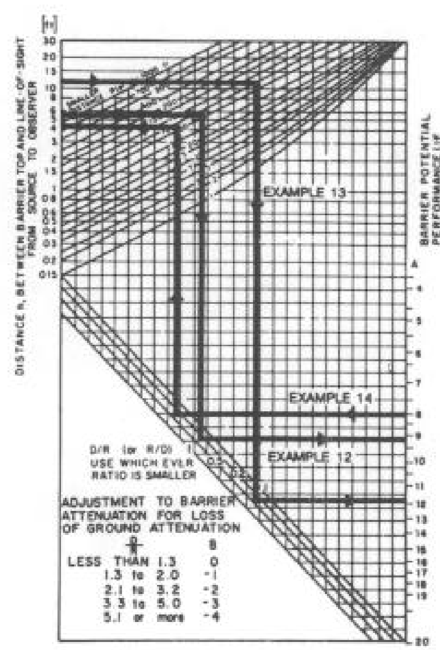
1. Elevation of barrier top minus elevation of source	[H 150]	−	[S 133]	=	[1 17]	
2. Elevation of observer minus elevation of source	[O 185]	−	[S 133]	=	[2 52]	
3. Map distance between source and observer (R' + D')					[3 270]	
4. Map distance between barrier and source (R')					[4 60]	
5. Line 2 divided by line 3	[2 52]	÷	[3 270]	=	[5 0.19]	
6. Square the quantity on line 5 (i.e., multiply it by itself), always positive	[5 0.19]	×	[5 0.19]	=	[6 0.04]	
7. 40% of line 6	[0.4]	×	[6 0.04]	=	[7 0.016]	
8. One minus line 7	[1.0]	−	[7 0.016]	=	[8 0.984]	
9. Line 5 times line 4 (will be negative if line 2 is negative)	[5 0.19]	×	[4 60]	=	[9 11.4]	
10. Line 1 minus line 9	[1 17]	−	[9 11.4]	=	[10 5.6]	
11. Line 10 times line 8	[10 5.6]	×	[8 0.984]	=	[11 5.5]	= h
12. Line 5 times line 10	[5 0.19]	×	[10 5.6]	=	[12 1.06]	
13. Line 4 divided by line 8	[4 60]	÷	[8 0.984]	=	[13 61]	
14. Line 13 plus line 12	[13 61]	+	[12 1.06]	=	[14 62]	= R
15. Line 3 minus line 4	[3 270]	−	[4 60]	=	[15 210]	
16. Line 15 divided by line 8	[15 210]	÷	[8 0.984]	=	[16 213]	
17. Line 16 minus line 12	[16 213]	−	[12 1.06]	=	[17 212]	= D

(Note: the value on line 2 may be negative, in which case so will the values on lines 5, 9, and 12; line 1 may also be negative. Remember, then, in lines 10, 14, and 17, that adding a negative number is the same as subtracting: x + (−y) = x − y. And subtracting a negative number is like adding: x − (−y) = x + y.)

Round off R and D to nearest integer, h to one decimal place.

Figure 11.
Use of Workchart 6 to Evaluate Barrier in Examples 12b, 13 and 14

Noise Barrier Workchart 6



to the right until we meet the value of R or D, whichever is smaller: in this example, R = 62 feet. From that point we drop vertically downward until we meet the value of R/D or D/R, whichever is smaller: in this case, R/D = 0.29. From that point, move horizontally to the right to find the value for A = 9 dB. Entering the table for determining loss of ground attenuation effect due to the barrier with a value for D/R of 3.5, the reduction in attenuation (B) is found to be 3 dB. Substracting 3 dB from 9 dB provides a net attenuation of 6 dB. With 6 dB of attenuation, the original DNL of 69 dB (Example 12a) is reduced to 63 dB.

Example 13: An alternative approach, which is somewhat more direct, is illustrated here for the noise of automobiles on Road No. 3.

A preliminary step is to make an accurately scaled sketch of the general geometry introduced on page 8. It must include the positions of the source (this time at the road surface), the observer, and the top of the barrier; and will show the distances h, R, and D. Such a sketch is shown superimposed on the profile of the road and its neighborhood in Figure 12.

If we carefully scale the dimensions directly from this sketch, we find the following values for h, R, and D:

R=63 feet

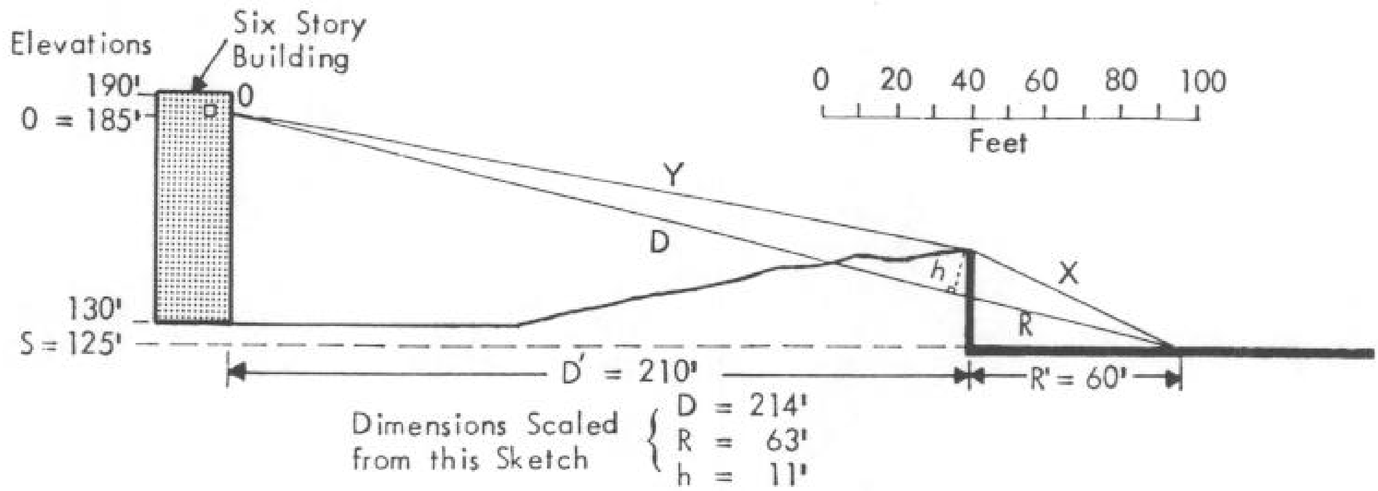
R/D=0.3

D=214 feet

h=11 feet

The barrier attenuation is found, by entering Workchart 6 with these values, to be A=12 dB. It is larger than that found for trucks because the noise source is lower and is, therefore, better shielded by the barrier. The loss from ground attenuation is again B=3 dB for a net attenuation of 12 - 3 = 9 dB. In Example 9b, we found that the DNL

Figure 12.
Sketch Showing Dimensions for Example 13



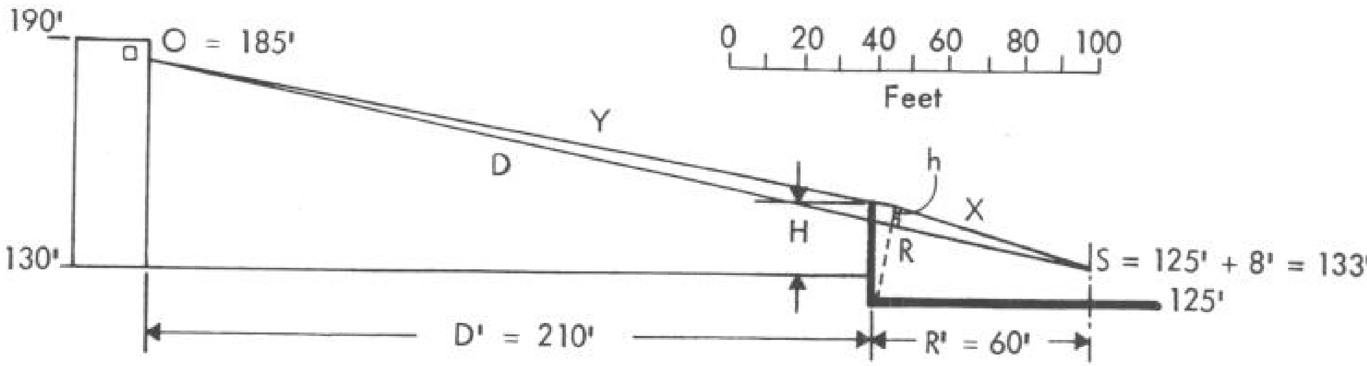
for the projected traffic volume of 100,000 vehicles per day was 69 dB if no consideration was given the shielding provided by the terrain. Subtracting the 9 dB attenuation from 69, we find the partial DNL for automobiles is 60 dB.

In order to find the combined truck and automobile noise for Road No. 3, we combine the 63 dB of truck noise with the 60 dB of automobile noise using Table 1. We find that 1.8 should be added to 63 dB, for a combined DNL of 64.8 dB, or 65 dB when rounded to the nearest whole number.

Example 14: Where no natural barrier exists, Workchart 6 can be used in reverse to estimate the height of a barrier needed to obtain a required attenuation. In example 9b we found that, without any attenuation from terrain or a barrier, the automobile traffic produced a DNL of 69 dB, and in Example 12a the heavy truck traffic produced a DNL of 69 dB. When combined, the total DNL is 72 dB. Suppose the terrain were not rising between NAL and Road No. 3, as shown in Figure 12, but instead was level between the NAL and the edge of the road, as shown in Figure 13. We want to find out how high a wall, infinite in length, would be required at the edge of the road to reduce the combined truck and automobile noise to less than 65 dB. We have found in the previous examples that a barrier of a given height will provide more attenuation for automobiles than it will for trucks. As a first step in our analysis, we will find the height of a wall that will reduce the truck noise to just below 65 dB, say 64 dB, and then find out whether the additional attenuation it provides for automobile noise will be sufficient to reduce the combined truck and automobile noise to less than 65 dB. We begin by finding the height of wall that will provide 5 dB attenuation for truck noise.

We estimate that the ratio of R/D is about the same as R'/D', the ratio of horizontal distance in Figure 13, which is equal to 0.29. Before entering Workchart 6, we find from the loss of ground attenuation table that for D/R = 3.4 we will lose 3 dB attenuation from an ideal barrier. In order to have a net attenua-

Figure 13.
Sketch Showing Dimensions for Example 14



tion of 5 dB, we must have an ideal barrier that provides 5 + 3 = 8 dB attenuation.

Entering Workchart 6 on the right side scale A at 8 decibels, we move across to the diagonal lines, finding 0.29 by interpolating between the lines marked at 0.2 and 0.5. Moving directly up to a point midway between the R lines of 50 and 70, we find our estimated R of approximately 60. Moving across to the left we find that the line of sight between the observer and the truck source height must be broken by a value of h equal to 4.5 feet.

