5. GENERAL NOISE ASSESSMENT

This chapter contains procedures for the computation of both project and existing ambient noise levels for use in noise assessments required beyond the stage of the screening procedure of Chapter 4.

The **Screening Procedure** described in Chapter 4 is used to determine whether any noise-sensitive receivers are within a distance where impact is likely to occur. The distance given in the table defines the study area of any subsequent noise impact assessment. Where there is potential for noise impact, the procedures of Chapters 5 and 6 will be used to determine the extent and severity of impact. In some cases, a general assessment may be all that is needed. On the other hand, if the proposed project is in close proximity to noise-sensitive land uses and it appears at the outset that the impact would be substantial, it is prudent to conduct a detailed noise analysis.

The **General Assessment** is used for a wide range of projects which show potential noise impact from the screening procedure. For a variety of smaller transit projects, a general assessment may be all that is needed to evaluate noise impact and propose mitigation measures where necessary. It is also used to compare alternatives, such as locations of facilities or alignments, or even candidate transportation modes. A General Assessment can provide the appropriate level of detail about noise impacts for a "corridor" or "sub-area" study which is undertaken during the planning of a major transportation investment. The procedure involves noise predictions commensurate with the level of detail of data available in the early stages of major investment planning. Estimates are made of project noise levels and of existing noise conditions to estimate the location of a noise impact contour, defining an impact corridor or area. An inventory of noise impacts within the area identifies locations where noise mitigation is likely and is used in comparing noise impact among alternatives. Noise mitigation policy considerations are discussed in Section 3.2.4 and the application of noise mitigation measures is described in Section 6.7.

Detailed Analysis is undertaken when the greatest accuracy is needed to assess impacts and the effectiveness of mitigation measures on a site-specific basis. In order to do this, the project must be defined to the extent that location, alignment, mode and operating characteristics are determined. Detailed Analysis is often accomplished during the preliminary engineering phase. The results of the Detailed Analysis would be used in predicting the effectiveness of noise mitigation measures on particular noise-sensitive receivers. The procedures for performing a Detailed Analysis are described in Chapter 6.

This chapter describes the procedure for performing a General Noise Assessment. The General Assessment is based on noise source and land use information likely to be available at an early stage in the project development process. Sections of this chapter cover the key elements of the prediction procedure:

- Section 5.2 describes how to predict noise source levels with preliminary estimations of the effect of mitigation.
- Section 5.3 covers a simplified procedure for estimating noise propagation characteristics assuming flat terrain, with approximate shielding by rows of buildings or other barriers.
- Section 5.4 includes a simplified procedure for estimating existing noise.
- Section 5.5 shows how to estimate the Noise Impact Contour that defines the approximate outer limit of noise impact.
- Section 5.6 describes how to conduct the noise impact inventory and how to present the information in an environmental document or a technical noise report.
- Two examples of General Assessments are given at the end of this chapter.

5.1 OVERVIEW

The steps in the General Noise Assessment are shown in Figure 5-1 and are described below. When several alternatives are evaluated in an environmental document, this approach can be applied to each alternative and the results compared.

Project Alternatives – Place the alternative under study into one of three categories, fixed guideway transit, highway/transit, or stationary facility. Determine the Source Reference Level from the tables in Section 5.2. Each Source Reference Level pertains to a typical operation for one hour for a stationary source or one vehicle passby under reference operating conditions. Each utilizes the SEL noise descriptor, as discussed in Chapter 2.

Operational Characteristics – Convert the Source Reference Level to Noise Exposure in terms of L_{eq}(h) or L_{dn} under approximate project operating conditions, using the appropriate equations depending upon the type of source. The noise exposure is determined at the reference distance of 50 feet.

Propagation Characteristics – Draw Noise Exposure vs. Distance Curve for this source, using the graphic in Section 5.3. This curve will show the source’s noise exposure as a function of distance, ignoring shielding. To account for shielding attenuation from rows of buildings, use a general rule for estimating the reduction in noise level and draw an adjusted Exposure-vs-Distance Curve.

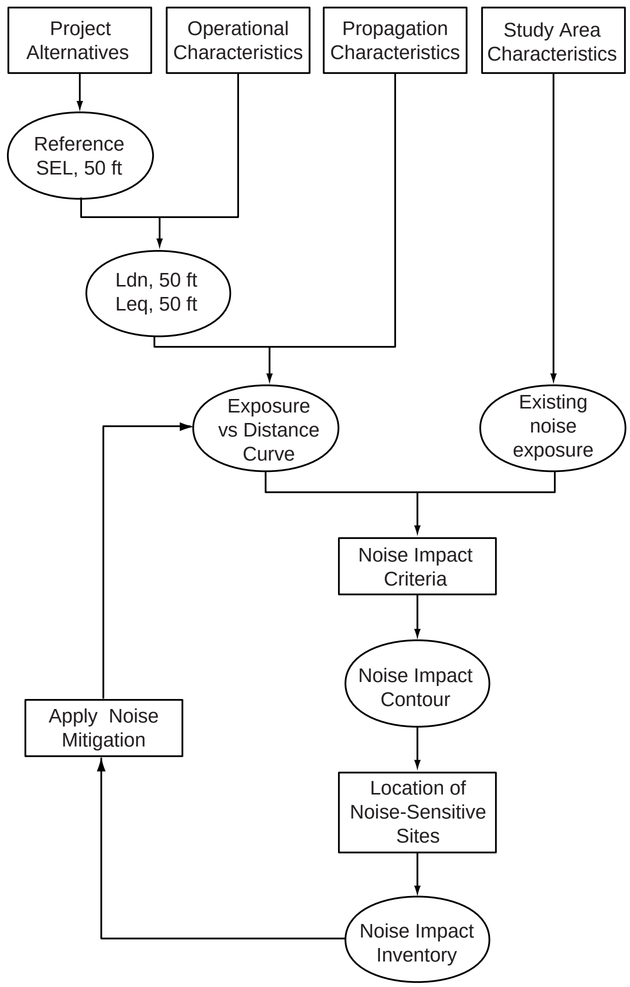


Figure 5-1. Procedure for General Noise Assessment

Study Area Characteristics – Estimate the existing noise exposure for areas surrounding the project from Table 5-7 in Section 5.4.

Noise Impact Contour Estimation – On a point-by-point basis, locate the project noise exposure and existing noise exposure combination that results in Impact according to the impact criteria from Chapter 3. Connect the points to obtain a contour line around the project which signifies the outer limits of Impact.

