

Channel Law Group, LLP

8383 Wilshire Blvd.
Suite 750
Beverly Hills, CA 90211

Phone: (310) 347-0050
Fax: (323) 723-3960
www.channellawgroup.com

JULIAN K. QUATTLEBAUM, III
JAMIE T. HALL *
CHARLES J. McLURKIN

Writer's Direct Line: (310) 982-1760
jamie.hall@channellawgroup.com

*ALSO Admitted in Texas

December 7, 2021

VIA ELECTRONIC MAIL

Planning and Land Use Management Committee
Los Angeles City Council
c/o City Clerk
200 North Spring Street
Los Angeles, CA 90012
clerk.plumcommittee@lacity.org
armando.bencomo@lacity.org

Re: Item No. 11 Agenda for December 7, 2021; ZA-2020-2164-ELD-SPR-1A; ENV-2020-2165-CE-1A; Council File No. 21-0593-S1

Dear Members of the Planning and Land Use Management Committee ("Committee"):

This firm represents Holt Partners ("Association") with regard to the proposed development project located at 825-837 Holt Avenue ("Project"). This letter supplements the correspondence that was submitted earlier today objecting to the Project on CEQA grounds. It has come to my attention that a revised Class 32 Memorandum ("Memorandum") prepared by the City and/or Real Party in Interest. This Memorandum recast the mitigation measure pertaining to noise (temporary noise barriers) as a component of the project in order to avoid the legal maxim that you cannot utilize a mitigation measure to reach a conclusion that a project is exempt from CEQA. See *Salmon Protection & Watershed Network v. County of Marin* (2004) 125 Cal.App.4th 1098.

However, this component is clearly a mitigation measure intended to reduce project impacts. The City cannot now recast it as something else.

In *Lotus v. Department of Transportation* (2014) 223 Cal. App. 4th 645 ("*Lotus*"), Caltrans was found to have certified an insufficient EIR based on its failure to properly evaluate the potential impacts of a highway project. The *Lotus* court found that Caltrans erred by:

. . . incorporating the proposed mitigation measures into its description of the project and then concluding that any potential impacts from the project will be less than significant. As the trial court held, the “avoidance, minimization and/or mitigation measures,” as they are characterized in the EIR, are not “part of the project.” They are mitigation measures designed to reduce or eliminate the damage to the redwoods anticipated from disturbing the structural root zone of the trees by excavation and placement of impermeable materials over the root zones. ***By compressing the analysis of impacts and mitigation measures into a single issue, the EIR disregards the requirements of CEQA.***

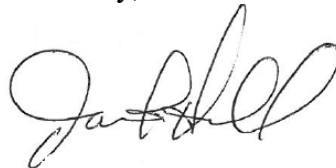
(*Id.* at 655–656, *emph. added.*) The court ordered Caltrans’ certification of the EIR be set aside, finding:

. . . this shortcutting of CEQA requirements subverts the purposes of CEQA by omitting material necessary to informed decisionmaking and informed public participation. It precludes both identification of potential environmental consequences arising from the project and also thoughtful analysis of the sufficiency of measures to mitigate those consequences. The deficiency cannot be considered harmless.

The City is poised to make the same mistake as Caltrans in *Lotus v. Department of Transportation*. In any event, Petitioner’s expert has concluded that the mitigation measure proposed by the City is inadequate to reduce the project’s impacts to a less than significant level.

I may be contacted at 310-982-1760 or at jamie.hall@channellawgroup.com if you have any questions, comments or concerns.

Sincerely,

A handwritten signature in black ink, appearing to read "Jamie T. Hall", written in a cursive style.

Jamie T. Hall

Channel Law Group, LLP

8383 Wilshire Blvd.
Suite 750
Beverly Hills, CA 90211

Phone: (310) 347-0050
Fax: (323) 723-3960
www.channellawgroup.com

JULIAN K. QUATTLEBAUM, III
JAMIE T. HALL *
CHARLES J. McLURKIN

Writer's Direct Line: (310) 982-1760
jamie.hall@channellawgroup.com

*ALSO Admitted in Texas

December 7, 2021

VIA ELECTRONIC MAIL

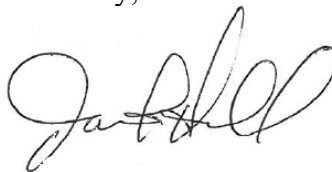
Planning and Land Use Management Committee
Los Angeles City Council
c/o City Clerk
200 North Spring Street
Los Angeles, CA 90012
clerk.plumcommittee@lacity.org
armando.bencomo@lacity.org

Re: Item No. 11 Agenda for December 7, 2021; ZA-2020-2164-ELD-SPR-1A; ENV-2020-2165-CE-1A; Council File No. 21-0593-S1

Dear Members of the Planning and Land Use Management Committee ("Committee"):

This firm represents Holt Partners ("Association") with regard to the proposed development project located at 825-837 Holt Avenue ("Project"). Holt Partners has cited to a variety of reference materials in the letters submitted to the City thus far. This letter is intended to provide the City with copies of the referenced documents cited to in previous correspondence to ensure that they are made part of the Administrative Record.