We can determine the height of the wall H in several ways. By drawing h=4.5 feet to scale on Figure 13, we can scale the total wall height H to be approximately 20 feet. Those who feel comfortable with geometry can calculate H by using the similar triangle relationships in Figure 13 to determine that H is 19.1 feet.

Now we must find how much a wall 19 feet high will attenuate automobile noise, remembering that the source height for automobiles is at the road surface elevation of 125 feet. By scaling the drawing, or by geometry, we determine that the line of sight between the observer position and the automobile source is broken by a value of h that is approximately 13 feet. Entering Workchart 6 at 13 feet we find, for R=60 feet and R/D=0.29, that the potential barrier attenuation is 12dB. We must reduce this by 3 dB for loss of ground attenuation to find the actual shielding of automobile noise to be 9 dB. The original 69 dB of automobile noise is reduced to 69 - 9 = 60 dB.

Finally, we combine the heavy truck noise, attenuated by the wall to 69 - 5 = 64 dB, with the automobile noise reduced to 60 dB, to find a combined DNL of 65.5 dB, or 66 dB when rounded upward. Remember, however, that this is for an infinite wall. Further adjustments would have to be made once the actual length was known.

Railways

Necessary Information

To evaluate a site's exposure to railway noise, you will need to consider all rapid transit lines and railroads within 3000 feet of the site (except totally covered subways). The information required for this evaluation is listed below under headings that indicate the most likely source.

Before beginning the evaluation, you should record the following information on Worksheet D:

From the area map and/or the (County) Engineer:

- The distance from the appropriate NAL on the site to the center of the railway track carrying most of the traffic.

From the Supervisor of Customer Relations for the railway:

- The number of diesel trains and the number of electrified trains in both directions during an average 24-hour day.
- The fraction of trains that operate during nighttime (10 p.m. - 7 a.m.) If this is unknown, assume 0.15.
- The average number of diesel locomotives per train. If this is unknown, assume 2.
- The average number of railway cars per diesel train and per electrified train. If this is unknown, assume 50 for diesel trains and 8 for electrified trains.
- The average train speed. If this is unknown, assume 30 mph.
- Is the track made from welded or bolted rails?

From the Engineering Department of the railway:

- Is the site near a grade crossing that requires prolonged use of the train's horn or whistle? if so, where are the whistle posts located? (Whistle posts are signposts which tell the engineer to start blowing the horn or whistle. Every grade crossing has whistle posts and they are listed on the railroad's "track charts." If traffic on the track is one-way, there will be only one whistle post. The grade crossing itself is the other "whistle post."

Electrified rapid transit and commuter trains that do not use diesel engines should be treated the same as railway cars.

Note: Buildings closer than 100 feet to a railroad track are often subject to excessive vibration transmitted through the ground. Construction at such sites is discouraged.

Evaluation of Site Exposure to Railway Noise

Railway noise is produced by the combination of diesel engine noise and railway car noise. These Guidelines provide for the separate evaluation of diesel locomotives and railroad cars, and then the combination of the two, in order to obtain the DNL from trains. When rapid transit or electrified trains that do *not* use diesel engines are the only trains passing near a site go directly to the second part of the evaluation since these trains are treated in the same manner as railway cars.

Diesel Locomotives

Workchart 3 was derived with the following assumptions:

- A clear line of sight exists between the railway track and the Noise Assessment Location.
- There are two diesel locomotives per train.
- The average train speed is 30 mph.
- Nighttime operations are 0.15 of the 24-hour total.
- The site is not near a grade crossing requiring prolonged use of the train's horn or whistle.

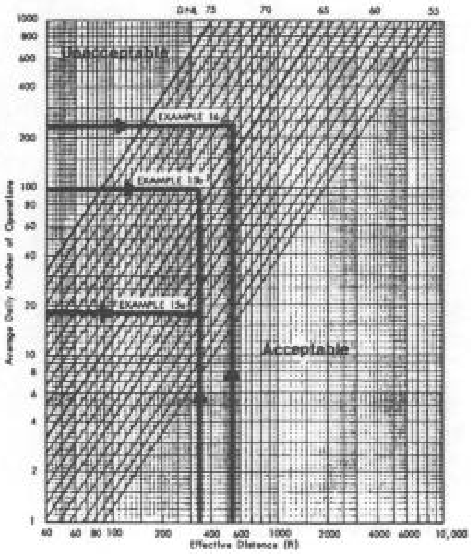
If the situation meets these conditions, proceed to Workchart 3 for an immediate evaluation of diesel locomotive noise.

But:

If any of the conditions is different, make the necessary adjustments listed below and *then* use Workchart 3 for the evaluation.

Figure 14.
Use of Workchart 3 to Evaluate Diesel Locomotive Noise

Railroads – Diesel Locomotives



Adjustments for Diesel Locomotives

Number of Locomotives:

If the average number of diesel locomotives per train is not 2, divide the average number by 2. Enter this value in column 9 of Worksheet D.

Example 15a: The distance from NAL number 1 to Railway Number 1 is 339 feet. Two percent of the 35 daily operations occur at night; there is clear line of sight between the tracks and the NAL, and no horns or whistles are used. No information is available on train size or speed, therefore we will assume 2 engines per train and a speed of 30 mph.

Since the percentage of nighttime operations is different from 15 percent, we must adjust the actual number of daily operations, multiplying by 0.50 according to Table 5.

0.50 x 35 = 17.5 = 18

Entering Workchart 3 with 18 daily operations and a distance of 339 feet, we find that the contribution of diesel engine noise is a DNL of 59 dB (see Figure 14).

In order to find the total contribution of the trains to the total DNL, we must also find the noise level produced by the train's cars. Entering Workchart 4 (see Figure 15) with 18 daily operations and a distance of 339 feet, we find the DNL is below 50 on the chart, or more than 10 decibels lower than the noise level produced by the engines. Based on the chart for decibel addition, the combination of the noise from the engines and the cars adds less than 0.5 decibels to the DNL value for the engines alone, 59 dB.

Example 15b: Suppose that a forecast of train operations for Railway 1 indicates that there will still be 35 trains per day, but now 50 percent of the operations will occur at night, the average train will have 4 engines and 75 cars, and the average speed will be 50 mph.

We first find the contribution to DNL made by diesel locomotives by using the following adjustment factors:

- number of engines adjustment: 2
- speed adjustment: 0.60
- day/night adjustment: 2.34

We multiply these adjustments together with the number of trains:

2 X 0.60 X 2.34 X 35 = 98

Entering Workchart 3 (see Figure 14) with 98 daily operations and a distance of 339

Average Train Speed:

If the average train speed is different from 30 mph, find the appropriate adjustment factor from Table 9 and list in column 10 of Worksheet D.

Table 9

Average Speed (mph)	Speed Adjustment Factor
10	3.00
20	1.50
30	1.00
40	0.75
50	0.60
60	0.50
70	0.43

Horns or Whistles:

If the NAL is perpendicular to any point on the track between the whistle posts for the grade crossing, enter the number 10 in column 11, Worksheet D.

Nighttime Adjustment:

Remember to adjust for nightime operations, if different from 0.15 of the total, by selecting the appropriate adjustment factor from Table 5 on page 8. Enter in column 12, Worksheet D.

Multiply the adjustment factors together, times the number of diesel trains per day (you have listed this number previously on line 2a, page 1, of Worksheet D, and should enter this number again in column 13) to obtain the adjusted number of trains per day. Enter the adjusted number of diesel trains per day in column 14. Use this value, in conjunction with the distance from the NAL to the track (line 1, page 1, of Worksheet D), to find from Workchart 3 the DNL produced by diesel locomotives. List in column 15 of Worksheet D.

Railway Cars and Rapid Transit Systems

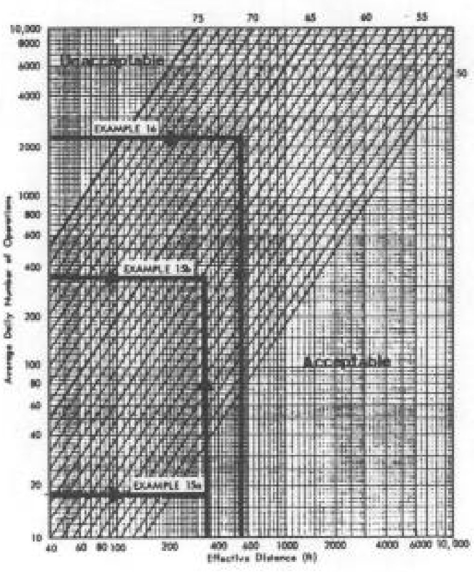
Workchart 4 was derived with the following assumptions:

- A clear line of sight exists between the railway and the NAL.
- There are 50 cars per train.
- The average train speed is 30 mph.
- Nighttime operations are 0.15 of the 24-hour total.
- Rails are welded together.

If the situation meets these conditions, proceed to Workchart 4 for an immediate evaluation of railway car noise. Again, if any of the conditions is different, make the necessary adjustments listed below and then use Workchart 4 for the evaluation.

Figure 15.
Use of Workchart 4 to Evaluate Railway Car Noise

Railroads – Cars and Rapid Transit



Adjustments for Railway Cars and Rapid Transit Trains

Number of Cars:

Divide the average number of cars by 50 and enter this number in column 18 of Workchart D.

Average Speed:

Make this adjustment, if the average speed is not 30 mph, by selecting the appropriate value from Table 10, entering it in column 19 of Worksheet D.

Table 10

Average Speed (mph)	Speed Adjustment Factor
10	0.11
20	0.44
30	1.00
40	1.78
50	2.78
60	4.00
70	5.44
80	7.11
90	9.00
100	11.11

Bolted Rails:

Enter the number 4 in column 20 of Worksheet D.

Nighttime Adjustment:

Enter the appropriate adjustment factor from Table 5 in column 21 of Worksheet D.

feet, we find that the site has an engine noise contribution to DNL of 66 dB.

We next obtain the adjustment factors for the noise produced by the cars:

- number of cars adjustment: 1.50
- speed adjustment: 2.78
- day/night adjustment: 2.34

Multiplying the adjustment factors times the average daily number of trains:

1.5 X 2.78 X 2.34 X 35 = 342

Entering Workchart 4 (see Figure 15) with 342 operations and a distance of 339 feet, we find the contribution of the cars to the DNL is 60 dB. Using Table 1 for combining levels, we find that the 6 dB difference between engine noise at 66 and car noise at 60 gives a combined DNL of 67 dB for these trains.

Example 16: The distance from NAL number 2 to Railroad Number 2 is 550 feet; there are 100 operations per day, of which 30 percent occur at night. A clear line of sight exists between the site and the railroad, and no horns or whistles are used nearby. An average train on this track uses 4 engines, has 100 cars, the average speed is 40 miles per hour, and the track has bolted, not welded, rails.