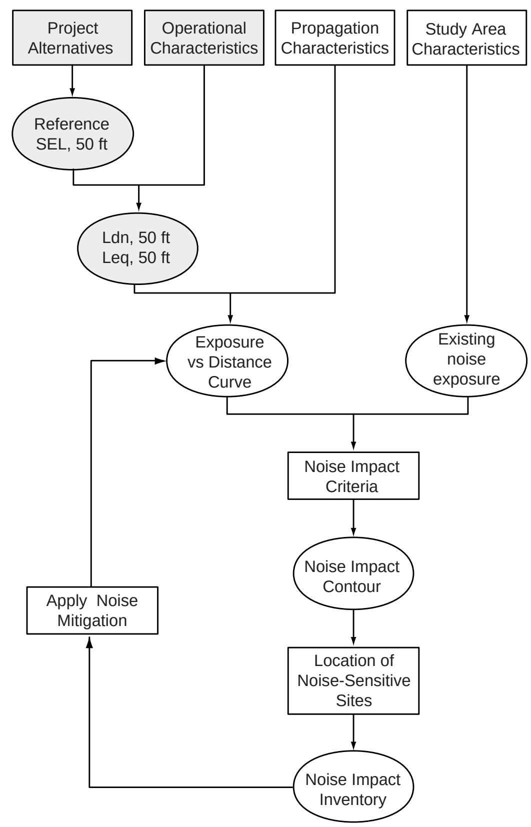
Alternatively, in the case where it is desired to make a comparison among different modal alternatives, specific noise contours can be determined from the Exposure-vs-Distance curves (for example, 60dB, 65dB, 70dB contours).

Noise Impact Inventory – Tabulate noise-sensitive land uses within the specific contours using general assumptions for shielding attenuation from rows of buildings.

Noise Mitigation – Apply estimates of the noise reduction from mitigation in the community areas where potential impact has been identified and repeat the tabulation of noise impacts.

5.2 NOISE SOURCE LEVELS FOR GENERAL ASSESSMENT

The General Noise Assessment procedure begins by determining the project noise exposure at a reference distance for the various project alternatives. The steps involved in this calculation are shaded in the flow chart at right. The reference noise exposure estimation procedures differ depending on the type of project (fixed guideway, highway/transit, or stationary facility) as described in the following sections.



5.2.1 Fixed Guideway Transit Sources

Fixed guideway transit sources include commuter rail, rail rapid transit, light rail transit, automated guideway transit (AGT), monorail, and magnetically levitated vehicles (maglev). The noise characteristics of each depend on the system characteristics described in Chapter 2. At an early project stage, the information available includes:

- Candidate transit mode
- Guideway options
- Time of operation
- Operational headways
- Design speed
- Alternative alignments.

This information is not sufficient to predict noise levels at all locations along the right-of-way, but by using conservative estimates (for example, maximum design speeds and operations at design capacities) it is sufficient to estimate worst case noise impact contours.

Reference Levels in SEL – The procedure starts with predicting the source noise levels, expressed in terms of SEL at a reference distance and a reference speed. These are given in Table 5-1 below.

The reference SEL's are used in the equations of Table 5-2 to predict the noise exposure at 50 feet. Also shown in Table 5-2 are rough estimates of the noise reduction available from wayside noise barriers, the most common noise mitigation measure. See Chapter 6 for a complete description of the benefits resulting from noise mitigation. The approximate noise barrier lengths and locations developed in a General Assessment provide a preliminary basis for evaluating the costs and benefits of impact mitigation.

Table 5-1 Reference SEL's at 50 feet from Track and 50 mph

Source / Type		Reference Conditions	Reference SEL (SEL_{ref}), dBA
Commuter Rail, At-Grade	Locomotives	Diesel-electric, 3000 hp, throttle 5	92
		Electric	90
	Cars	Ballast, welded rail	82
Rail Transit		At-grade, ballast, welded rail	82
AGT	Steel wheel	Aerial, concrete, welded rail	80
	Rubber Tire	Aerial, concrete guideway	78
Monorail		Aerial straddle beam	82
Maglev		Aerial, open guideway	72

Noise Exposure at 50 feet – After determining the reference levels for each of the noise sources, the next step is to determine the noise exposure at 50 feet expressed in terms of L_{eq}(h) and L_{dn}. The additional data needed include:

- Number of train passbys during the day (defined as 7am to 10 pm) and night (defined as 10 pm to 7 am).
- Maximum number of train passbys during hours that Category 1 or Category 3 land uses are normally in use. This is usually the peak hour train volume.
- Number of vehicles per train (if this number varies during the day, take the average).
- Speed (maximum expected).
- Guideway configuration.
- Noise barrier location (if noise mitigation is determined necessary at the end of the first pass on the General Assessment).

These data are used in the equations in Table 5-2 to obtain adjustment factors to calculate L_{dn} and L_{eq}(h) at 50 feet.

Table 5-2 Computation of Noise Exposure at 50 feet for Fixed Guideway General Assessment

LOCOMOTIVES	
Hourly L_{eq} at 50 ft:	$L_{eqL}(h) = SEL_{ref} + 10\log(N_{locos}) - 10\log\left(\frac{S}{50}\right) + 10\log(V) - 35.6$
RAIL VEHICLES[†]	
Hourly L_{eq} at 50 ft:	$L_{eqC}(h) = SEL_{ref} + 10\log(N_{cars}) + 20\log\left(\frac{S}{50}\right) + 10\log(V) - 35.6$ use the following adjustments as applicable: + 5 → JOINTED TRACK + 3 → EMBEDDED TRACK ON GRADE + 4 → AERIAL STRUCTURE WITH SLAB TRACK (except AGT & monorail) - 5 → if a NOISE BARRIER blocks the line of sight
COMBINED	
Hourly L_{eq} at 50 ft:	$L_{eq}(h) = 10\log\left[10^{\left(L_{eqL}/10\right)} + 10^{\left(L_{eqC}/10\right)}\right]$
Daytime L_{eq} at 50 ft:	$L_{eq}(day) = L_{eq}(h)\Big\vert_{V=V_d}$
Nighttime L_{eq} at 50 ft:	$L_{eq}(night) = L_{eq}(h)\Big\vert_{V=V_n}$
L_{dn} at 50 ft:	$L_{dn} = 10\log\left[(15)\times 10^{\left(L_{eq}(day)/10\right)} + (9)\times 10^{\left(L_{eq}(night)+10/10\right)}\right] - 13.8$

N_{locos} = average number of locomotives per train

N_{cars} = average number of cars per train

S = train speed, in miles per hour

V = average hourly volume of train traffic, in trains per hour

V_d = average hourly daytime volume of train traffic, in trains per hour

$$= \frac{\text{number of trains, 7 am to 10 pm}}{15}$$

V_n = average hourly nighttime volumes of train traffic, in trains per hour

$$= \frac{\text{number of trains, 10 pm to 7 am}}{9}$$

[†] Includes all commuter rail cars, transit cars, AGT and monorail

5.2.2 Highway/Transit Sources

The highway/transit type sources include most transit modes that do not require a fixed guideway. Examples are high occupancy vehicles, such as city bus, commuter bus, commuter vanpools and carpools. The noise characteristics of each depend on the system characteristics described in Chapter 2. At an early project development stage, the information available is as follows:

- Vehicle type
- Transitway design options
- Time of operation
- Typical headways
- Design speed
- Alternative alignments.

This information is not sufficient to predict noise levels at all locations along the right-of-way, but is sufficient to estimate worst case noise impact contours. The procedure is consistent with the highway noise prediction method authorized by the Federal Highway Administration (see Section 6.6.2 for a discussion of detailed FHWA computation methods), with commuter buses, city buses and vans corresponding to source emission levels for heavy trucks, medium trucks and automobiles, respectively.[(1)]

Reference Levels in SEL – Projections of noise from highway/transit sources begin by defining the source SEL at a reference distance of 50 feet and a reference speed. These are given in Table 5-3. The reference distance SEL's are used in the equations of Table 5-4 to predict the noise exposure at 50 feet. Also shown in Table 5-4 is a rough estimate of the minimum noise reduction available with wayside sound barriers. See Chapter 6 for descriptions of other mitigation measures and procedures for developing more accurate estimates of noise reduction from mitigation measures. The approximate noise barrier lengths and locations developed in a General Assessment allow preliminary estimates of the costs and benefits of impact mitigation.