Sincerely,

A handwritten signature in black ink, appearing to read 'Jamie T. Hall', written in a cursive style.

Jamie T. Hall

Exhibit 1



F E D E R A L T R A N S I T A D M I N I S T R A T I O N

Transit Noise and Vibration Impact Assessment Manual

SEPTEMBER 2018

FTA Report No. 0123
Federal Transit Administration

PREPARED BY
John A. Volpe National Transportation Systems Center



U.S. Department of Transportation
Federal Transit Administration

COVER PHOTO

Courtesy of Edwin Adilson Rodriguez, Federal Transit Administration

DISCLAIMER

This document is disseminated under the sponsorship of the U.S. Department of Transportation in the interest of information exchange. The United States Government assumes no liability for its contents or use thereof. The United States Government does not endorse products or manufacturers. Trade or manufacturers' names appear herein solely because they are considered essential to the objective of this report.

Transit Noise and Vibration Impact Assessment Manual

SEPTEMBER 2018

FTA Report No. 0123

PREPARED BY

Antoinette Quagliata
Federal Transit Administration
Office of Planning and Environment

Meghan Ahearn
Eric Boeker
Christopher Roof
John A. Volpe National Transportation
Systems Center
Cambridge, MA 02142

Lance Meister
Herbert Singleton
Cross Spectrum Acoustics
East Longmeadow, MA 01028
Utah: Salt Lake City, UT 84102

SPONSORED BY

Federal Transit Administration
Office of Planning and Environment
U.S. Department of Transportation
1200 New Jersey Avenue, SE
Washington, DC 20590

Metric Conversion Table

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
LENGTH				
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
VOLUME				
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft ³	cubic feet	0.028	cubic meters	m ³
yd ³	cubic yards	0.765	cubic meters	m ³
NOTE: volumes greater than 1000 L shall be shown in m ³				
MASS				
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
TEMPERATURE (exact degrees)				
°F	Fahrenheit	$\frac{5}{9}(F-32)$ or $(F-32)/1.8$	Celsius	°C



Form Approved OMB No.
0704-0188

The public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing the burden, to Department of Defense, Washington Headquarters Services, Directorate for Information Operations and Reports (0704-0188), 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to any penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.

PLEASE DO NOT RETURN YOUR FORM TO THE ABOVE ADDRESS.

1. REPORT DATE September 2018		2. REPORT TYPE Final		3. DATES COVERED	
4. TITLE AND SUBTITLE Transit Noise and Vibration Impact Assessment Manual				5a. CONTRACT NUMBER	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S) Quagliata, Antoinette (FTA) Ahearn, Meghan (VOLPE) Boeker, Eric (VOLPE) Roof, Christopher (VOLPE) Meister, Lance (CSA) Singleton, Herbert (CSA)				5d. PROJECT NUMBER TF09A1	
				5e. TASK NUMBER NLJ56	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) U.S. Department of Transportation Volpe National Transportation Systems Center 55 Broadway Cambridge, MA 02142				8. PERFORMING ORGANIZATION REPORT NUMBER FTA Report No. 0123	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) U.S. Department of Transportation Federal Transit Administration Office of Planning and Environment 1200 New Jersey Avenue, S.E. Washington, DC 20590				10. SPONSOR/MONITOR'S ACRONYM(S) FTA	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S) FTA Report No. 0123	
12. DISTRIBUTION/AVAILABILITY STATEMENT This document is available through the FTA website: http://www.fta.dot.gov/ .					
13. SUPPLEMENTARY NOTES					
14. ABSTRACT This report is the third edition of a guidance manual originally issued in 1995. It includes clarifications to existing policy and updates to outdated references where applicable. Topics presented in this manual include procedures for predicting and assessing noise and vibration impacts of proposed transit projects for different stages of project development and different levels of analysis. Additional topics include descriptions of noise and vibration mitigation measures, construction noise and vibration, and how to present these analyses in the Federal Transit Administration's environmental documents. This guidance is for technical specialists who conduct the analyses, as well as project sponsor staff, Federal agency reviewers, and members of the general public who may be affected by the projects.					
15. SUBJECT TERMS Transit noise and vibration analysis, noise and vibration impact criteria, noise and vibration mitigation measures, environmental impact assessment, Nation Environmental Policy Act compliance.					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES 258	19a. NAME OF RESPONSIBLE PERSON
a. REPORT Unclassified	b. ABSTRACT Unclassified	c. THIS PAGE Unclassified			19b. TELEPHONE NUMBER (Include area code)

