APPENDICES

APPENDIX A. BACKGROUND FOR TRANSIT NOISE IMPACT CRITERIA

The noise criteria, presented in Chapter 3 of this manual, have been developed based on well-documented criteria and research into human response to community noise. The primary goals in developing the noise criteria were to ensure that the impact limits be firmly founded in scientific studies, be realistically based on noise levels associated with new transit projects, and represent a reasonable balance between community benefit and project costs. This appendix provides the background information.

A.1 Relevant Literature

Following is an annotated list of the documents that are particularly relevant to the noise impact criteria:

1. US Environmental Protection Agency "Levels Document":[(1)] This report identifies noise levels consistent with the protection of public health and welfare against hearing loss, annoyance, and activity interference. It has been used as the basis of numerous community noise standards and ordinances.

2. CHABA Working Group 69, "Guidelines for Preparing Environmental Impact Statements on Noise":[(2)] This report was the result of deliberations by a group of leading acoustical scientists with the goal of developing a uniform national method for noise impact assessment. Although the CHABA's proposed approach has not been adopted, the report serves as an excellent resource documenting research in noise effects. It provides a strong scientific basis for quantifying impacts in terms of L_{dn}.

3. American Public Transit Association Guidelines:[(3)] The noise and vibration sections of the APTA Guidelines have been used successfully in the past for the design of rail transit facilities. The APTA Guidelines include criteria for acceptable community noise and vibration. Experience has shown that meeting the APTA Guidelines will usually result in acceptable noise levels. However, there are some problems in using the APTA Guidelines for environmental assessment purposes. The criteria are in terms of L_{max} for conventional rail rapid transit vehicles and they cannot be used to compare among

different modes of transit. Since the APTA Guidelines are expressed in terms of maximum passby noise, they are not sensitive to the frequency or duration of noise events for transit modes other than conventional rail rapid transit operations with 5 to 10 minute headways. Therefore, the APTA criteria are questionable for assessing the noise impact of other transit modes which differ from conventional rapid transit with respect to source emission levels and operating characteristics (e.g., commuter rail, AGT and a variety of bus projects).

4. <u>"Synthesis of Social Surveys on Noise Annoyance"</u>:[4] In 1978, Theodore J. Schultz, an internationally known acoustical scientist, synthesized the results of a large number of social surveys, each concerning annoyance due to transportation noise. Remarkable consistency was found in a group of these surveys, and the author proposed that their average results be taken as the best available prediction of transportation noise annoyance. This synthesis has received essentially unanimous acceptance by acoustical scientists and engineers. The "universal" transportation response curve developed by Schultz (Figure 2-7) shows that the percent of the population highly annoyed by transportation noise increases from zero at an L_{dn} of approximately 50 dBA to 100-percent when L_{dn} is about 90 dBA. Most significantly, this curve indicates that for the same increase in L_{dn}, there is a greater increase in the number of people highly annoyed at high noise levels than at low noise levels. In other words, a 5 dB increase at low ambient levels (40 - 50 dB) has less impact than at higher ambient levels (65 - 75 dB). A recent update of the original research, containing several railroad, transit and street traffic noise surveys, confirmed the shape of the original Schultz curve.[5]

5. <u>HUD Standards</u>:[6] The U.S. Department of Housing and Urban Development has developed noise standards, criteria and guidelines to ensure that housing projects supported by HUD achieve the goal of a suitable living environment. The HUD site acceptability standards define 65 dB (L_{dn}) as the threshold for a normally unacceptable living environment and 75 dB (L_{dn}) as the threshold for an unacceptable living environment.

A.2 Basis for Noise Impact Criteria Curves

The lower curve in Figure 3-1 representing the onset of Impact is based on the following considerations:

- The EPA finding that a community noise level of L_{dn} less than or equal to 55 dBA is "requisite to protect public health and welfare with an adequate margin of safety."[1]

- The conclusion by EPA and others that a 5 dB increase in L_{dn} or L_{eq} is the minimum required for a change in community reaction.

- The research finding that there are very few people highly annoyed when the L_{dn} is 50 dBA, and that an increase in L_{dn} from 50 dBA to 55 dBA results in an average of 2% more people highly annoyed (see Figure 2-7 in Chapter 2).