Noise Exposure at 50 feet – After determining the reference levels for each of the noise sources, the next step is to determine the noise exposure at 50 feet. The additional data needed include:

- Number of vehicle passbys during the day (7am to 10 pm) and night (10 pm to 7 am).
- Number of vehicle passbys during hours that Category 1 or Category 3 land uses are normally in use.
- Speed (maximum expected).
- Transitway configuration (with or without noise barrier).

These data are used in the equations in Table 5-4 with the reference SEL's to calculate L_{eq}(h) and L_{dn} at 50 feet.

Table 5-3 Source Reference Levels at 50 Feet from Roadway, 50 mph	
Source[†]	**Reference SEL (dBA)**
Automobiles and Vans	73
City Buses	84
Commuter Buses	88
† Assumes normal roadway surface conditions	

Table 5-4 Computation of L_{eq} and L_{dn} at 50 feet for Highway/Transit General Assessment	
Hourly L_{eq} at 50 ft:	$L_{eq}(h) = SEL_{ref} + 10\log(V) + C_S \log\left(\frac{S}{50}\right) - 35.6$
Daytime L_{eq} at 50 ft:	$L_{eq}(day) = L_{eq}(h)\big\|_{V=V_d}$
Nighttime L_{eq} at 50 ft:	$L_{eq}(night) = L_{eq}(h)\big\|_{V=V_n}$
L_{dn} at 50 ft:	$L_{dn} = 10\log\left[(15)\times 10^{\left(L_{eq}(day)/10\right)} + (9)\times 10^{\left(L_{eq}(night)+10/10\right)}\right] - 13.8$
Speed Constant:	$C_S = 14.6$, Commuter Buses $= 23.9$, City Buses $= 28.1$, Automobile and van pools
Adjustment:	- 5 Noise Barrier

V = hourly volume of vehicles of this type, in vehicles per hour.

V_d = average hourly daytime volume of vehicles of this type, in vehicles per hour

$$= \frac{\text{total vehicle volume, 7 am to 10 pm}}{15}$$

V_n = average hourly nighttime volume of vehicles of this type, in vehicles per hour

$$= \frac{\text{total vehicle volume, 10 pm to 7 am}}{9}$$

S = average vehicle speed, in miles per hour

5.2.3 Stationary Sources

This section covers the general approach to assessment of noise from fixed facilities associated with a transit system. New transit facilities undergo a site review for best location which includes consideration of the noise sensitivity of surrounding land uses. Although many facilities, such as bus maintenance garages, are usually located in industrial and commercial areas, some facilities such as bus terminals, train stations and park and ride lots may be placed near residential neighborhoods where noise impact may occur. Access roads to some of these facilities may also pass through noise-sensitive areas. In a general assessment, only the salient features of each fixed facility are considered in the noise analysis.

Reference Levels in SEL – The source reference levels given in Table 5-5 are determined based on measurements for the peak hour of operation of a typical stationary source of the type and size noted. A large facility, such as a rail yard, is spread out over considerable area with various noise levels depending on the layout of the facility. Specifying the reference SEL at a distance of 50 feet from the property line would be misleading in this case. Consequently, the reference distance is described as "the equivalent distance of 50 feet," which is determined by estimating the noise levels at a greater distance and projecting back to 50 feet, assuming the noise sources are concentrated at the center of the site. If the location of noise sources is known, then the distance should be taken from the point of the noisiest activity on the site. The reference SEL's are used in the equations of Table 5-6 to predict noise exposure at an equivalent distance of 50 feet from the center of the site. Noise from access roads is treated according to the procedures described in Section 5.2.2.

Table 5-6 also includes an estimate of the minimum noise reduction available with wayside noise barriers. Only approximate locations and lengths for barrier or other noise mitigation measures are developed during a General Assessment to provide a preliminary indication of the costs and benefits of mitigation.

Noise Exposure at Equivalent Distance of 50 feet – After determining the reference SEL's for each of the noise sources, the next step is to determine the noise exposure expressed in terms of L_{eq} and L_{dn} at an equivalent distance of 50 feet. The additional data needed include:

- Number of layover tracks and hours of use.
- Number of buses, if different from assumed reference conditions (if this number varies during the day, take the average).
- Actual capacity of parking garage or lot.

These data are used in the equations in Table 5-6 with the reference SEL's to calculate $L_{eq}(h)$ and L_{dn} at an equivalent distance of 50 feet.

Table 5-5 Source Reference Levels at 50 Feet from Center of Site, Stationary Sources

Source	**Reference SEL (dBA)**	**Reference Conditions**
Rail System:		
Yards and Shops	118	20 train movements in peak activity hour
Layover Tracks (commuter rail)	116	One train with diesel locomotive idling for one hour
Bus System:		
Storage Yard	111	100 buses accessing facility in peak activity hour
Operating Facility	114	100 buses accessing facility, 30 buses serviced and cleaned in peak activity hour
Transit Center	101	20 buses in peak activity hour
Parking Garage	92	1000 cars in peak activity hour
Park & Ride Lot	101	12 buses, 1000 cars in peak activity hour

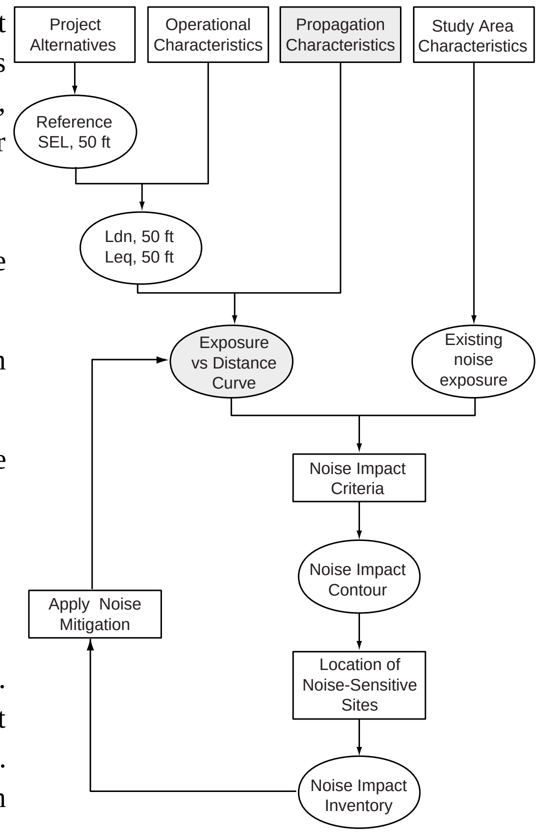
Table 5-6 Computation of L_{eq} and L_{dn} at 50 feet for Stationary Source General Assessment