Table of Contents

SECTION 1: INTRODUCTION	1
1.1 PURPOSE.....	1
1.2 ORGANIZATION OF THE MANUAL	2
SECTION 2: PROJECT CLASS OF ACTION AND PLANNING	3
2.1 PROJECT CLASS OF ACTION	3
2.2 PROJECT PLANNING AND DEVELOPMENT	4
2.3 MITIGATION POLICY CONSIDERATIONS.....	5
SECTION 3: TRANSIT NOISE.....	9
3.1 NOISE METRICS.....	10
3.2 SOURCES OF TRANSIT VEHICLE NOISE.....	10
3.3 PATHS OF TRANSIT NOISE FROM SOURCE TO RECEIVER.....	14
3.4 RECEIVER RESPONSE TO TRANSIT NOISE.....	16
SECTION 4: NOISE IMPACT ANALYSIS	19
4.1 DETERMINE NOISE IMPACT CRITERIA.	20
Step 1: Identify Project Type.	21
Step 2: Choose Land Use Category for FTA Criteria.....	23
Step 3: Determine Appropriate FTA Criteria Presentation.....	25
4.2 DETERMINE NOISE ANALYSIS LEVEL.....	31
4.3 EVALUATE IMPACT: NOISE SCREENING PROCEDURE	33
Step 1: Identify Project Type	33
Step 2: Determine the Screening Distance.....	33
Step 3: Identify Study Area.....	34
Step 4: Locate Noise-Sensitive Land Uses.....	34
4.4 EVALUATE IMPACT: GENERAL NOISE ASSESSMENT	37
Step 1: Identify Noise-Sensitive Receivers.....	38
Step 2: Determine Project Noise Source Reference Levels	39
Step 3: Estimate Project Noise Exposure by Distance.....	48
Step 4: Combine Noise Exposure from All Sources.....	49
Step 5: Estimate Existing Noise Exposure.....	50
Step 6: Inventory Noise Impacts	52
Step 7: Determine Noise Mitigation Needs.....	54
4.5 EVALUATE IMPACT: DETAILED NOISE ANALYSIS	64
Step 1: Identify Noise-Sensitive Receivers.....	66
Step 2: Determine Project Noise Source Reference Levels	70
Step 3: Determine Propagation Characteristics.....	84
Step 4: Combine Noise Exposure from All Sources.....	91
Step 5: Determine Existing Noise Exposure.....	92
Step 6: Assess Noise Impact.....	95
Step 7: Determine Noise Mitigation Measures	97
SECTION 5: TRANSIT VIBRATION.....	109
5.1 GROUND-BORNE VIBRATION AND NOISE METRICS	110
5.2 SOURCES OF TRANSIT GROUND-BORNE VIBRATION AND NOISE.....	112
5.3 PATHS OF TRANSIT GROUND-BORNE VIBRATION AND NOISE.....	116