We first find the adjustment factors for the diesel engines:

- number of engines adjustment: 2
- speed adjustment: 0.75
- day/night adjustment: 1.57

Multiplying the adjustments together, times the number of trains:

2 X 0.75 X 1.57 X 100 = 236

Entering Workchart 3 (see Figure 14) with 236 operations at a distance of 550 feet, we find the DNL contribution from engine noise to be 67 dB.

Next we find the adjustment factors for the railroad cars:

- number of cars adjustment: 2
- speed adjustment: 1.78
- bolted track adjustment: 4
- day/night adjustment: 1.57

Multiplying the adjustments together, times the number of trains:

2 X 1.78 X 4 X 1.57 X 100 = 2236

Entering Workchart 4 (see Figure 15) with

(Continued next page)

Figure 16.
Sketch Showing Dimensions for Example 16

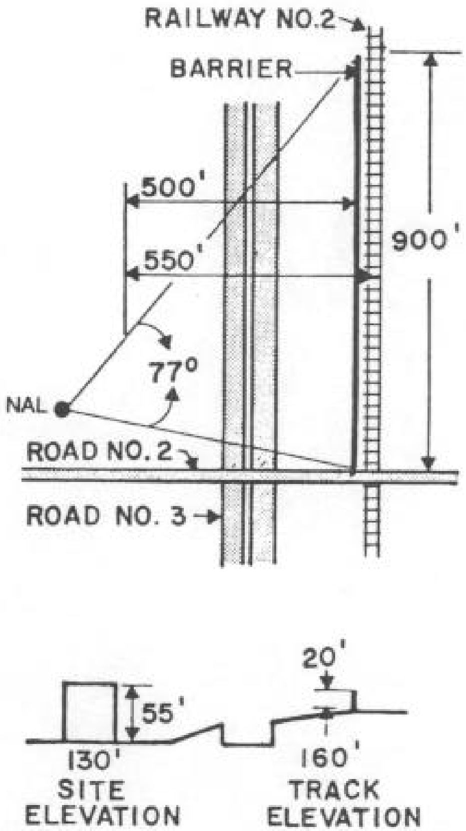


Figure 17.
Use of Workchart 6 in Example 16

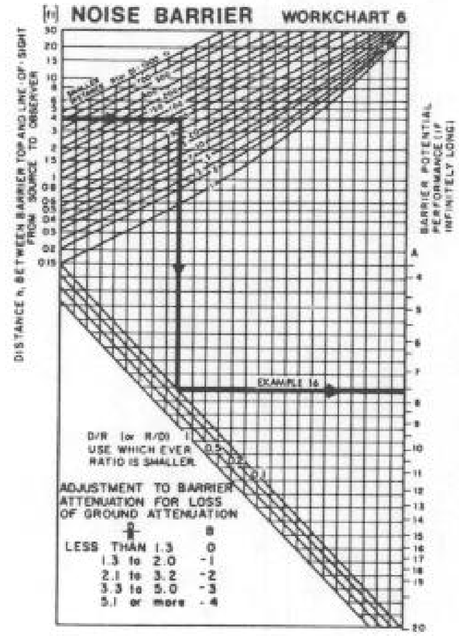
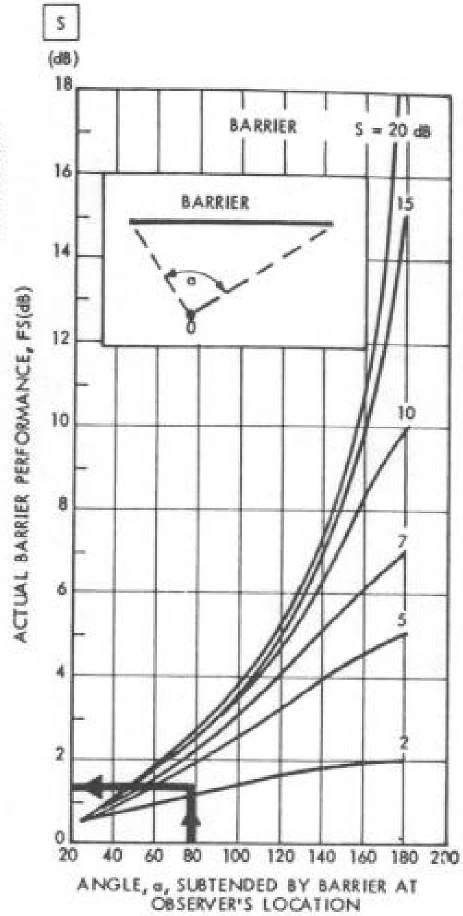


Figure 18.
Use of Workchart 7 in Example 16



2236 operations at a distance of 550 feet, we find the DNL contribution from the railroad cars to be 65 dB. Combining the engine sound levels with the car sound levels we find the total DNL from the trains to be 69 dB.

It would be possible to erect a 20-foot noise barrier, running parallel to the track at a distance of 50 feet; it could start at Road Number 2 and run 900 feet north toward the airport, as shown in Figure 16. Both the railroad track and the ground level at the barrier location are at an elevation of 160 feet. Thus, we have the following values with which to calculate the potential reduction in engine noise (using Workchart 5). (Because the distances involved are so unequal, this situation does not lend itself to direct scaling of the distances.)

H = 180 feet (20' above the ground)

S = 175 feet (15' above the track, see page 19)

0 = 285 feet (from Example 11 in the section on roadway noise)

R' = 50 feet

D' = 500 feet

We find from Worksheet 5 that the values of R and D are no different (within the accuracy of the calculation) from R' and D', a situation that will always occur when the differences in elevation are so much smaller than the distances from the site to the noise source. The value of h is 4 feet; R/D = 0.1

We can now use these numbers to enter Workchart 6 to find the *potential* barrier performance (that is, the barrier adjustment factor that would apply in the case of an infinitely long barrier). Entering Workchart 6 at h = 4 feet, with R/D = 0.1, we find the basic attenuation of the barrier to be 7.5 dB. However, with D/R = 10, we find from the table of loss-of-ground-effect attenuation that we must subtract 4 dB from the 7.5, or a net effect of 3.5 dB. However, the situation is even worse, since the barrier is finite in length.

To find the actual attenuation for this *finite* barrier, we must first find the angle subtended by the barrier to the NAL. Referring to Figure 16, we draw lines from the NAL each end of the barrier. With

References

1. D.E. Bishop, A.P. Hays, "Handbook for Developing Noise Exposure Contours for General Aviation Airports," FAA-AS-75-1, December 1975 (NTIS No. AD-A023429).

2. D.E. Bishop, et al., "Calculation of Day-Night Levels Resulting From Civil Aircraft Operations," BBN Report 3157 for Environmental Protection Agency, March 1976 (NTIS No. PB 266 165).

3. B.A. Kugler, D.E. Commins, W.J. Galloway, "Highway Noise – A Design Guide for Prediction and Control," NCHRP Report 174, Transportation Research Board, National Research Council, 1976.

4. T.J. Schultz, W.J. Galloway, "Noise Assessment Guidelines – Technical Background," Office of Policy Development and Research, U.S. Department of Housing and Urban Development," 1980.

5. M.A. Simpson, "Noise Barrier Design Handbook," FHWA-RD-76-58, Federal Highway Administration, February 1976 (NTIS No. PB 266 378).

a protractor we measure the angle between the two lines to be 77 degrees. Locate the curve on Workchart 7 corresponding to the potential barrier attenuation of 3.5 dB; it lies midway between the two lowest curves (see Figure 18). The point on this curve corresponding to a subtended angle of 77 degrees indicates that the actual barrier performance would be only 1.5 dB. With only 1.5 dB of attenuation, the barrier is clearly not cost-effective. In order to achieve a usable attenuation from the barrier, it would have to be extended beyond the other side of Road Number 2 to obtain a larger subtended angle. This extension, however, would still not be cost-effective unless the height of the barrier were increased substantially.

Summary of Adjustment Factors

Combination of Sound Levels

Table 1

Difference in Sound Level	Add to Larger Level
0	3.0
1	2.5
2	2.1
3	1.8
4	1.5
5	1.2
6	1.0
7	0.8
8	0.6
9	0.5
10	0.4
12	0.3
14	0.2
16	0.1
greater than 16	0.

Aircraft

Table 2 DNL Outside 65 dB Contour

D1 = distance from 65 dB contour to flight path
D2 = distance from site to flight path

D2 / D1	DNL dB
1.0	65
1.12	64
1.26	63
1.41	62
1.58	61
1.78	60
2.00	59
2.24	58
2.51	57
2.82	56
3.16	55

Automobile Traffic

Table 3 Stop-and-go

Distance from Site to Stop Sign feet	Automobile Stop-and-go Adjustment Factor
0	0.10
100	0.25
200	0.40
300	0.55
400	0.70
500	0.85
600	1.00

Table 4 Average Traffic Speed

Average Traffic Speed	Adjustment Factor
20 (mph)	0.13
25	0.21
30	0.30
35	0.40
40	0.53
45	0.67
50	0.83
55	1.00
60	1.19
65	1.40
70	1.62

Table 5 Nighttime (applies to all sources)

Nighttime Fraction of ADT	Nighttime Adjustment Factor
0	0.43
0.01	0.46
0.02	0.50
0.05	0.62
0.10	0.81
0.15	1.00
0.20	1.19
0.25	1.38
0.30	1.57
0.35	1.78
0.40	1.96
0.45	2.15
0.50	2.34

Medium Trucks

(less than 26,000 pounds, greater than 10,000 pounds)

Multiply adjusted automobile traffic by 10.

Heavy Trucks

Table 6 Road Gradient

Percent of Gradient	Adjustment Factor
2	1.4
3	1.7
4	2.0
5	2.2
6 or more	2.5

Table 7 Average Speed

Average Traffic Speed (mph)	Truck Speed Adjustment Factor
50 or less	0.81
55	1.00
60	1.17
65	1.38

Table 8 Stop-and-go

Heavy Truck Traffic Volume per Day	Heavy Truck Stop-and-Go Adjustment Factor
Less than 1200	1.8
1201 to 2400	2.0
2401 to 4800	2.3
4801 to 9600	2.8
9601 to 19,200	3.8
More than 19,200	4.5

Railroads - Diesel Engines

Number of Engines per Train
The number of engines divided by 2.

Table 9 Average Train Speed

Average Speed (mph)	Speed Adjustment Factor
10	3.00
20	1.50
30	1.00
40	0.75
50	0.60
60	0.50
70	0.43

Whistles or horns
Multiply number of trains by 10.

Railroads - Cars and Rapid Transit

Numbers of cars.
Number of cars per train divided by 50.