Hourly L_{eq} at 50 ft:	$L_{eq}(h) = SEL_{ref} + C_N - 35.6$	
Daytime L_{eq} at 50 ft:	$L_{eq}(day) = 10\log\left[\left(\frac{1}{15}\right)\sum_{\text{7am-10pm}} 10^{L_{eq}(h)/10}\right]$	
Nighttime L_{eq} at 50 ft:	$L_{eq}(night) = 10\log\left[\left(\frac{1}{9}\right)\sum_{\text{10pm-7am}} 10^{L_{eq}(h)/10}\right]$	
L_{dn} at 50 ft:	$L_{dn} = 10\log\left[(15)\times 10^{\left(L_{eq}(day)/10\right)} + (9)\times 10^{\left(L_{eq}(night)+10/10\right)}\right] - 13.8$	
Volume Adjustment:	$C_N = 10\log\left(\frac{N_T}{20}\right)$,	Rail Yards and Shops
	$= 10\log(2N_T)$,	Layover Tracks
	$= 10\log\left(\frac{N_B}{100}\right)$,	Bus Storage Yard
	$= 10\log\left(\frac{N_B}{200} + \frac{N_S}{60}\right)$,	Bus Operating Facility
	$= 10\log\left(\frac{N_B}{20}\right)$,	Bus Transit Center
	$= 10\log\left(\frac{N_A}{1000}\right)$,	Parking Garage
	$= 10\log\left(\frac{N_A}{2000} + \frac{N_B}{24}\right)$,	Park & Ride Lot
Other Adjustment:	-5	Noise Barrier at Property Line

N_T = Number of trains per hour
N_B = Number of buses per hour
N_S = Number of buses serviced and cleaned per hour
N_A = Number of automobiles per hour

Note: If any of these numbers is zero, then omit that term

5.3 COMPUTATION OF NOISE EXPOSURE VS. DISTANCE CURVES



The previous section results in estimates of noise exposure at 50 feet for each type of project. The following procedure is used to estimate the project noise exposure at other distances, resulting in a noise exposure vs. distance curve sufficient for use in a General Assessment. The procedure is as follows:

1. Determine the L_{dn} or L_{eq} at 50 feet for one of the three project types in Section 5.2.

2. Select the appropriate distance correction curve from Figure 5-2.

3. Apply the Distance Corrections ($C_{distance}$) to the noise exposure at 50 feet using:

$$L_{dn} \text{ (or } L_{eq}\text{)}\Big|_{\text{at new distance}} = L_{dn} \text{ (or } L_{eq}\text{)}\Big|_{\text{at 50 feet}} - C_{distance}$$

4. Plot the noise exposure curve as a function of distance. This curve will be used to determine the noise impact contour for the first row of unobstructed buildings. This plot can be used to display noise from both unmitigated and mitigated conditions in order to assess the benefits from mitigation measures.

5. For second row receivers and beyond, it is necessary to account for shielding attenuation from rows of intervening buildings. Without accounting for shielding, impact may be substantially over-estimated. Use the following general rules of thumb to determine the effect of shielding from intervening rows of buildings:

   - Assign -4.5 dB of shielding attenuation for the *first* row of intervening buildings only.
   - Assign -1.5 dB of shielding attenuation for each subsequent row, up to a maximum total attenuation of 10 dB.

   Figure 5-2 can then be used to develop a curve of noise exposure vs. distance when there is shielding. The curve of noise exposure as a function of this distance will be used to determine the location of the noise impact contours.

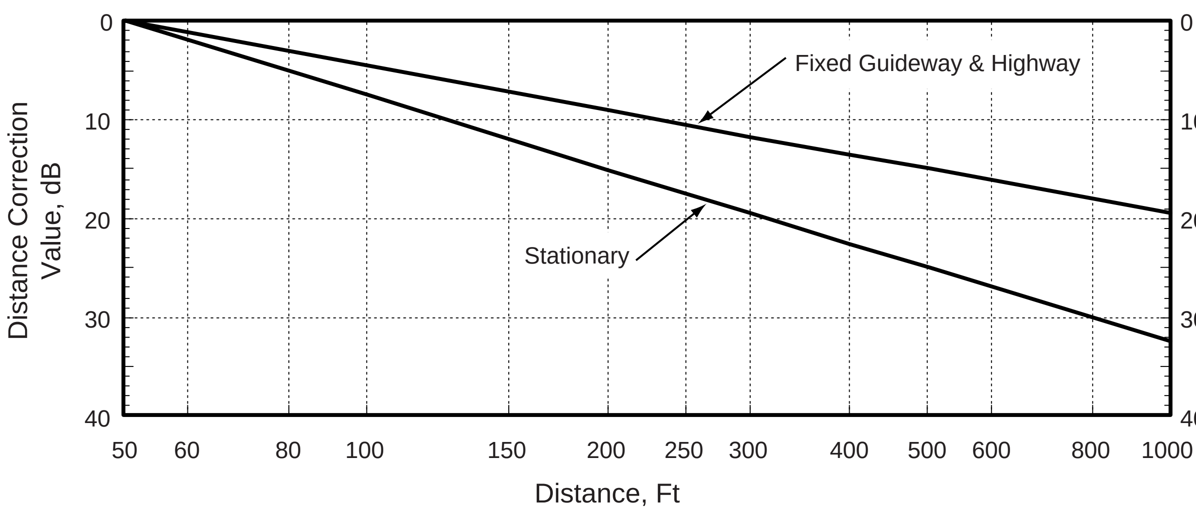
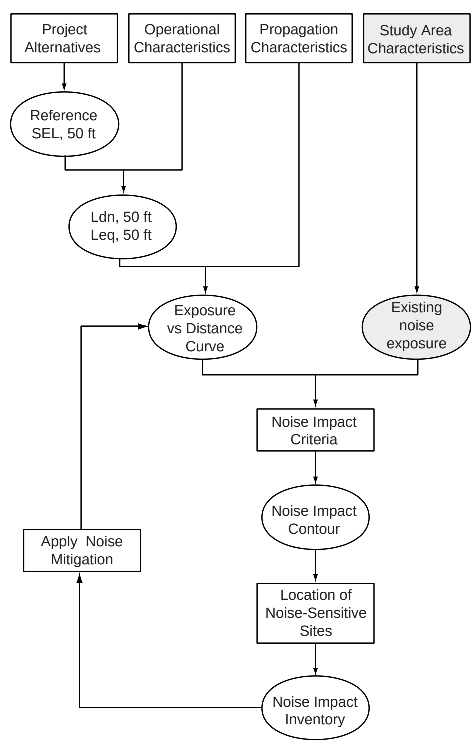


Figure 5-2. Curves for Estimating Exposure vs. Distance in General Noise Assessment

5.4 ESTIMATING EXISTING NOISE EXPOSURE



The existing noise in the vicinity of the project is required to determine the noise impact according to the criteria described in Chapter 3. Recall that impact is assessed based on a combination of the existing ambient noise exposure and the additional noise exposure that will be caused by the project. In the Detailed Analysis, the existing noise exposure is based on noise measurements at representative locations in the community. It is generally a good idea to base all estimates of existing noise on measurements, especially at locations known to be noise-sensitive. However, measurements are not always available at the General Assessment stage. This section describes how to estimate the existing noise in the project study area from general data available early in project planning. The procedure uses Table 5-7, where a neighborhood's existing noise exposure is based on proximity to nearby major roadways or railroads or on population density. The process is as follows:

1. Mapping: Obtain scaled mapping and aerial photographs showing the project location and alternatives. A scale of 1" = 200' or 400' is convenient for the accuracy needed in the noise assessment. The size of the base map should be sufficient to show distances of at least 1000' from the center of the alignment or property center, depending on whether the project is a guideway/roadway or a stationary facility.