5.4	RECEIVER FACTORS THAT INFLUENCE GROUND-BORNE VIBRATION AND NOISE	117
5.5	HUMAN RESPONSE TO TRANSIT GROUND-BORNE VIBRATION AND NOISE	117
SECTION 6: VIBRATION IMPACT ANALYSIS		121
6.1	DETERMINE VIBRATION ANALYSIS LEVEL	121
6.2	DETERMINE VIBRATION IMPACT CRITERIA.....	123
	<i>Option A: General Vibration Assessment Criteria.....</i>	<i>123</i>
	<i>Step 1: Land Use Categories.....</i>	<i>123</i>
	<i>Step 2: Identify Event Frequency.....</i>	<i>125</i>
	<i>Step 3: Apply Impact Criteria by Land Use and Event Frequency</i>	<i>125</i>
	<i>Option B: Vibration Impact Criteria for a Detailed Vibration Analysis</i>	<i>130</i>
	<i>Step 1: Ground-Borne Vibration</i>	<i>130</i>
	<i>Step 2: Ground-borne Noise.....</i>	<i>132</i>
6.3	EVALUATE IMPACT: VIBRATION SCREENING PROCEDURE.....	132
	<i>Step 1: Classify project vehicles</i>	<i>133</i>
	<i>Step 2: Determine Project Type</i>	<i>134</i>
	<i>Step 3: Determine Screening Distance</i>	<i>135</i>
	<i>Step 4: Identify Vibration-Sensitive Land Uses</i>	<i>136</i>
6.4	EVALUATE IMPACT: GENERAL VIBRATION ASSESSMENT	136
	<i>Step 1: Select Base Curve for Ground Surface Vibration Level</i>	<i>136</i>
	<i>Step 2: Apply Adjustments.....</i>	<i>139</i>
	<i>Step 3: Inventory of Vibration Impact.....</i>	<i>147</i>
6.5	EVALUATE IMPACT: DETAILED VIBRATION ANALYSIS	149
	<i>Step 1: Characterize Existing Vibration Conditions</i>	<i>149</i>
	<i>Step 2: Estimate Vibration Impact.....</i>	<i>152</i>
	<i>Step 3: Assess Vibration Impact</i>	<i>165</i>
	<i>Step 4: Determine Vibration Mitigation Measures</i>	<i>165</i>
SECTION 7: NOISE AND VIBRATION DURING CONSTRUCTION.....		172
7.1	CONSTRUCTION NOISE ASSESSMENT	172
	<i>Step 1: Determine Level of Construction Noise Assessment</i>	<i>173</i>
	<i>Step 2: Use a Qualitative Construction Noise Assessment to Estimate Construction Noise</i>	<i>174</i>
	<i>Step 3: Use a Quantitative Construction Noise Assessment to Estimate Construction Noise</i>	<i>174</i>
	<i>Step 4: Assess Construction Noise Impact.....</i>	<i>178</i>
	<i>Step 5: Determine Construction Noise Mitigation Measures</i>	<i>179</i>
7.2	CONSTRUCTION VIBRATION ASSESSMENT.....	182
	<i>Step 1: Determine Level of Construction Vibration Assessment.....</i>	<i>182</i>
	<i>Step 2: Use a Qualitative Construction Vibration Assessment</i>	<i>183</i>
	<i>Step 3: Use a Quantitative Construction Vibration Assessment.....</i>	<i>183</i>
	<i>Step 4: Assess Construction Vibration Impact.....</i>	<i>185</i>
	<i>Step 5: Determine Construction Vibration Mitigation Measures</i>	<i>186</i>
SECTION 8: DOCUMENTATION OF NOISE AND VIBRATION ASSESSMENT		188
8.1	ENVIRONMENTAL DOCUMENT.....	188
	<i>Step 1: Choose the information to include.....</i>	<i>189</i>
	<i>Step 2: Organize information in the Environmental Document</i>	<i>190</i>
8.2	TECHNICAL REPORT ON NOISE AND VIBRATION.....	192

APPENDIX A GLOSSARY OF TERMS	195
APPENDIX B FUNDAMENTALS OF NOISE	200
B.1 AMPLITUDE	200
B.1.1 DECIBEL ADDITION.....	201
B.1.2 FREQUENCY.....	203
B.1.3 TIME PATTERN.....	205
B.1.4 NOISE METRICS.....	206
B.1.4.1 A-WEIGHTED SOUND LEVEL: THE BASIC NOISE UNIT.....	206
B.1.4.2 MAXIMUM SOUND LEVEL (L_{MAX}) DURING A SINGLE NOISE EVENT	207
B.1.4.3 SOUND EXPOSURE LEVEL (SEL): EXPOSURE FROM A SINGLE NOISE EVENT	208
B.1.4.4 EQUIVALENT SOUND LEVEL ($L_{EQ(T)}$).....	210
B.1.4.5 DAY-NIGHT SOUND LEVEL (L_{DN}): 24-HOUR EXPOSURE FROM ALL EVENTS.....	214
APPENDIX C BACKGROUND FOR TRANSIT NOISE IMPACT CRITERIA	217
C.1 RELEVANT LITERATURE.....	217
C.2 BASIS FOR NOISE IMPACT CRITERIA CURVES.....	218
C.3 EQUATIONS FOR NOISE IMPACT CRITERIA CURVES.....	219
APPENDIX D CLUSTERING RECEIVERS OF INTEREST	221
APPENDIX E DETERMINING EXISTING NOISE.....	225
APPENDIX F COMPUTING SOURCE LEVELS FROM MEASUREMENTS	229
F.1 HIGHWAY AND RAIL VEHICLE PASSBYS.....	229
F.2 STATIONARY SOURCES.....	233
F.3 L_{MAX} FOR SINGLE TRAIN PASSBY	234
APPENDIX G NON-STANDARD MODELING PROCEDURES AND METHODOLOGY	237