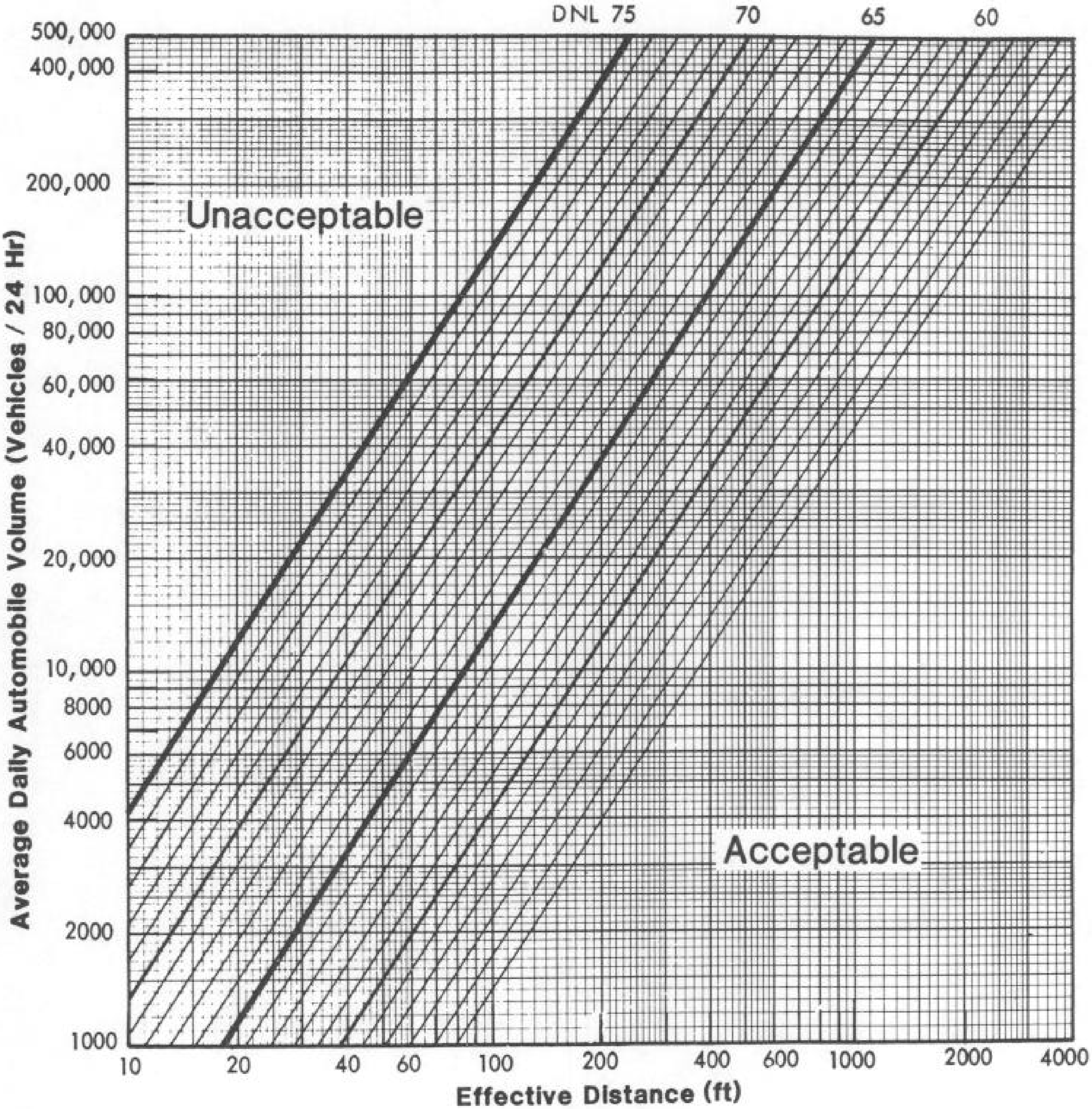
Table 10 Average Train Speed

Average Speed (mph)	Speed Adjustment Factor
10	0.11
20	0.44
30	1.00
40	1.78
50	2.78
60	4.00
70	5.44
80	7.11
90	9.00
100	11.11

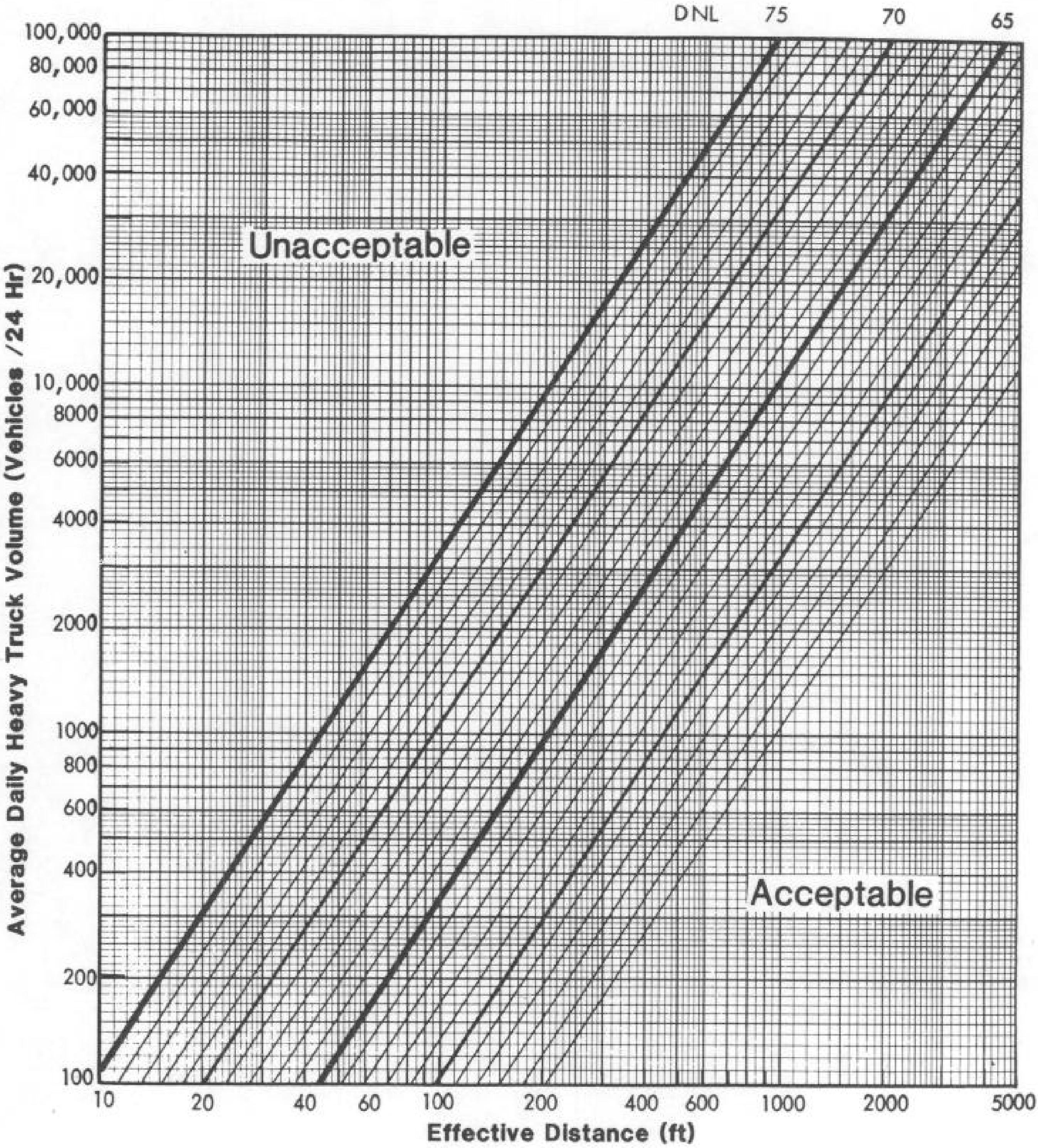
Bolted Rails
Multiply number of trains by 4.

Whistles or Horns
Multiply number of trains by 100.

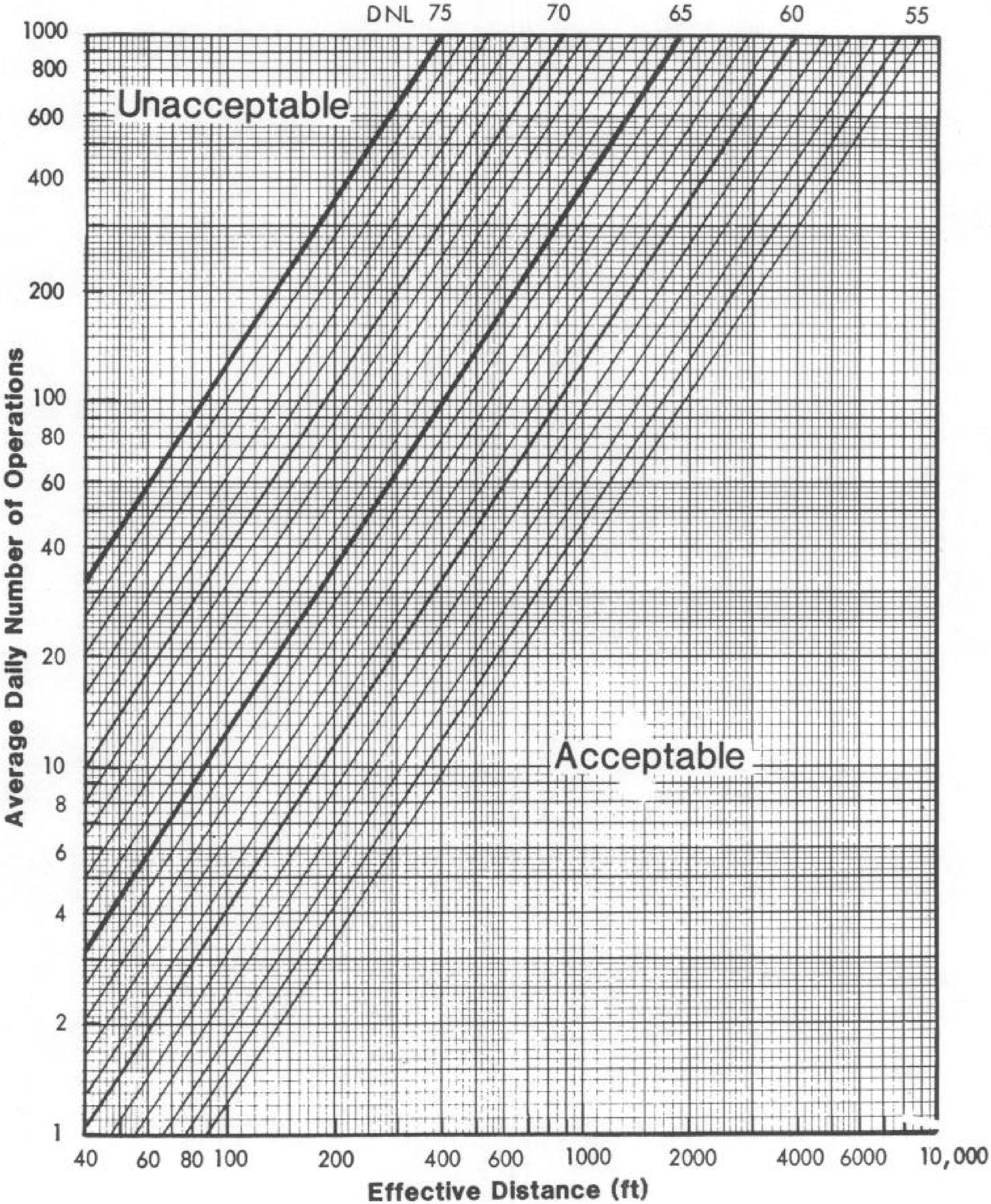
Workchart 1
Autos (55 mph)