2. Identify Sensitive Receivers: Review the maps, together with the most current land use information, to determine the proximity of noise-sensitive land uses to the project and to the nearest major roadways and railroad lines. When necessary, windshield surveys or more detailed land use maps may be used to confirm the location of sensitive receivers. For land uses more than 1000 feet from major roadways or railroad mainlines (see definitions in Table 5-7), obtain an estimate of the population density in the immediate area, expressed in people per square mile.

3. Use Table 5-7 to Estimate Existing Noise Exposure: Existing noise exposure is estimated by first looking at a site's proximity to major roads and railroad lines. If these noise sources are far enough away that ambient noise is dominated by local streets and community activities, then the estimate is made based on population density. The decision of which to use is made by comparing the noise levels from each of the three categories, roadways, railroads and population density, and selecting the highest level.

   Major roadways are separated into two categories: "Interstates," or roadways with four or more lanes that allow trucks; and "Others," parkways without trucks and city streets with the equivalent of 75 or more heavy trucks per hour or 300 or more medium trucks per hour. The estimated roadway noise levels are based on data for light to moderate traffic on typical highways and parkways using the FHWA highway noise prediction model. Where a range of distances is given, the predictions are made at the outer limit, thereby underestimating the traffic noise at the inner distance. For highway noise, distances are measured from the centerline of the near lane for roadways with two lanes, while for roadways with more than two lanes the distance is measured from the geometric mean of the roadway. This distance is computed as follows:

$$D_{GM} = \sqrt{(D_{NL})(D_{FL})}$$

   where D_{GM} is the distance to the geometric mean, D_{NL} and D_{FL} are distances to the nearest lane and farthest lane centerlines, respectively.

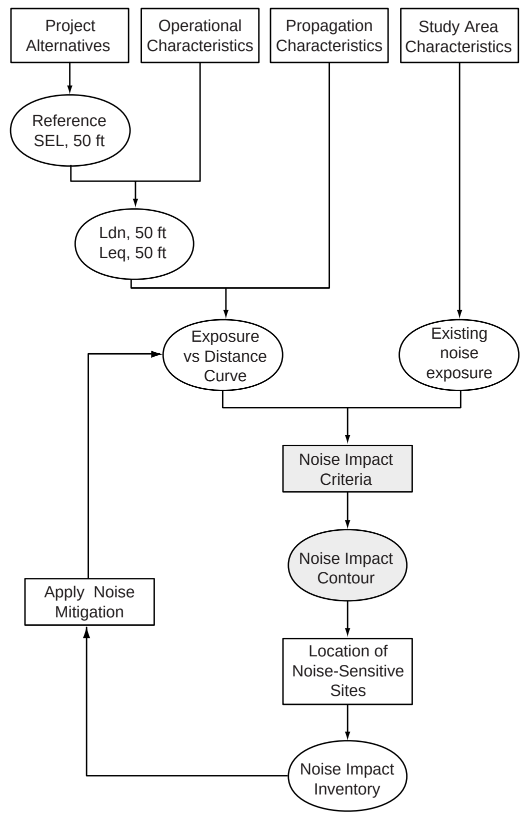
   For railroads, the estimated noise levels are based on an average train traffic volume of 5-10 trains per day at 30-40 mph for main line railroad corridors, and the noise levels are provided in terms of L_{dn} only. Distances are referenced to the track centerline, or in the case of multiple tracks, to the centerline of the rail corridor. Because of the intermittent nature of train operations, train noise will affect the L_{eq} only during certain hours of the day, and these hours may vary from day to day. Therefore, to avoid underestimating noise impact when using the one-hour L_{eq} descriptor, it is recommended that the L_{eq} at sites near rail lines be estimated based on nearby roadways or population density unless very specific train information is available.

In areas away from major roadways, noise from local streets or in neighborhoods is estimated using a relationship determined during a research program by the U.S. EPA.[2] EPA determined that ambient noise can be related to population density in locations away from transportation corridors, such as airports, major roads and railroad tracks, according to the following relation:

$$L_{dn} = 22 + 10\log(p) \qquad \text{(in dBA)}$$

where p = population density in people per square mile.

5.5 DETERMINING NOISE IMPACT CONTOURS



It is often desirable to draw noise impact contours on the land use map mentioned in the previous section to aid the impact inventory. Once the contours are on the map, the potential noise impacts can be estimated by counting the buildings inside the contours.

The first step is to identify the noise-sensitive neighborhoods and buildings and estimate existing noise exposure following the procedures described in Section 5.4. The estimate of existing noise exposure is used along with the Noise Impact Criteria in Figure 3-1 to determine how much additional noise exposure would need to be created by the project before there would be Impact or Severe Impact.

The next step is to determine the distances from the project boundary to the two impact levels using the noise exposure vs. distance curves from Section 5.3. Plot points on the map corresponding to those distances in the neighborhood under study. Continue this process for all areas surrounding the project. The plotted points are connected by lines to represent the Noise Impact Contours.

Alternatively, if it is desired to plot specific noise contours at, for example, 65 dBA, the distances can also be determined directly from the approach described in Section 5.3. Again, the points associated with a given noise level are plotted on the map and connected by lines to represent that contour.

Locations of points will change with respect to the project boundary as the existing ambient exposure changes, as project source levels change, and as shielding effects change. In general, the points should be placed close enough to allow a smooth curve to be drawn. For a General Assessment, the contours may be drawn through buildings and salient terrain features as if they were not present. This practice is acceptable considering the level of detail associated with a project in its early stages of development.

Table 5-7 Estimating Existing Noise Exposure for General Assessment

Distance from Major Noise Source[1] (feet)			Population Density (people per sq mile)	Noise Exposure Estimates			
Interstate Highways[2]	Other Roadways[3]	Railroad Lines[4]		L_{eq} Day	L_{eq} Evening	L_{eq} Night	L_{dn}
10 - 50				75	70	65	75
50 - 100				70	65	60	70
100 - 200				65	60	55	65
200 - 400				60	55	50	60
400 - 800				55	50	45	55
800 and up				50	45	40	50
	10 - 50			70	65	60	70
	50 - 100			65	60	55	65
	100 - 200			60	55	50	60
	200 - 400			55	50	45	55
	400 and up			50	45	40	50
		10 - 30		--	--	--	75
		30 - 60		--	--	--	70
		60 - 120		--	--	--	65
		120 - 240		--	--	--	60
		240 - 500		--	--	--	55
		500 - 800		--	--	--	50
		800 and up		--	--	--	45
			1 - 100	35	30	25	35
			100 - 300	40	35	30	40
			300 - 1000	45	40	35	45
			1000 - 3000	50	45	40	50
			3000 - 10000	55	50	45	55
			10000 - 30000	60	55	50	60
			30000 and up	65	60	55	65

NOTES:

1 Distances do not include shielding from intervening rows of buildings. General rule for estimating shielding attenuation in populated areas: Assume 1 row of buildings every 100 ft; -4.5 dB for the first row, -1.5 dB for every subsequent row up to a maximum of -10 dB attenuation.