List of Figures

Figure 3-1	Source-Path-Receiver Framework	9
Figure 3-2	Sound Level Dependence on Speed	12
Figure 3-3	Attenuation Due to Distance (Divergence).....	15
Figure 3-4	Attenuation due to Soft Ground	15
Figure 3-5	Noise Barrier Geometry	16
Figure 3-6	Community Reaction to New Noise, Relative to Existing Noise in a Residential Urban Environment	18
Figure 3-7	Community Annoyance Due to Noise	18
Figure 4-1	Noise Impact Criteria Flow Chart by Project Segment.....	20
Figure 4-2	Noise Impact Criteria for Transit Projects.....	27
Figure 4-3	Increase in Cumulative Noise Levels Allowed by Criteria (Land Use Cat. 1 & 2).....	30
Figure 4-4	Increase in Cumulative Noise Levels Allowed by Criteria (Land Use Cat. 3).....	30
Figure 4-5	Procedure for General Noise Assessment	38
Figure 4-6	Curves for Estimating Exposure vs. Distance in General Noise Assessment	48
Figure 4-7	Noise Impacts of Hypothetical Commuter Rail.....	57
Figure 4-8	Example of Project for General Noise Assessment: Siting of Transit Center in Mixed Commercial/Residential Area.....	64
Figure 4-9	Procedure for Detailed Noise Analysis	66
Figure 4-10	Guide to Selecting Noise-Sensitive Receivers of Interest	67
Figure 4-11	Flow Diagram for Determining Project Noise at 50 ft	70
Figure 4-12	Flat Ground.....	86
Figure 4-13	Source in Shallow Cut.....	86
Figure 4-14	Elevated Receiver	86
Figure 4-15	Source in Sloped Cut.....	86
Figure 4-16	Source and Receiver Separated by Trench	86
Figure 4-17	Example Exposure vs. Distance Curves.....	88
Figure 4-18	Noise Barrier Parameter "P"	89
Figure 4-19	Recommended Microphone Locations for Existing Noise Measurements	93
Figure 5-1	Propagation of Ground-Borne Vibration into Buildings.....	109
Figure 5-2	Vibration Signal in Absolute Units.....	111
Figure 5-3	Vibration Signal in RMS Velocity Decibels.....	112
Figure 5-4	Typical Levels of Ground-Borne Vibration	113
Figure 5-5	Response to Transit-Induced Residential Vibration.....	119
Figure 6-1	Existing Vibration Criteria Flow Chart	129
Figure 6-2	Criteria for Detailed Vibration Analysis	131
Figure 6-3	Flow Chart of Vibration Screening Process.....	133
Figure 6-4	Generalized Ground Surface Vibration Curves	137
Figure 6-5	Ground-Borne Vibration and Noise Model	154
Figure 6-6	Typical Force Densities for Rail Transit Vehicles, 40 mph	157
Figure 6-7	Typical Force Densities for LRT Vehicles, 40 mph	157
Figure 6-8	Test Configuration for Measuring Transfer Mobility	158
Figure 6-9	Example of Point-Source Transfer Mobility	159
Figure 6-10	Equipment Required for Field Testing and Laboratory Analysis	160
Figure 6-11	Analysis of Transfer Mobility	161
Figure 6-12	Schematic of Transfer Mobility Measurements Using a Line of Impacts	162
Figure 6-13	Example of Line-source Transfer Mobility	163
Figure 6-14	Foundation Response for Various Types of Buildings	164
Figure B-1	RMS Pressure Illustration	200

Figure B-2	Graph for Approximate Decibel Addition	202
Figure B-3	Noise Spectrum of Transit Train on Curve and Elevated Structure	204
Figure B-4	A-Weighting Curve	205
Figure B-5	Typical A-weighted Sound Levels	207
Figure B-6	Typical Transit-Vehicle Passby	208
Figure B-7	Typical Fixed-Facility Noise Event	208
Figure B-8	An Energy Vice of Noise Events	210
Figure B-9	Typical Hourly $L_{eq(1hr)}$'s	211
Figure B-10	Example A-weighted Sound Level Time Histories	212
Figure B-11	Typical L_{dn} 's	214
Figure D-1	Example of Receiver Map Showing Cluster Boundaries	224