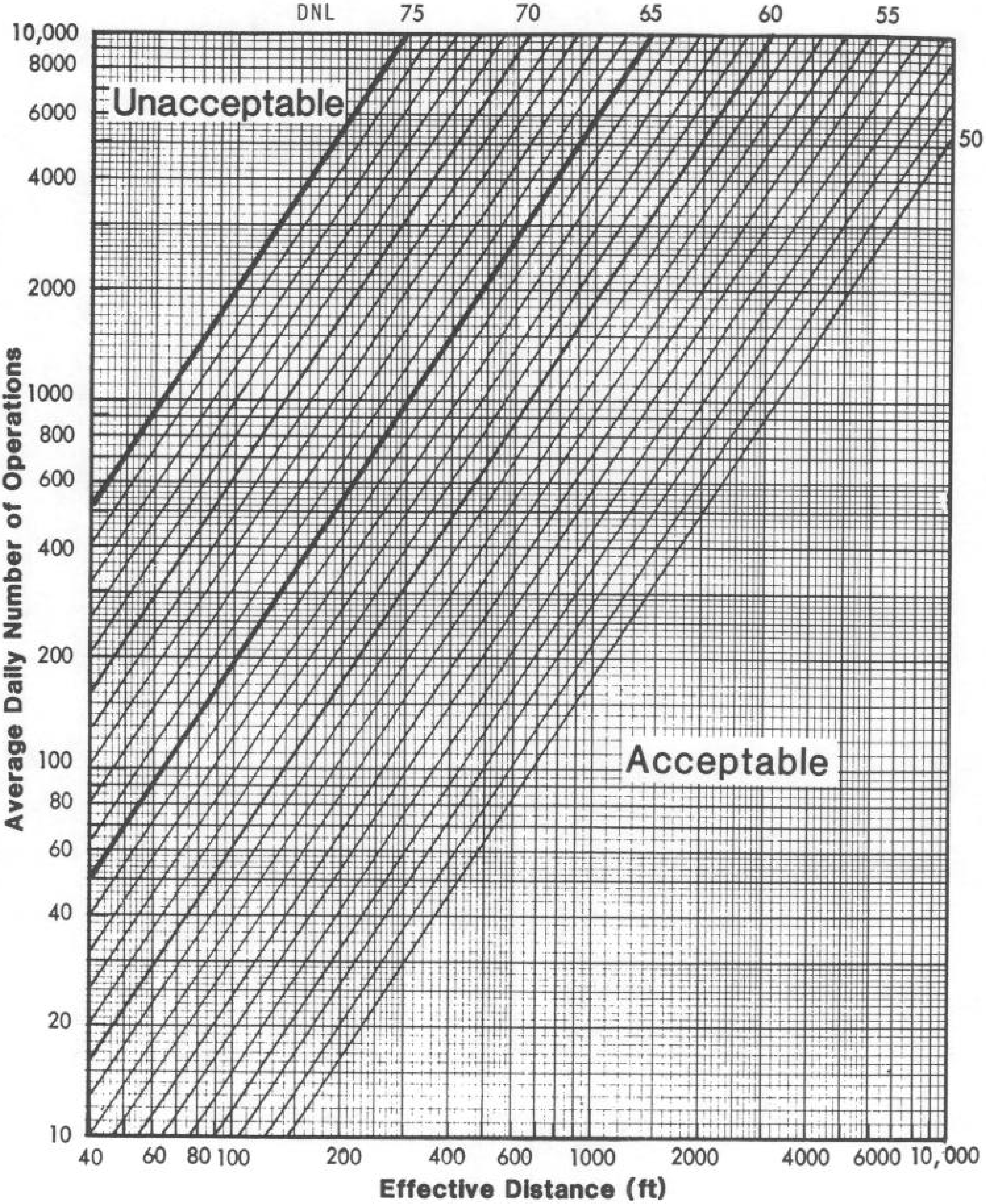
Workchart 2
Heavy Trucks (55 mph)



Workchart 3
Railroads - Diesel Locomotives



Workchart 4
Railroads - Cars and Rapid Transit



Workchart 5
Noise Barrier

To find R, D and h from Site Elevations and Distances

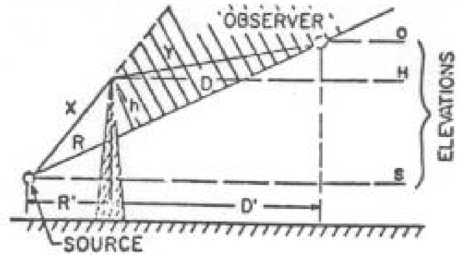
Fill out the following worksheet (all quantities are in feet):

Enter the values for:

H= ____________ R'= ____________

S= ____________ D'= ____________

O= ____________

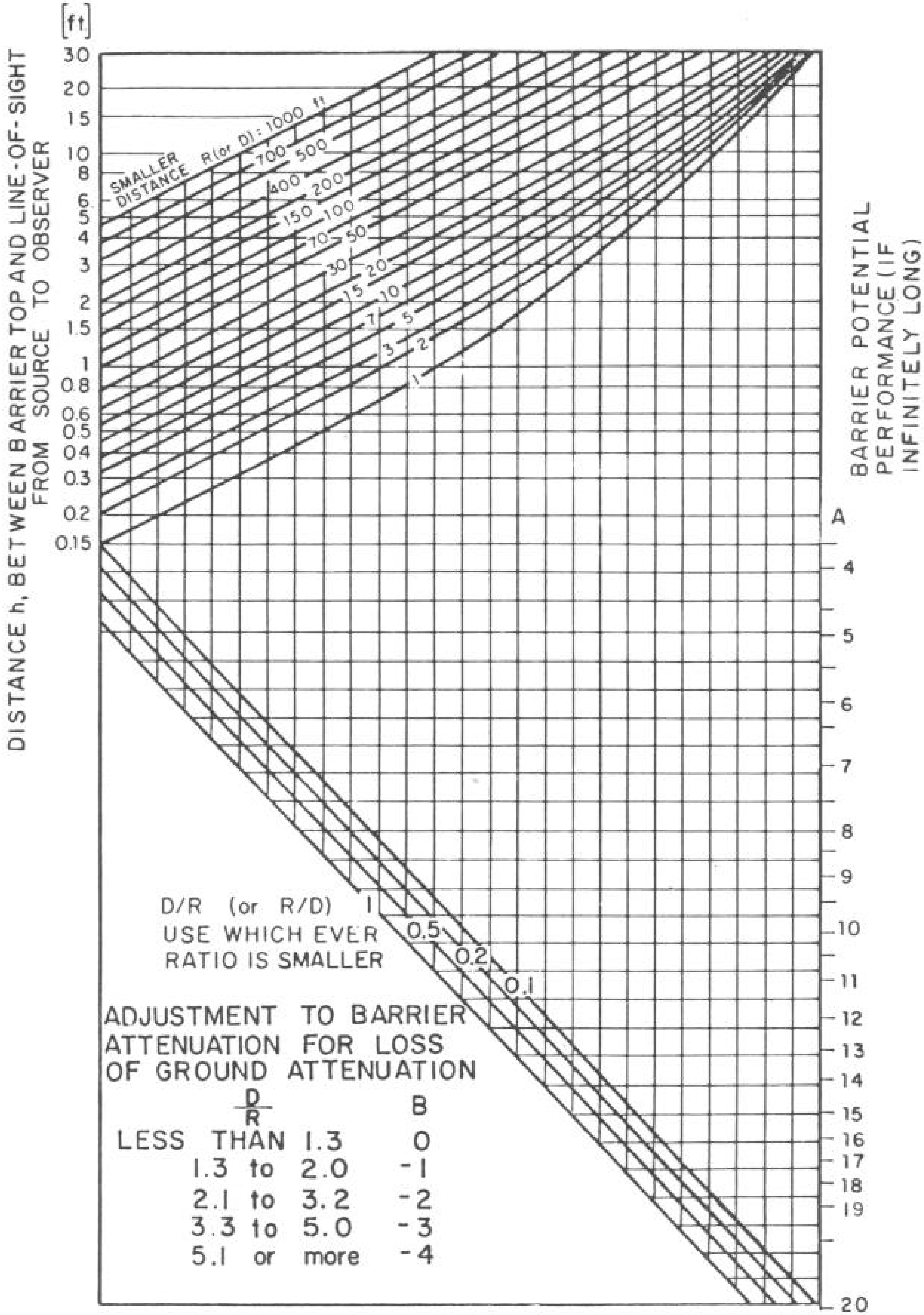


Line						
1. Elevation of barrier top minus elevation of source	[H]	−	[S]	=	[1]	
2. Elevation of observer minus elevation of source	[O]	−	[S]	=	[2]	
3. Map distance between source and observer (R' + D')					[3]	
4. Map distance between barrier and source (R')					[4]	
5. Line 2 divided by line 3	[2]	÷	[3]	=	[5]	
6. Square the quantity on line 5 (i.e., multiply it by itself); always positive	[5]	×	[5]	=	[6]	
7. 40% of line 6	[0.4]	×	[6]	=	[7]	
8. One minus line 7	[1.0]	−	[7]	=	[8]	
9. Line 5 times line 4 (will be negative if line 2 is negative)	[5]	×	[4]	=	[9]	
10. Line 1 minus line 9	[1]	−	[9]	=	[10]	
11. Line 10 times line 8	[10]	×	[8]	=	[11]	= h
12. Line 5 times line 10	[5]	×	[10]	=	[12]	
13. Line 4 divided by line 8	[4]	÷	[8]	=	[13]	
14. Line 13 plus line 12	[13]	+	[12]	=	[14]	= R
15. Line 3 minus line 4	[3]	−	[4]	=	[15]	
16. Line 15 divided by line 8	[15]	÷	[8]	=	[16]	
17. Line 16 minus line 12	[16]	−	[12]	=	[17]	= D

[**Note:** the value on line 2 may be negative, in which case so will the values on lines 5,9, and 12; line 1 may also be negative. Remember, then, in lines 10, 14, and 17, that adding a negative number is the same as subtracting: $x+(-y)=x-y$. And subtracting a negative number is like adding: $x-(-y)=x+y$.