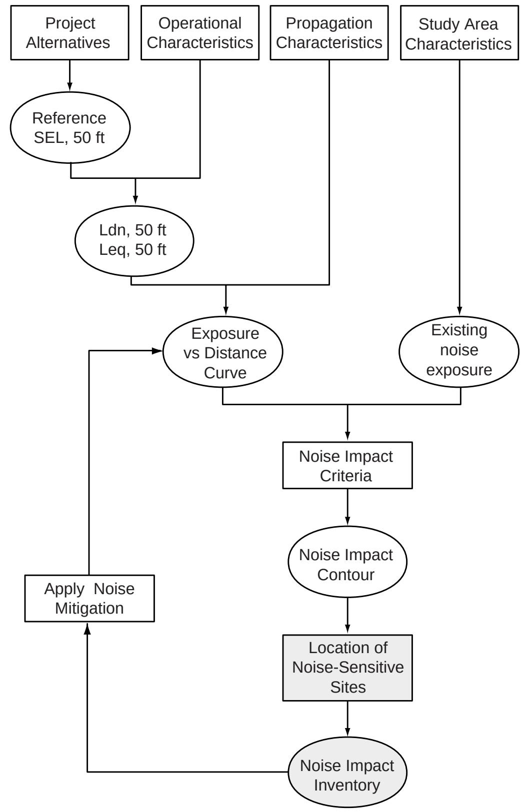
2 Roadways with 4 or more lanes that permit trucks, with traffic at 60 mph.

3 Parkways with traffic at 55 mph, but without trucks, and city streets with the equivalent of 75 or more heavy trucks per hour and 300 or more medium trucks per hour at 30 mph.

4 Main line railroad corridors typically carrying 5-10 trains per day at speeds of 30-40 mph.

5.6 INVENTORY NOISE IMPACT

The final step in the General Assessment is to develop an inventory of noise-impacted land uses. Using the land use information and noise impact contours from the Sections 5.4 and 5.5, it should be possible to locate which buildings are within the impact contours. In some cases it may be necessary to supplement the land use information or determine the number of dwelling units within a multi-family building with a visual survey.



The steps for developing the inventory are:

1. Construct tables for all the noise-sensitive land uses identified in the three land use categories from Section 5.4.
2. Tabulate buildings and sites that lie between the impact contours and the project boundary. For residential buildings, estimate the number of dwelling units. This is done for each alternative being considered.
3. Prepare summary tables showing the number of buildings and dwelling units within each impact zone for each alternative. Various alternatives can be compared in this way, including those with and without noise mitigation measures.
4. Determine the need for mitigation based on the policy considerations discussed in Section 3.2.4 and the application guidelines provided in Section 6.8.

Example 5-1. General Noise Assessment for a Transit Center

The following example illustrates the procedure for performing a General Noise Assessment. The example represents a typical FTA-assisted project in an urban area, the siting of a busy transit center in a mixed commercial and residential area, as shown in Figure 5-3.

Assumptions for Example

The assumptions for the Transit Center and its environs are as follows:

- **Main Street Traffic:** Peak hour traffic of 1200 autos, 20 heavy trucks, 300 medium trucks.

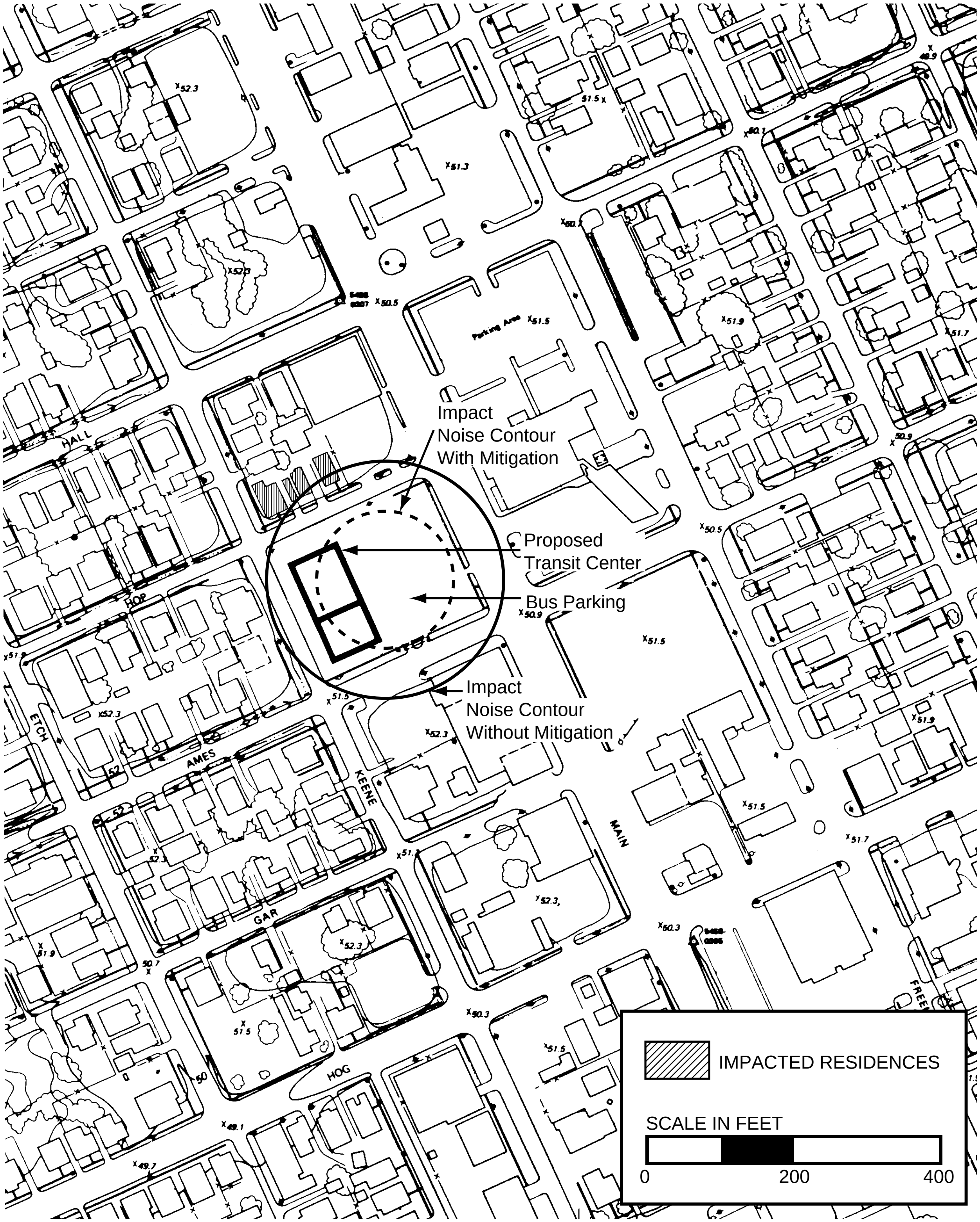


Figure 5-3 Example of Project for General Assessment: Siting of Transit Center in Mixed Commercial/Residential Area

- **Population Density:** 12 houses per block; single family homes; 3 people per family.