Consequently, the change in noise level from an existing ambient level of 50 dBA to a cumulative level of 55 dBA caused by a project is assumed to be a minimal impact. Expressed another way, this is considered to be the lowest threshold where impact starts to occur. Moreover, the 2% increment represents the minimum measurable change in community reaction. Thus the curve's hinge point is placed at a project noise level of 53 dBA and an existing ambient noise level of 50 dBA, the combination of which yields a cumulative level of 55 dBA. The remainder of the lower curve in Figure 16 was determined from the annoyance curve (Figure 2-7) by allowing a fixed 2% increase in annoyance at other levels of existing ambient noise. As cumulative noise increases, it takes a smaller and smaller increment to attain the same 2% increase in highly annoyed people. While it takes a 5 dB noise increase to cause a 2% increase in highly annoyed people at an existing ambient noise level of 50 dB, an increase of only 1 dB causes the 2% increase of highly annoyed people at an existing ambient noise level of 70 dB.

The upper curve delineating the onset of Severe Impact was developed in a similar manner, except that it was based on a total noise level corresponding to a higher degree of impact. The Severe Noise Impact curve is based on the following considerations:

- The Department of Housing and Urban Development (HUD) in its environmental noise standards defines an L_{dn} of 65 as the onset of a normally unacceptable noise zone.[6] Moreover, the Federal Aviation Administration (FAA) considers that residential land uses are not compatible with noise environments where L_{dn} is greater than 65 dBA [7].

- The common use of a 5 dBA increase in L_{dn} or L_{eq} as the minimum required for a change in community reaction.

- The research finding that the foregoing step represents a 6.5% increase in the number of people highly annoyed (see Figure 2-7 in Chapter 2).

Consequently, the increase in noise level from an existing ambient level of 60 dBA to a cumulative level of 65 dBA caused by a project represents a change from an acceptable noise environment to the threshold of an unacceptable noise environment. This is considered to be the level at which severe impact starts to occur. Moreover, the 6.5% increment represents the change in community reaction associated with severe impact. Thus the upper curve's hinge point is placed at a project noise level of 63 dBA and existing ambient noise level of 60 dBA, the combination of which yields a cumulative level of 65 dBA. The remainder of the upper curve in Figure 3-1 was determined from the annoyance curve (Figure 2-7) by fixing the 6.5% increase in annoyance at all existing ambient noise levels.

Both curves incorporate a maximum limit for the transit project noise in noise-sensitive areas. Independent of existing noise levels, Impact for land use categories 1 and 2 is considered to occur whenever the <u>transit</u> L_{dn} equals or exceeds 65 dBA and Severe Impact occurs whenever the <u>transit</u> L_{dn} equals or exceeds 75 dBA. These absolute limits are intended to restrict activity interference caused by the transit project alone.

Both curves also incorporate a maximum limit for cumulative noise increase at low existing noise levels (below about 45 dBA). This is a conservative measure that reflects the lack of social survey data on people's reaction to noise at such low ambient levels. Similar to the FHWA approval in assessing the relative impact of a highway project, the transit noise criteria include caps on noise increase of 10 dB and 15 dB for Impact and Severe Impact, respectively, relative to the existing noise level.

Finally, it should be noted that due to the types of land use included in Category 3, the criteria allow the project noise for Category 3 sites to be 5 decibels greater than for Category 1 and Category 2 sites. This difference is reflected by the offset in the vertical scale on the right side of Figure 3-1. With the exception of active parks, which are clearly less sensitive to noise than Category 1 and 2 sites, Category 3 sites include primarily indoor activities and thus the criteria account for the noise reduction provided by the building structure.

A.3 Equations for Noise Impact Criteria Curves

The noise impact criteria can be quantified through the use of mathematical equations which approximate the curves shown in Figure 3-1. These equations may be useful when performing the noise assessment methodology through the use of spreadsheets, computer programs or other analysis tools. Otherwise, such mathematical detail is generally not necessary in order to properly implement the criteria, and direct use of Figure 3-1 is likely to be adequate and less time-consuming.