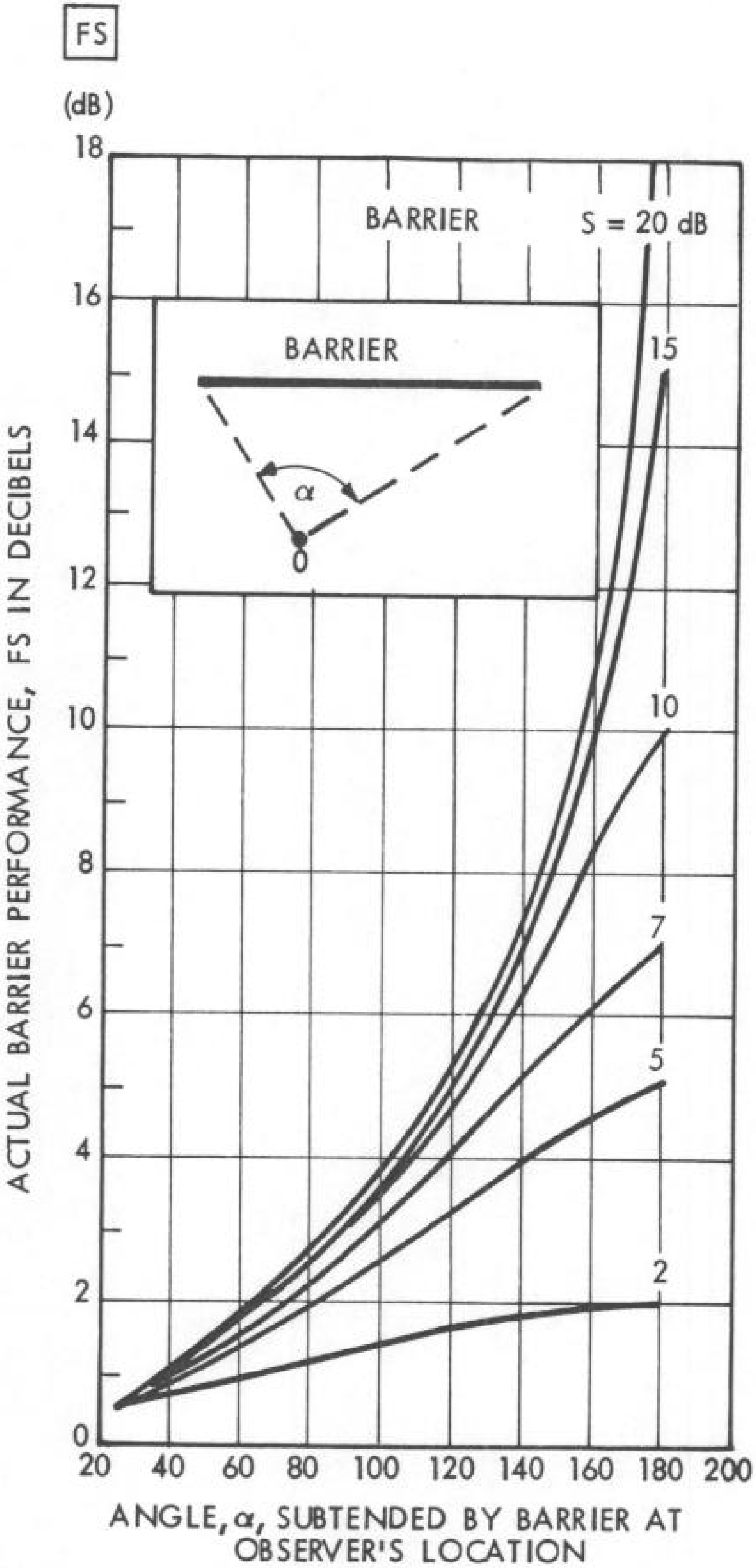
Round off R and D to nearest integer, h to one decimal place.

Workchart 6
Noise Barrier



D/R	B
LESS THAN 1.3	0
1.3 to 2.0	-1
2.1 to 3.2	-2
3.3 to 5.0	-3
5.1 or more	-4

Workchart 7



Correction to be applied to barrier potential in order to find the actual performance of the barrier of the same construction but of finite length.

Worksheet A
Site Evaluation

Site Location

Program

Project Name

Locality

File Number

Sponsor's Name | Phone

Street Address | City, State

	Acceptability Category	DNL	Predicted for Operations in Year
1. Roadway Noise	________	____	________
2. Aircraft Noise	________	____	________
3. Railway Noise	________	____	________
Value of DNL for all noise sources: (see page 3 for combination procedure)		____	

Final Site Evaluation (circle one)

Acceptable

Normally Unacceptable

Unacceptable

Signature ______________________________ Date ______________

Clip this worksheet to the top of a package containing Worksheets B-E and Workcharts 1-7 that are used in the site evaluations

Worksheet B
Aircraft Noise

List all airports within 15 miles of the site:

1. ______________________________

2. ______________________________

3. ______________________________

Necessary Information:	**Airport 1**	**Airport 2**	**Airport 3**
1. Are DNL, NEF or CNR contours available? (yes/no)	______	______	______
2. Any supersonic aircraft operations? (yes/no)	______	______	______
3. Estimating approximate contours from Figure 3:			
a. number of nighttime jet operations	______	______	______
b. number of daytime jet operations	______	______	______
c. effective number of operations (10 times a + b)	______	______	______
d. distance A for 65 dB	______	______	______
70dB	______	______	______
75 dB	______	______	______
e. distance B for 65 dB	______	______	______
70 dB	______	______	______
75 dB	______	______	______
4. Estimating DNL from Table 2:			
a. distance from 65 dB contour to flight path, D^1	______	______	______
b. distance from NAL to flight path, D^2	______	______	______
c. D^2 divided by D^1	______	______	______
d. DNL	______	______	______
5. Operations projected for what year?	______	______	______
6. Total DNL from all airports		______	

Signed ______________________________ Date ______________

List all major roads within 1000 feet of the site:

1. ______________________________

2. ______________________________

3. ______________________________

4. ______________________________

Necessary Information	Road 1	Road 2	Road 3	Road 4
1. Distance in feet from the NAL to the edge of the road				
a. nearest lane	____	____	____	____
b. farthest lane	____	____	____	____
c. average (effective distance)	____	____	____	____
2. Distance to stop sign	____	____	____	____
3. Road gradient in percent	____	____	____	____
4. Average speed in mph				
a. Automobiles	____	____	____	____
b. heavy trucks - uphill	____	____	____	____
c. heavy trucks - downhill	____	____	____	____
5. 24 hour average number of automobiles and medium trucks in both directions (ADT)				
a. automobiles	____	____	____	____
b. medium trucks	____	____	____	____
c. effective ADT (a + (10xb))	____	____	____	____
6. 24 hour average number of heavy trucks				
a. uphill	____	____	____	____
b. downhill	____	____	____	____
c. total	____	____	____	____
7. Fraction of nighttime traffic (10 p.m. to 7 a.m.)	____	____	____	____
8. Traffic projected for what year?	____	____	____	____

Adjustments for Automobile Traffic

	9 Stop and-go Table 3		10 Average Speed Table 4		11 Night-Time Table 5		12 Auto ADT (line 5c)		13 Adjusted Auto ADT	14 DNL (Workchart 1)		15 Barrier Attenuation		16 Partial DNL
Road No. 1	____	X	____	X	____	X	____	=	____	____	–	____	=	____
Road No. 2	____	X	____	X	____	x	____	=	____	____	–	____	=	____
Road No. 3	____	X	____	X	____	X	____	=	____	____	–	____	=	____
Road No. 4	____	X	____	X	____	X	____	=	____	____	–	____	=	____

Adjustments for Heavy Truck Traffic

	17 Gradient Table 6		18 Average Speed Table 7		19 Truck ADT/2		20	21		22 Stop and-go Table 8		23 Night-Time Table 5		24 Adjusted Truck ADT	25 DNL (Work-chart 2)		26 Barrier Attn.		27 Partial DNL
Uphill	____	X	____	X	____	=	____													
Road No. 1								Add ____	X	____	X	____	=	____	____	–	____	=	____	
Downhill			____	X	____	=	____													
Uphill	____	X	____	X	____	=	____													
Road No. 2								Add ____	X	____	X	____	=	____	____	–	____	=	____	
Downhill			____	X	____	=	____													
Uphill	____	X	____	X	____	=	____													
Road No. 3								Add ____	X	____	X	____	=	____	____	–	____	=	____	
Downhill			____	X	____	=	____													
Uphill	____	X	____	X	____	=	____													
Road No. 4								Add ____	X	____	X	____	=	____	____	–	____	=	____	
Downhill			____	X	____	=	____													

Combined Automobile & Heavy Truck DNL

Road No. 1 ________ Road No. 2 ________ Road No. 3 ________ Road No. 4 ________ Total DNL for All Roads ________

Signature ______________________ Date ______________

List All Railways within 3000 feet of the site:

1. ____________________

2. ____________________

3. ____________________

Necessary Information:	**Railway No. 1**	**Railway No. 2**	**Railway No. 3**
1. Distance in feet from the NAL to the railway track:	______	______	______
2. Number of trains in 24 hours:			
a. diesel	______	______	______
b. electrified	______	______	______
3. Fraction of operations occuring at night (10 p.m. – 7 a.m.):	______	______	______
4. Number of diesel locomotives per train:	______	______	______
5. Number of rail cars per train:			
a. diesel trains	______	______	______
b. electrified trains	______	______	______
6. Average train speed:	______	______	______
7. Is track welded or bolted?	______	______	______
8. Are whistles or horns required for grade crossings?	______	______	______

Adjustments for Diesel Locomotives

	9 No. of Locomotives / 2		10 Average Speed Table 9		11 Horns (enter 10)		12 Night-time Table 5		13 No. of Trains (line 2a)		14 Adj. No. of Opns.	15 DNL Workchart 3		16 Barrier Attn.		17 Partial DNL
Railway No. 1	______	X	______	X	______	X	______	X	______	=	______	______	–	______	=	______
Railway No. 2	______	X	______	X	______	X	______	X	______	=	______	______	–	______	=	______
Railway No. 3	______	X	______	X	______	X	______	X	______	=	______	______	–	______	=	______

Adjustments for Railway Cars or Rapid Transit Trains

	18 Number of cars / 50		19 Average Speed Table 10		20 Bolted Rails (enter 4)		21 Night-time Table 5		22 No. of Trains (Line 2a or 2b)		23 Adj. No. of Opns.	24 DNL Work-chart 4		25 Barrier Attn.		26 Partial DNL
Railway No. 1	______	X	______	X	______	X	______	X	______	=	______	______	–	______	=	______
Railway No. 2	______	X	______	X	______	X	______	X	______	=	______	______	–	______	=	______
Railway No. 3	______	X	______	X	______	X	______	X	______	=	______	______	–	______	=	______

Combined Locomotive and Railway Car DNL

Railway No. 1 ________ Railway No. 2 ________ Railway No. 3 ________ Total DNL for all Railways ________

Signature________________________________ Date________________

ERRATA SHEET

The Noise Guidebook

Railway Noise Guidance and Calculation Corrections

February 2009

The following should replace the paragraph entitled "Horns and Whistles" on page 63 (also marked 15) in the Noise Assessment Guidelines, Chapter 5, of *The Noise Guidebook* (September 1991).