List of Tables

Table 3-1	Noise Metrics.....	10
Table 3-2	Sources of Transit Noise.....	13
Table 4-1	Multimodal Project Noise Factors	22
Table 4-2	Multimodal Project Assessment Methods.....	22
Table 4-3	Land Use Categories and Metrics for Transit Noise Impact Criteria	23
Table 4-4	Levels of Impact.....	26
Table 4-5	Noise Levels Defining Impact for Transit Projects	28
Table 4-6	Noise Impact Criteria: Effect on Cumulative Noise Exposure	31
Table 4-7	Screening Distance for Noise Assessments.....	35
Table 4-8	Assumptions for Screening Distances for Noise Assessments	36
Table 4-9	Reference SEL's 50 ft from Track and at 50 mph, One Vehicle.....	40
Table 4-10	Computation of Noise Exposure at 50 ft for Fixed-Guideway General Noise Assessment	42
Table 4-11	Source Reference Levels at 50 ft from Roadway, 50 mph	43
Table 4-12	Computation of $L_{eq(1hr)}$ and L_{dn} at 50 ft for Highway/Transit General Noise Assessment	44
Table 4-13	Source Reference Levels at 50 ft From the Center of Site, Stationary Sources.....	45
Table 4-14	Computation of $L_{eq(1hr)}$ and L_{dn} at 50 ft for Stationary Source General Noise Assessment..	47
Table 4-15	Distance Correction Factor Equations for General Noise Assessment.....	49
Table 4-16	Computing Total Noise Exposure	49
Table 4-17	Estimating Existing Noise Exposure for General Noise Assessment	52
Table 4-18	Land Uses of Interest	68
Table 4-19	Sources of Transit Noise.....	71
Table 4-20	Source Reference SELs at 50 ft: Fixed-Guideway Sources at 50 mph.....	73
Table 4-21	Computation of $L_{eq(1hr)}$ and L_{dn} at 50 ft: Fixed-Guideway Sources	76
Table 4-22	Source Reference SELs at 50 ft: Highway/Transit Sources at 50 mph	78
Table 4-23	Computation of $L_{eq(1hr)}$ and L_{dn} at 50 ft: Highway/Transit Sources.....	80
Table 4-24	Source Reference SELs at 50 ft: Stationary Sources.....	82
Table 4-25	Computation of $L_{eq(1hr)}$ and L_{dn} at 50 ft: Stationary Sources.....	83
Table 4-26	Ground Factor G, for Ground Attenuation	86
Table 4-27	Distance Correction Factor Equations for Detailed Noise Analysis	87
Table 4-28	Barrier Insertion Loss.....	88
Table 4-29	Attenuation due to Buildings	89
Table 4-30	Attenuation due to Trees	89
Table 4-31	Calculate L_{dn} or $L_{eq(1hr)}$	91
Table 4-32	Computing Total Noise Exposure	91
Table 4-33	Transit Noise Mitigation Measures – Source Treatments.....	97
Table 4-34	Transit Noise Mitigation Measures – Path Treatments	104
Table 4-35	Transit Noise Mitigation Measures – Receiver Treatments	106
Table 5-1	Ground-borne Vibration and Noise Metrics	110
Table 5-2	Factors that Influence Levels of Ground-Borne Vibration and Noise at the Source.....	114
Table 5-3	Factors that Influence Levels of Ground-borne Vibration and Noise along the Path	117
Table 5-4	Factors that Influence Levels of Ground-Borne Vibration and Noise at the Receiver	117
Table 5-5	Human Response to Different Levels of Ground-Borne Vibration and Noise	120
Table 6-1	Land Use Categories for General Vibration Assessment Impact Criteria	124
Table 6-2	Event Frequency Definitions.....	125
Table 6-3	Indoor Ground-Borne Vibration (GBV) and Ground-Borne Noise (GBN) Impact Criteria for General Vibration Assessment.....	126
Table 6-4	Indoor Ground-Borne Vibration and Noise Impact Criteria for Special Buildings	126

Table 6-5	Impact Criteria Considering Existing Conditions.....	128
Table 6-6	Interpretation of Vibration Criteria for Detailed Vibration Analysis	131
Table 6-7	Project Types for Vibration Screening Procedure	135
Table 6-8	Screening Distances for Vibration Assessments.....	136
Table 6-9	Ground Surface Vibration Level Base Curve Descriptions.....	137
Table 6-10	Generalized Ground Surface Vibration Equations	138
Table 6-11	Source Adjustment Factors for Generalized Predictions of GB Vibration and Noise.....	140
Table 6-12	Path Adjustment Factors for Generalized Predictions of GB Vibration and Noise.....	143
Table 6-13	Receiver Adjustment Factors for Generalized Predictions of GB Vibration and Noise.....	145
Table 6-14	Conversion to Ground-borne Noise	146
Table 7-1	Construction Equipment Noise Emission Levels.....	176
Table 7-2	General Assessment Construction Noise Criteria.....	179
Table 7-3	Detailed Analysis Construction Noise Criteria	179
Table 7-4	Vibration Source Levels for Construction Equipment	184
Table 7-5	Construction Vibration Damage Criteria.....	186
Table C-1	Threshold of Moderate and Severe Impacts	220
Table F-1	Conversion to Source Reference Levels at 50 ft – Highway and Rail Sources	231
Table F-2	Conversion to Source Reference Levels at 50 ft – Stationary Sources	234
Table F-3	Conversion to L_{max} at the Receiver, for a Single Train Passby	235