  Block area 78,750 square feet.
  Population density = 9,750 people/square mile.

- **Bus Traffic:**

Period	Hours	Buses per Hour
Peak, Morning	7am - 9am	30
Peak, Afternoon	4pm - 6pm	30
Mid-day	9am - 4pm	15
Evening	6pm - 10pm	12
Early Morning (Night)	6am - 7am	15
Late Night	10pm - 1am	4

Procedure

Before beginning the General Assessment, note that the Screening Procedure calls for additional analysis if any residential or other noise-sensitive land use is within 150 feet of a Transit Center when there are intervening buildings. According to Figure 5-3 the nearest residence is about 140 feet from the center of the proposed Transit Center, thereby calling for further analysis. The General Assessment proceeds as follows:

Determination of Noise Exposure at 50 feet

1. Determine the average number of buses per hour during day and night.

   Day (7am - 10pm):

   N_B *(avg day)* = 273 buses/15 hours = 18.2 buses/hour average.

   Night (10pm - 7am):

   N_B *(avg night)* = 27 buses/9 hours = 3 buses/hour average

2. Calculate $L_{eq}(day)$ and $L_{eq}(night)$ at 50 feet, assuming no noise barrier.

   From Table 5-5 and Table 5-6 the levels are determined as follows:

   $$L_{eq}(day) = SEL_{ref} + C_N - 35.6$$
   $$= 101 + 10 \log (18.2/20) - 35.6$$
   $$= 65 \text{ dB}$$
   $$L_{eq}(night) = SEL_{ref} + C_N - 35.6$$
   $$= 101 + 10 \log (3/20) - 35.6$$
   $$= 57 \text{ dB}$$

3. Calculate L_{dn} at 50 ft for the project.

   From Table 5-6 the level at 50 feet is determined as follows:

   $$L_{dn} = 10 \log \left[(15)10^{Leq(day)/10} + (9)10^{(Leq(night)+10)/10}\right] - 13.8$$

   which gives:

   $$L_{dn} = 79.7 - 13.8$$

   or $$L_{dn} = 66 \text{ dB}$$

Estimate Existing Noise Exposure

4. Estimate existing noise at noise-sensitive sites from the dominant noise source, either major roadways or local streets (population density).

   Roadway Noise Estimate - The traffic on Main Street qualifies this street for the "Other Major Roadway" category in Table 5-7. According to the map, the nearest residence is 275 feet from the edge of Main Street. The table shows existing L_{dn} = 55 dB at this distance for representative busy city street traffic.

   Population Density Noise Estimate - As a check on which ambient noise category to use, noise from local streets is estimated from the population density of 9,750 people/square mile. Table 5-7 confirms that the L_{dn} should be approximately 55 dB.

   The existing noise level associated with the residential neighborhood is therefore taken to be L_{dn} = 55 dB.

Noise Impact Contours

5. Distance to Impact Contour - For an existing noise exposure of 55 dB, the noise impact criteria indicate that the onset of Impact will occur at a project noise level of 56 dB, and onset of Severe Impact will occur at 62 dB. The next step is to determine the distances from the center of the property at which these levels are reached. This is accomplished by use of Figure 5-2, the exposure-vs-distance curve. With the project noise level at 50 feet given as 66 dB and the two impact levels at 56 dB and 62 dB, the differences are 10 dB and 4 dB, respectively. Using the curve in Figure 5-2 labeled "Stationary" source, the distance to where the project level drops 10 dB is approximately 160 feet, and 4 dB attenuation occurs at about 80 feet. Consequently, the Impact contour occurs at 160 feet from the center of the property and the Severe Impact contour occurs at 80 feet.

6. Draw Contours - Lines are drawn at 80 feet and 160 feet from the center of the property of the proposed Transit Center. These lines represent the noise impact contours. (Note in Figure 5-4 the Severe Impact contour is left out for clarity: it is just within the dashed line representing the Impact contour after mitigation.)

7. Assessment - Within, or touching, the contour defining "Impact" are three residential buildings (shaded in Figure 5-4). No residences are within the "Severe Impact contour."

Noise Mitigation

8. Noise Barrier - The process is repeated with a hypothetical noise barrier at the property line on the residential side of the Transit Center. This would consist of a wall approximately 15 feet high partially enclosing the transit center, sufficient to screen the residences but not the commercial block facing Main Street. According to Table 5-6, the approximate noise barrier effect is -5 dB. Repeating the procedure above, the effect of the noise barrier is to shrink the Impact contour to 90 feet and the Severe Impact contour to 45 feet, which in this example eliminates all adverse effect on the residences.

End of Example 5-1

Example 5-2. General Noise Assessment for a LRT System in a Highway Corridor

The following example illustrates the General Noise Assessment procedure for a fixed guideway-type project. The hypothetical project is a light rail transit (LRT) system to be built within the median of a busy multi-lane highway. The LRT tracks are grade-separated on aerial structure. The example covers a segment of the corridor that passes through a densely developed area with mixed residential and commercial land use, and a school within 150 feet of the project, as shown in Figure 5-4.

Assumptions for Example

The assumptions for the project are as follows:

- **Project Corridor:** Median of a six-lane interstate highway, with typical vehicle speeds of 60-70 mph during freely flowing traffic conditions.
- **LRT System:** LRT train with two-car consists, 50-ft long cars. Double track system on elevated concrete slab, welded rail. Trains operating with 5 to 10 minute headways at a speed of 60 mph along the segment shown in Figure 5-4.

Operating Schedule:

	Period	Headway (minutes)		Trains per hour		
		Inbound	Outbound	Inbound	Outbound	Total
Daytime	7am - 9am	5	7	12.0	8.6	20.6
	9am - 12am	7	9	8.6	6.7	15.2
	12am - 4pm	8	6	7.5	10.0	17.5
	4pm - 6pm	7	5	8.6	12.0	20.6
	6pm - 8pm	8	6	7.5	10.0	12.0
	8pm - 10pm	10	10	6.0	6.0	6.0
Nighttime	10pm - 1am	15	15	4.0	4.0	8.0
	1am - 5am	--	--	0.0	0.0	0.0
	5am - 6am	10	10	6.0	6.0	12.0
	6am - 7am	6	10	10.0	6.0	16.0

Procedure

The Screening Procedure calls for additional analysis for noise-sensitive land use within 350 feet of a rail transit guideway. Figure 5-4 shows that the closest residences are about 120 ft from the LRT corridor centerline, thereby requiring further noise analysis. The procedure is summarized as follows:

Determination of Noise Exposure at 50 feet

1. Determine average hourly daytime and nighttime volumes of train traffic.

   Daytime (7am - 10pm):