A total of four continuous curves are obtained from the criteria: two threshold curves ("Impact" and "Severe Impact") for Category 1 and 2; and two for Category 3. Note that for each level of impact, the overall curves for Categories 1 and 2 are offset by 5 dB from Category 3. While each curve is graphically continuous, it is defined by a set of three discrete equations which represent three "regimes" of existing noise exposure. These equations are approximately continuous at the transition points between regimes.

The first equation in each set is a linear relationship, representing the portion of the curve in which the existing noise exposure is low and the allowable increase is capped at 10 dB and 15 dB for Impact and Severe Impact, respectively. The second equation in each set represents the impact threshold over the range of existing noise exposure for which a fixed percentage of increase in annoyance is allowed, as described in the previous section. This curve, a third-order polynomial approximation derived from the Schultz curve,[(4)] covers the range of noise exposure encountered in most populated areas and is used in determining noise impact in the majority of cases for transit projects. Finally, the third equation in each of the four sets represents the absolute limit of project noise imposed by the criteria, for areas with high existing noise exposure. For land use category 1 and 2, this limit is 65 dBA for Impact and 70 dBA for Severe Impact. For land use category 3, the limit is 75 dBA for Impact and 80 dBA for Severe Impact.

The four sets of equations corresponding to the curves are given below. Each curve represents a threshold of noise impact, with impact indicated for points on or above the curve.

Threshold of Impact:

$$L_P = \begin{cases} 11.450 + 0.953\, L_E & L_E < 42 \\ 71.662 - 1.164\, L_E + 0.018\, L_E^{\,2} - 4.088 \times 10^{-5}\, L_E^{\,3} & 42 \le L_E \le 71 \\ 65 & L_E > 71 \end{cases} \Bigg\} \text{ Category 1 and 2}$$

$$L_P = \begin{cases} 16.450 + 0.953\, L_E & L_E < 42 \\ 76.662 - 1.164\, L_E + 0.018\, L_E^{\,2} - 4.088 \times 10^{-5}\, L_E^{\,3} & 42 \le L_E \le 71 \\ 70 & L_E > 71 \end{cases} \Bigg\} \text{ Category 3}$$

Threshold of Severe Impact:

$$L_P = \begin{cases} 17.322 + 0.940\, L_E & L_E < 44 \\ 96.725 - 1.992\, L_E + 3.02 \times 10^{-2}\, L_E^{\,2} - 1.043 \times 10^{-4}\, L_E^{\,3} & 44 \le L_E \le 77 \\ 75 & L_E > 77 \end{cases} \Bigg\} \text{ Category 1 and 2}$$

$$L_P = \begin{cases} 22.322 + 0.940\, L_E & L_E < 44 \\ 101.725 - 1.992\, L_E + 3.02 \times 10^{-2}\, L_E^{\,2} - 1.043 \times 10^{-4}\, L_E^{\,3} & 44 \le L_E \le 77 \\ 80 & L_E > 77 \end{cases} \Bigg\} \text{ Category 3}$$

where L_E is the existing noise exposure in terms of L_{dn} or L_{eq}(h) and L_P is the project noise exposure which determines impact, also in terms of L_{dn} or L_{eq}(h).

REFERENCES

1. U.S. Environmental Protection Agency, "Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety," EPA report number 550/9-74-004, March 1974.

2. National Academy of Sciences, "Guidelines for Preparing Environmental Impact Statements on Noise," Report from Committee on Bioacoustics and Biomechanics (CHABA) Working Group 69, February 1977.

3. American Public Transit Association, *1981 Guidelines for Design of Rapid Transit Facilities*, Section 2.7, "Noise and Vibration," 1981.

4. T.J. Schultz, "Synthesis of Social Surveys on Noise Annoyance," Journal of the Acoustical Society of America, Vol. 64, No. 2, pp. 377-405, August 1978.

5. S. Fidell, D.S. Barber and T.J. Schultz, "Updating a Dosage-Effect Relationship for the Prevalence of Annoyance Due to General Transportation Noise," Journal of the Acoustical Society of America, Vol. 89, No. 1, January 1991.

6. U.S. Department of Housing and Urban Development, "Environmental Criteria and Standards", 24 CFR Part 51,v 12 July 1979; amended by 49 FR 880, 6 January 1984.

7. U.S. Department of Transportation, Federal Aviation Administration, "Federal Aviation Regulations Part 150: Airport Noise Compatibility Planning," January 1981.