> If the Noise Assessment Location (NAL) is perpendicular to any point on along a railroad track between the whistle posts for a road crossing, a factor to account for the noise of warning horns or whistles must be included in the calculation. There are 2 factors to be used based on the type of locomotive. If the locomotive is diesel-powered, enter the number 10 in column 11 of Worksheet D. If the locomotive is electric-powered, enter the number 100 in column 18 of Worksheet D. If the NAL is not between the whistle posts for a road crossing, enter the number 1 in each column.
>
> *Note: Whichever horn factor is appropriate, it must only be applied once. If a factor is applied for diesel locomotives in the first section of the worksheet, it must not be applied to the railcar noise calculation in the second part. In that instance, enter the number 10 in column 11 and the number 1 in column 18.*

A revised Worksheet D also accompanies this correction. It is easily distinguished from the original. The new Worksheet D has an additional column in the second section of page 2 for a total of 27 columns. The original version, with 26 columns, is hereby void.

List All Railways within 3000 feet of the site: **Notes**

1. ____
2. ____
3. ____

Necessary Information	Railway No. 1	Railway No. 2	Railway No. 3	Notes
1. Effective distance:	______	______	______	Measured in feet from NAL to center of track
2. Number of Trains in 24 hours:				
a. diesel	______	______	______	
b. electrified	______	______	______	
3. Fraction of operations occuring at night:	______	______	______	10 p.m. - 7a.m.
4. Number of diesel locomotives per train:	______	______	______	
5. Number of rail cars per train:				
a. diesel trains	______	______	______	
b. electrified trains	______	______	______	Include locomotive for electrified trains
6. Average train speed:	______	______	______	
7. Is track welded or bolted?	______	______	______	
8. Is the site opposite a section of tracks between whistle stops?	______	______	______	

Adjustments for Diesel Locomotives

	9 No. of Locomotives / 2		10 Average Speed (Table 9)		11 Horns (Enter 10)		12 Night-time (Table 5)		13 No. of Trains (Line 2a)		14 Adj. No of Opns.	15 DNL (Workchart 3)		16 Barrier Attn.		17 Partial DNL
Railway No. 1	________	x	________	x	________	x	________	x	________	=	________	________	-	________	=	________
Railway No. 2	________	x	________	x	________	x	________	x	________	=	________	________	-	________	=	________
Railway No. 3	________	x	________	x	________	x	________	x	________	=	________	________	-	________	=	________

Adjustments for Railway Cars or Rapid Transit Trains and Electric Locomotives

	18 Horns on Electric Trains only (Enter 100)		19 Number of cars / 50		20 Average Speed (Table 10)		21 Bolted Rails (Enter 4) Welded (Enter 1)		22 Night-time (Table 5)		23 No. of Trains (Lines 2a and 2b)		24 Adj. No. of Opns.	25 DNL (Workchart 4)		26 Barrier Attn.		27 Partial DNL
Railway No. 1	________	x	________	x	________	x	________	x	________	x	________	=	________	________	-	________	=	________
Railway No. 2	________	x	________	x	________	x	________	x	________	x	________	=	________	________	-	________	=	________
Railway No. 3	________	x	________	x	________	x	________	x	________	x	________	=	________	________	-	________	=	________

Combined Locomotive and Railway Car DNL (See combining noise levels table for procedures)

Partial DNL Railway No. 1 ________

Partial DNL Railway No. 2 ________

Partial DNL Railway No. 3 ________

Partial DNL Total DNL for all Railways ________

Signed ______________________________ Date ______________________

Appendix B

HUD Noise Assessment Computational Work Sheets

One-Story House

160' Distance to NAL

Workchart 5
Noise Barrier

To find R, D and h from Site Elevations and Distances

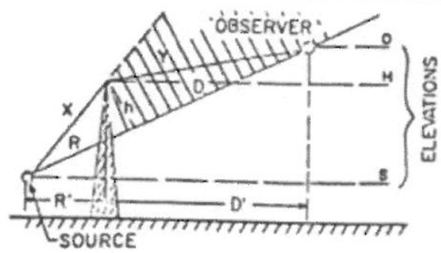
Enter the values for:

H= 758' R'= 100'

S= 755' D'= 60'

O= 748'

Fill out the following worksheet (all quantities are in feet):



1. Elevation of barrier top minus elevation of source	[H 758]	−	[S 755]	=	[1 3]	
2. Elevation of observer minus elevation of source	[O 748]	−	[S 755]	=	[2 −7]	
3. Map distance between source and observer (R' + D')					[3 160]	
4. Map distance between barrier and source (R')					[4 100]	
5. Line 2 divided by line 3	[2 −7]	÷	[3 160]	=	[5 −0.04]	
6. Square the quantity on line 5 (i.e., multiply it by itself); always positive	[5 0.04]	×	[5 0.04]	=	[6 0.002]	
7. 40% of line 6	[0.4]	×	[6 0.002]	=	[7 0.0008]	
8. One minus line 7	[1.0]	−	[7 0.0008]	=	[8 1]	
9. Line 5 times line 4 (will be negative if line 2 is negative)	[5 −0.04]	×	[4 100]	=	[9 −4]	
10. Line 1 minus line 9	[1 3]	−	[9 −4]	=	[10 7]	
11. Line 10 times line 8	[10 7]	×	[8 1]	=	[11 7]	= h
12. Line 5 times line 10	[5 −0.04]	×	[10 7]	=	[12 −0.28]	
13. Line 4 divided by line 8	[4 100]	÷	[8 1]	=	[13 100]	
14. Line 13 plus line 12	[13 100]	+	[12 −0.28]	=	[14 100]	= R
15. Line 3 minus line 4	[3 160]	−	[4 100]	=	[15 60]	
16. Line 15 divided by line 8	[15 60]	÷	[8 1]	=	[16 60]	
17. Line 16 minus line 12	[16 60]	−	[12 −0.28]	=	[17 60]	= D

[**Note:** the value on line 2 may be negative, in which case so will the values on lines 5,9, and 12; line 1 may also be negative. Remember, then, in lines 10, 14, and 17, that adding a negative number is the same as subtracting: $x+(-y)=x-y$. And subtracting a negative number is like adding: $x-(-y)=x+y$.

Round off R and D to nearest integer, h to one decimal place.

One-Story House — 400' Distance to NAL

Workchart 5
Noise Barrier

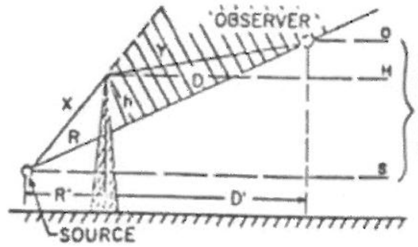
To find R, D and h from Site Elevations and Distances

Enter the values for:

H= 758' R'= 100'

S= 755' D'= 300'

O= 748'



Fill out the following worksheet (all quantities are in feet):

1. Elevation of barrier top minus elevation of source	[H 758] − [S 755] = [1 3]	
2. Elevation of observer minus elevation of source	[O 748] − [S 755] = [2 −7]	
3. Map distance between source and observer (R' + D')	[3 400]	
4. Map distance between barrier and source (R')	[4 100]	
5. Line 2 divided by line 3	[2 −7] ÷ [3 400] = [5 −0.02]	
6. Square the quantity on line 5 (i.e., multiply it by itself); always positive	[5 0.02] × [5 0.02] = [6 0.0004]	
7. 40% of line 6	[0.4] × [6 0.0004] = [7 0.0002]	
8. One minus line 7	[1.0] − [7 0.0002] = [8 1]	
9. Line 5 times line 4 (will be negative if line 2 is negative)	[5 −0.02] × [4 100] = [9 −2]	
10. Line 1 minus line 9	[1 3] − [9 −2] = [10 5]	
11. Line 10 times line 8	[10 5] × [8 1] = [11 5]	= h
12. Line 5 times line 10	[5 −0.02] × [10 5] = [12 −0.10]	
13. Line 4 divided by line 8	[4 100] ÷ [8 1] = [13 100]	
14. Line 13 plus line 12	[13 100] + [12 −0.10] = [14 100]	= R
15. Line 3 minus line 4	[3 400] − [4 100] = [15 300]	
16. Line 15 divided by line 8	[15 300] ÷ [8 1] = [16 300]	
17. Line 16 minus line 12	[16 300] − [12 −0.10] = [17 300]	= D

[Note: the value on line 2 may be negative, in which case so will the values on lines 5,9, and 12; line 1 may also be negative. Remember, then, in lines 10, 14, and 17, that adding a negative number is the same as subtracting: $x+(-y)=x-y$. And subtracting a negative number is like adding: $x-(-y)=x+y$.

Round off R and D to nearest integer, h to one decimal place.

One - Story House

600' Distance to NAL

Workchart 5
Noise Barrier

To find R, D and h from Site Elevations and Distances

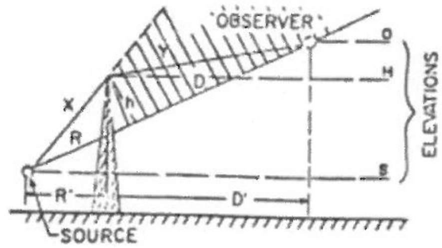
Enter the values for:

H= 758' R'= 100

S= 755' D'= 500

O= 748'

Fill out the following worksheet (all quantities are in feet):



1. Elevation of barrier top minus elevation of source	[H 758] − [S 755] = [1 3]	
2. Elevation of observer minus elevation of source	[O 748] − [S 755] = [2 −7]	
3. Map distance between source and observer (R' + D')	[3 600]	
4. Map distance between barrier and source (R')	[4 100]	
5. Line 2 divided by line 3	[2 −7] ÷ [3 600] = [5 −0.01.]	
6. Square the quantity on line 5 (i.e., multiply it by itself); always positive	[5 0.01] × [5 0.01] = [6 0.0001]	
7. 40% of line 6	[0.4] × [6 0.0001] = [7 0.00004]	
8. One minus line 7	[1.0] − [7 0.00004] = [8 1]	
9. Line 5 times line 4 (will be negative if line 2 is negative)	[5 −0.01] × [4 100] = [9 −1]	
10. Line 1 minus line 9	[1 3] − [9 −1] = [10 4]	
11. Line 10 times line 8	[10 4] × [8 1] = [11 4]	= h
12. Line 5 times line 10	[5 −0.01] × [10 4] = [12 −0.04]	
13. Line 4 divided by line 8	[4 100] ÷ [8 1] = [13 100]	
14. Line 13 plus line 12	[13 100] + [12 −0.04] = [14 100]	= R
15. Line 3 minus line 4	[3 600] − [4 100] = [15 500]	
16. Line 15 divided by line 8	[15 500] ÷ [8 1] = [16 500]	
17. Line 16 minus line 12	[16 500] − [12 −0.04] = [17 500]	= D

[**Note:** the value on line 2 may be negative, in which case so will the values on lines 5,9, and 12; line 1 may also be negative. Remember, then, in lines 10, 14, and 17, that adding a negative number is the same as subtracting: $x + (-y) = x - y$. And subtracting a negative number is like adding: $x - (-y) = x + y$.