List of Examples

Example 4-1	General Noise Assessment – Commuter Rail.....	54
Example 4-2	General Noise Assessment – Highway/Transit.....	59
Example 4-3	General Noise Assessment – BRT System.....	60
Example 4-4	General Noise Assessment – Transit Center.....	62
Example 4-5	Detailed Noise Analysis – Fixed Guideway Noise Sources	77
Example 4-6	Detailed Noise Analysis – Highway Transit Noise Sources	80
Example 4-7	Detailed Noise Analysis – Stationary Noise Sources	84
Example 4-8	Detailed Noise Analysis – Exposure Vs. Distance Curve.....	87
Example 4-9	Detailed Noise Analysis – Shielding	89
Example 4-10	Detailed Noise Analysis – Combine Sources	91
Example 6-1	General Vibration Assessment – LRT	148
Example B-1	Decibel Addition – Identical Buses.....	203
Example B-2	Decibel Addition – Two Sources	203
Example D-1	Clustering Receivers.....	223
Example F-1	Calculate SEL_{ref} – Locomotives.....	232
Example F-2	Calculate SEL_{ref} – Rail Cars.....	232
Example F-3	Calculate SEL_{ref} – Bus.....	233
Example F-4	Calculate SEL_{ref} – Signal Crossing.....	234
Example F-5	Calculate L_{max} – Train Passby.....	236

Abstract

This report is the third edition of a guidance manual originally issued in 1995. It includes clarifications to existing policy and updates to outdated references where applicable. Topics presented in this manual include procedures for predicting and assessing noise and vibration impacts of proposed transit projects for different stages of project development and different levels of analysis. Additional topics include descriptions of noise and vibration mitigation measures, construction noise and vibration, and how to present these analyses in the Federal Transit Administration's environmental documents. This guidance is for technical specialists who conduct the analyses, as well as project sponsor staff, Federal agency reviewers, and members of the general public who may be affected by the projects.

Acknowledgments

The original 1995 version of this manual was developed by the firm Harris Miller Miller & Hanson Inc. (HMMH) and peer-reviewed by a group of specialists in the fields of acoustics and environmental planning and analysis. HMMH updated the original manual in 2006.

The updates for this current version were provided by the John A. Volpe National Transportation Systems Center, Cross Spectrum Acoustics, and FTA, and it was peer-reviewed by a panel of experts.

The U.S. Department of Transportation FTA Office of Planning and Environment wishes to thank the following for their participation in the peer review of this manual:

- | | |
|-----------------------|---------------------|
| ▪ Scott Edwards | ▪ Shankar Rajaram |
| ▪ Anthony Evans | ▪ Judith Rochat |
| ▪ Timothy Johnson | ▪ Jason Ross |
| ▪ Shannon McKenna | ▪ Hugh Saurenman |
| ▪ Lance Meister | ▪ Herbert Singleton |
| ▪ James Nelson | ▪ David Towers |
| ▪ Anthony Joseph Ossi | |

SECTION

Introduction

1.1 Purpose

The Council on Environmental Quality (CEQ) regulations for implementing the procedural provisions of the National Environmental Policy Act of 1969 (NEPA)^(1,2) require that a federally-funded project be assessed for its impact on the human and natural environment prior to implementation. The Federal Transit Administration (FTA), in conjunction with the Federal Highway Administration (FHWA), has issued detailed regulations implementing NEPA for transit and highway projects. The regulations are codified in part 771 of title 23, Code of Federal Regulations, and are titled “Environmental Impact and Related Procedures.” (23 CFR part 771).⁽³⁾

The Federal Transit Administration (FTA) provides financial assistance for a range of public transportation projects from new rail rapid transit (RRT) systems to bus maintenance facilities and vehicle purchases. As required by NEPA and its implementing regulations, each project must undergo environmental review.

Noise and vibration are sometimes among the major concerns regarding the effects of a transit project on the surrounding community and are key elements of the environmental impact assessment process for public transportation projects. A transit system is often placed near population centers by necessity and may cause noise and vibration at nearby residences and other sensitive types of land use.

This manual provides technical guidance for conducting noise and vibration analyses for transit projects, as well as direction regarding preparation of the information for FTA’s environmental documents. Some situations may not be explicitly covered in this manual; the exercise of professional judgment may be required to extend the basic methods in these cases and frequent consultation with FTA staff is important to ensure the methods used meet the requirements for environmental reviews. See Appendix G for information on using non-standard modeling procedures.

In general, the noise and vibration impact assessment process for projects includes the following steps:

1. Determine appropriate impact criteria (Section 4.1).
2. Conduct screening and determine appropriate level of noise analysis, analyze project noise impacts, and evaluate mitigation options if appropriate (Sections 4.2–4.5).
3. Determine appropriate level of vibration analysis, analyze project vibration impacts, and evaluate mitigation options if appropriate (Sections 6.1–6.5).
4. Analyze construction noise and vibration impacts (Section 7).
5. Document findings (Section 8).

1.2 Organization of the Manual

This guidance manual is organized by the following recommended analysis workflow. A glossary of terms used throughout this manual is available in Appendix A. Detailed information on the fundamentals of noise, noise impact criteria, clustering receivers, determining existing noise, computing source levels from measurements, and using non-standard methodology is available in the appendices.