   V_d = 257 trains/15 hours = 17.1 trains/hour

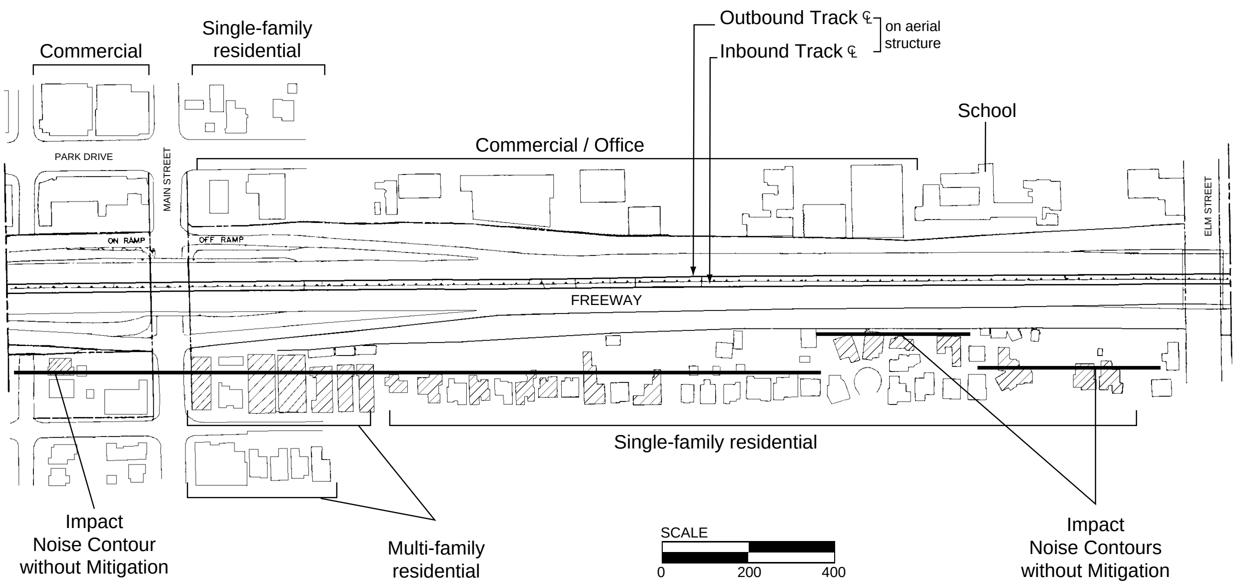


Figure 5-4 Example of Project for General Assessment: LRT System Corridor in Highway Median

Nighttime (10pm - 7am):

V_n = 52 trains/9 hours = 5.8 trains/hour

Peak Hour (of LRT operations during school hours):

V_p = 20.6 trains/hour

2. Calculate L_{eq}(day), L_{eq}(night) and L_{eq}(peak) at 50 ft, assuming no noise barrier.

From Table 5-1 and 5-2 these levels are determined as follows:

$$L_{eq}(day) = SEL_{ref} + 10\log(N_{cars}) + 20\log(S/50) + 10\log(V_d) - 35.6$$
$$= 82 + 4 + 10 \log (2) + 20 \log (60/50) + 10 \log (17.1) - 35.6$$
$$= 67.3 \text{ dB}$$

$$L_{eq}(night) = SEL_{ref} + 10 \log (N_{cars}) + 20 \log (S/50) + 10 \log (V_n) - 35.6$$
$$= 82 + 4 + 10 \log (2) + 20 \log (60/50) + 10 \log (5.8) - 35.6$$
$$= 62.6 \text{ dB}$$

$$L_{eq}(h) = SEL_{ref} + 10 \log (N_{cars}) + 20 \log (S/50) + 10 \log (V_p) - 35.6$$
$$= 82 + 4 + 10 \log (2) + 20 \log (60/50) + 10 \log (20.6) - 35.6$$
$$= 68.1 \text{ dB}$$

(Note that a +4 dB adjustment is added to account for track on aerial structure, per Table 5-2)

3. Calculate project L_{dn} at 50 ft.

From Table 5-2 this level is determined as follows:

$$L_{dn} = 10 \log \left[(15)10^{L_{eq}(day)/10} + (9)10^{(L_{eq}(night)+10)/10}\right] - 13.8$$

which gives

$$L_{dn} = 83.9 - 13.8$$

or

$$L_{dn} = 70 \text{ dB}$$

Estimate Existing Noise Exposure

4. Estimate existing noise at noise-sensitive sites. Since the freeway (the dominant noise source) is a major linear source from which noise attenuates rapidly with distance, it is inaccurate in this case to simply assign a "generalized" noise level to characterize a large area, as in Example 5-1. In other words, it is necessary to estimate the existing noise environment as a function of distance from the freeway on a site-specific basis.

   From Figure 5-4, unobstructed residences range from 80 to 200 ft from the freeway, while the school is located 130 ft from the freeway. Based on Table 5-7 the L_{dn} is 70 dB for residences closer than 100 ft from a major interstate, and 65 dB for residences between 100 and 200 ft. For the school, the applicable metric is daytime L_{eq}, which is estimated to be 65 dB at distances of 100 to 200 ft from a major interstate highway.

Noise Impact Contours

5. The following table is constructed using the impact criteria curves (Figure 3-1) to determine the project noise levels which cause impact:

Distance to Freeway	Existing Noise, L_{dn} or L_{eq}(day)	Onset of Impact		Onset of Severe Impact	
		L_{dn}	L_{eq}(h)	L_{dn}	L_{eq}(h)
50 - 100 ft	70 dB	64 dB	n/a	69 dB	n/a
100 - 200 ft	65 dB	61 dB	66 dB	66 dB	71 dB

   Note: The project criteria for L_{eq}(h) are not shown for the 50-100 ft distance range, since L_{eq}(h) only applies to the school in this example which is in the 100-200 ft range.

6. Distance to impact contours are determined using the curve in Figure 5-2 for "Fixed Guideway" and the project impact thresholds obtained above. The results are summarized as follows for the residences and school:

Distance to Freeway	Existing Noise, L_{dn} or L_{eq}(h)	Distance to Noise Impact Threshold, feet			
		Residences		School	
		Impact	Severe Impact	Impact	Severe Impact
50 - 100 ft	70 dB	120	55	n/a	n/a
100 - 200 ft	65 dB	210	90	75	30

7. Draw contours for each affected land use, based on the above table and its distance from the freeway. Note that the impact distances listed are in terms of distance to the *centerline of the LRT corridor*, not the freeway. Note that in Figure 5-4, only distances to "Impact" contours are shown. "Severe Impact" distances do not go beyond the edge of the freeway and are thus omitted for simplicity. The impact noise contours

are drawn at 2 different distances resulting from the change in existing noise for the closer residences.

8. Within the contours defining "Impact" are eighteen residential buildings (shaded in Figure 5-4). The school does not fall into the impact zone.

Noise Mitigation

9. The procedure is repeated assuming a noise barrier to be placed at the highway right-of-way line. The barrier serves to reduce not only project noise from the LRT by at least 5 dB but also the freeway noise. This, however, does not affect the project criteria to be used in determining impact. That is, the same existing noise levels (as the case without a barrier) are used to determine these thresholds.

   In the area of impact, the net effect of the noise barrier is to decrease the impact distance from 120 to 60 ft for residences within 100 feet of the freeway, and from 210 to 90 ft for residences between 100 and 200 feet of the freeway. Hence, the noise barrier eliminates all residential noise impact for this segment of the project area.

End of Example 5-2

REFERENCES

1. U.S. Department of Transportation, Federal Highway Administration. "FHWA Highway Traffic Noise Prediction Model," FHWA-RD-77-108, December 1978.

2. U.S. Environmental Protection Agency, "Population Distribution of the United States as a Function of Outdoor Noise Level," Report 550/9-74-009, June 1974.