Round off R and D to nearest integer, h to one decimal place.

Two-Story House 160' Distance to NAL

Workchart 5
Noise Barrier

To find R, D and h from Site Elevations and Distances

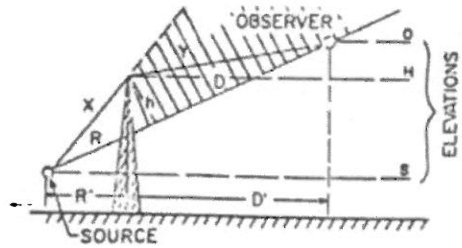
Fill out the following worksheet (all quantities are in feet):

Enter the values for:

H= 758' R'= 100'

S= 755' D'= 60'

O= 758'



1. Elevation of barrier top minus elevation of source	[H 758]	−	[S 755]	=	[1 3]
2. Elevation of observer minus elevation of source	[O 758]	−	[S 755]	=	[2 3]
3. Map distance between source and observer (R' + D')					[3 160]
4. Map distance between barrier and source (R')					[4 100]
5. Line 2 divided by line 3	[2 3]	÷	[3 160]	=	[5 0.02]
6. Square the quantity on line 5 (i.e., multiply it by itself); always positive	[5 0.02]	×	[5 0.02]	=	[6 0.0004]
7. 40% of line 6	[0.4]	×	[6 0.0004]	=	[7 0.0002]
8. One minus line 7	[1.0]	−	[7 0.0002]	=	[8 1]
9. Line 5 times line 4 (will be negative if line 2 is negative)	[5 0.02]	×	[4 100]	=	[9 2]
10. Line 1 minus line 9	[1 2]	−	[9 2]	=	[10 0]
11. Line 10 times line 8	[10 0]	×	[8 1]	=	[11 0] = h
12. Line 5 times line 10	[5 0.02]	×	[10 0]	=	[12 0]
13. Line 4 divided by line 8	[4 100]	÷	[8 1]	=	[13 100]
14. Line 13 plus line 12	[13 100]	+	[12 0]	=	[14 100] = R
15. Line 3 minus line 4	[3 160]	−	[4 100]	=	[15 60]
16. Line 15 divided by line 8	[15 60]	÷	[8 1]	=	[16 60]
17. Line 16 minus line 12	[16 60]	−	[12 0]	=	[17 60] = D

[**Note:** the value on line 2 may be negative, in which case so will the values on lines 5,9, and 12; line 1 may also be negative. Remember, then, in lines 10, 14, and 17, that adding a negative number is the same as subtracting: $x+(-y)=x-y$. And subtracting a negative number is like adding: $x-(-y)=x+y$.

Round off R and D to nearest integer, h to one decimal place.

Two-Story House 400' Distance to NAL

Workchart 5
Noise Barrier

To find R, D and h from Site Elevations and Distances

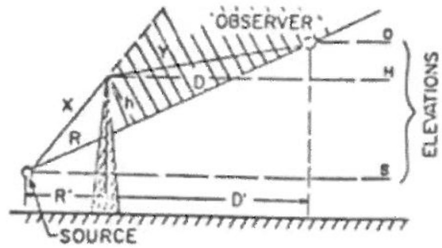
Fill out the following worksheet (all quantities are in feet):

Enter the values for:

H= 758' R'= 100'

S= 755' D'= 300'

O= 758'



Line	Description	Computation
1.	Elevation of barrier top minus elevation of source	[H 758] − [S 755] = [1 3]
2.	Elevation of observer minus elevation of source	[O 758] − [S 755] = [2 3]
3.	Map distance between source and observer (R' + D')	[3 400]
4.	Map distance between barrier and source (R')	[4 100]
5.	Line 2 divided by line 3	[2 3] ÷ [3 400] = [5 0.0075]
6.	Square the quantity on line 5 (i.e., multiply it by itself); always positive	[5 0.075] × [5 0.075] = [6 0.0006]
7.	40% of line 6	[0.4] × [6 0.0006] = [7 0.0002]
8.	One minus line 7	[1.0] − [7 0.0002] = [8 1]
9.	Line 5 times line 4 (will be negative if line 2 is negative)	[5 0.0075] × [4 100] = [9 0.75]
10.	Line 1 minus line 9	[1 3] − [9 0.75] = [10 2.25]
11.	Line 10 times line 8	[10 2.25] × [8 1] = [11 2.25] = h
12.	Line 5 times line 10	[5 0.0075] × [10 2.25] = [12 0.02]
13.	Line 4 divided by line 8	[4 100] ÷ [8 1] = [13 100]
14.	Line 13 plus line 12	[13 100] + [12 0.02] = [14 100] = R
15.	Line 3 minus line 4	[3 400] − [4 100] = [15 300]
16.	Line 15 divided by line 8	[15 300] ÷ [8 1] = [16 300]
17.	Line 16 minus line 12	[16 300] − [12 0.02] = [17 300] = D

[**Note:** the value on line 2 may be negative, in which case so will the values on lines 5,9, and 12; line 1 may also be negative. Remember, then, in lines 10, 14, and 17, that adding a negative number is the same as subtracting: x + (-y) = x-y. And subtracting a negative number is like adding: x-(-y)=x+y.

Round off R and D to nearest integer, h to one decimal place.

Two-Story House 600' Distance to NAL

Workchart 5
Noise Barrier

To find R, D and h from Site Elevations and Distances

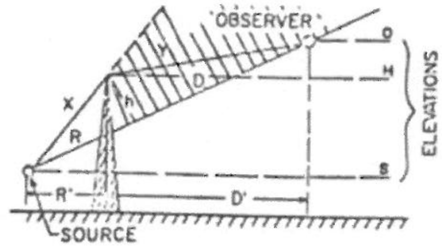
Fill out the following worksheet (all quantities are in feet):

Enter the values for:

H= 758' R'= 100'

S= 755' D'= 500'

O= 758'



1. Elevation of barrier top minus elevation of source	[H 758] − [S 755] = [1 3]
2. Elevation of observer minus elevation of source	[O 758] − [S 755] = [2 3]
3. Map distance between source and observer (R' + D')	[3 600]
4. Map distance between barrier and source (R')	[4 100]
5. Line 2 divided by line 3	[2 3] ÷ [3 600] = [5 0.005]
6. Square the quantity on line 5 (i.e., multiply it by itself); always positive	[5 0.005] × [5 0.005] = [6 0.00003]
7. 40% of line 6	[0.4] × [6 0.00003] = [7 0.00001]
8. One minus line 7	[1.0] − [7 0.00001] = [8 1]
9. Line 5 times line 4 (will be negative if line 2 is negative)	[5 0.005] × [4 100] = [9 0.50]
10. Line 1 minus line 9	[1 3] − [9 0.50] = [10 2.5]
11. Line 10 times line 8	[10 2.5] × [8 1] = [11 2.5] = h
12. Line 5 times line 10	[5 0.005] × [10 2.5] = [12 0.01]
13. Line 4 divided by line 8	[4 100] ÷ [8 1] = [13 100]
14. Line 13 plus line 12	[13 100] + [12 0.01] = [14 100] = R
15. Line 3 minus line 4	[3 600] − [4 100] = [15 500]
16. Line 15 divided by line 8	[15 500] ÷ [8 1] = [16 500]
17. Line 16 minus line 12	[16 500] − [12 0.01] = [17 500] = D

[**Note:** the value on line 2 may be negative, in which case so will the values on lines 5,9, and 12; line 1 may also be negative. Remember, then, in lines 10, 14, and 17, that adding a negative number is the same as subtracting: x + (-y) = x-y. And subtracting a negative number is like adding: x-(-y)=x+y.

Round off R and D to nearest integer, h to one decimal place.

Railway Noise
Computations and Findings

Noise Assessment Guidelines

Adjustments for Diesel Locomotives

	9 No. of Locomotives 2		10 Average Speed (Table 9)		11 Horns (Enter 10)		12 Night-time (Table 5)		13 No. of Trains (Line 2a)		14 Adj. No of Opns.	15 DNL (Workchart 3)		16 Barrier Attn.		17 Partial DNL	
Railway No. 1	1	x	0.75	x	10	x	1.19	x	20	=	178.5	73.5	-		=	73.5	160 ft.
Railway No. 2	1	x	0.75	x	10	x	1.19	x	20	=	178.5	67.5	-		=	67.5	400 ft.
Railway No. 3	1	x	0.75	x	10	x	1.19	x	20	=	178.5	65	-		=	65	600 ft.

Adjustments for Railway Cars or Rapid Transit Trains and Electric Locomotives

	18 Horns on Electric Trains only (Enter 100)		19 Number of cars 50		20 Average Speed (Table 10)		21 Bolted Rails (Enter 4) Welded (Enter 1)		22 Night-time (Table 5)		23 No. of Trains (Lines 2a and 2b)		24 Adj. No. of Opns.	25 DNL (Workchart 4)		26 Barrier Attn.		27 Partial DNL	
Railway No. 1		x	3.34	x	1.78	x	1	x	1.19	x	20	=	141.5	60.5	-		=	60.5	160 ft
Railway No. 2		x	3.34	x	1.78	x	1	x	1.19	x	20	=	141.5	55	-		=	55	400 ft
Railway No. 3		x	3.34	x	1.78	x	1	x	1.19	x	20	=	141.5	53	-		=	53	600 ft

Combined Locomotive and Railway Car DNL (See combining noise levels table for procedures)

Partial DNL Railway No. 1 73.7

Partial DNL Railway No. 2 67.8

Partial DNL Railway No. 3 65.3

Partial DNL Total DNL for all Railways ______

Signed ______________________ Date ______________________

Railway Noise
Data Sheet

Noise Assessment Guidelines

List All Railways within 3000 feet of the site: | **Notes**

1. Canadian National Railway
2. Canadian National Railway
3. Canadian National Railway

Necessary Information	**Railway No. 1**	**Railway No. 2**	**Railway No. 3**	
1. Effective distance:	160'	400	600'	Measured in feet from NAL to center of track
2. Number of Trains in 24 hours:				
a. diesel	20	20	20	
b. electrified	0	0	0	
3. Fraction of operations occuring at night:	0.20	0.20	0.20	10 p.m. - 7a.m.
4. Number of diesel locomotives per train:	2	2	2	
5. Number of rail cars per train:				
a. diesel trains	167	167	167	
b. electrified trains	0	0	0	Include locomotive for electrified trains
6. Average train speed:	40	40	40	
7. Is track welded or bolted?	CWR	CWR	CWR	
8. Is the site opposite a section of tracks between whistle stops?	Yes	Yes	Yes	