Section 2: Project Class of Action and Planning – This section describes the first step in the analysis process that is applicable to both noise and vibration analyses.

Section 3: Transit Noise – This section provides the reader with background information specific to transit noise.

Section 4: Noise Impact Analysis – This section provides a general outline of the entire noise impact analysis process: guidelines on determining noise impact criteria, methods for choosing the appropriate level of noise analysis (“Screening,” “General,” or “Detailed”), steps for evaluating noise impacts with the Noise Screening Procedure (a simplified method of evaluating the potential for noise impact from transit projects), steps for evaluating noise impact with the General Noise Assessment procedure (a simplified assessment method to estimate noise impact and compare alternatives for transit projects), and steps for evaluating noise impact with the Detailed Noise Analysis procedure (a comprehensive assessment method to produce the most accurate estimates of noise impact intended for certain major public transportation projects).

Section 5: Transit Vibration – This section contains background information specific to transit vibration.

Section 6: Vibration Impact Analysis – This section provides a general outline of the entire vibration impact analysis process: guidelines on determining vibration impact criteria, methods for choosing the appropriate level of vibration analysis (“Screening,” “General,” or “Detailed”), steps for evaluating vibration impact with the vibration screening procedure (a simplified method of evaluating the potential for vibration impact from transit projects), steps for evaluating vibration impact with the general vibration assessment procedure (a simplified assessment method to estimate vibration impact and compare alternatives for transit projects), and steps for evaluating vibration impact with the detailed vibration analysis procedure (a comprehensive assessment method to produce the most accurate estimates of vibration impact intended for certain major public transportation projects).

Section 7: Noise and Vibration During Construction – This section presents the process of assessing noise and vibration impact during construction, including determination of level of assessment, source levels, impact criteria, and mitigation.

Section 8: Documentation of Noise and Vibration Assessment – This section includes guidance for documenting the noise and vibration assessment in technical reports and environmental documents.

SECTION

2

Project Class of Action and Planning

The level of environmental analysis and review depends on the significance of any potential associated environmental impacts, which in turn depends in part on the scope and complexity of the proposed project. The goals of a transit noise and vibration impact assessment are to:

1. Determine existing noise and vibration levels.
2. Assess project noise and vibration for potential impact.
3. Evaluate the effect of mitigation options on impacts.

The class of action determination will inform the required level of analysis. The FTA Regional office⁽ⁱ⁾ determines the class of action based on project information provided by the project sponsor. The following types of information can assist the FTA Regional office in an initial class of action determination for a project:

- Project description
- Project-specific graphics, including:
 - Project location/sizes
 - Known land use and environmental features
- Additional information, as appropriate:
 - Summary of prior planning
 - Draft purpose and need statement

Project classes of action are described in Section 2.1. Project planning and development guidelines are presented in Section 2.2.

2.1 Project Class of Action

FTA's environmental regulations classify projects by level of environmental analysis. The class of action will determine the appropriate level of analysis and documentation for a project. Details of each class are described in the following sections. For more information, review FTA's environmental impact and related procedures at 23 CFR part 771.

Environmental Impact Statements

Environmental impact statements (EISs) apply to projects that are expected to cause significant environmental effects in the NEPA context. Typical examples include new or extensions of fixed-guideway projects, such as heavy rail, light rail, commuter rail, and automated guideway transit (AGT) systems that are not located within existing transportation right-of-way (ROW). It is likely that for major infrastructure projects requiring an EIS, the most detailed treatment of noise and vibration impacts will often be required.

Categorical Exclusions

Categorical exclusions (CEs) cover actions that are excluded from requiring an EIS or environmental assessment (EA) because FTA has determined that they do

ⁱ <http://www.fta.dot.gov/12926.html>.

not routinely cause significant environmental impacts. FTA's CEs are located at 23 CFR §§ 771.118(c) and (d), commonly referred to as the c-list and d-list, respectively. Examples of projects that would normally be CEs include vehicle purchases, maintenance of equipment, vehicles, or facilities, and ROW acquisition.

In general, CEs for transit capital construction projects often require at least a screening of noise impacts.

Environmental Assessments

When a proposed project is presented to FTA and it is uncertain whether the project requires an EIS or qualifies for a CE, FTA will normally direct the project sponsor to prepare an environmental assessment (EA) to assist in making the determination. An EA may be prepared for any type of project if uncertainty exists about the magnitude or extent of the impacts. Generally, an EA is selected over a CE if FTA determines that several types of potential impacts require further investigation, for example, air quality, noise, wetlands, historic sites, and/or traffic, but FTA's environmental regulation does not list typical projects that require EAs.

Experience shows that most of the EAs prepared for transit projects require at least a general assessment of noise impacts.

2.2 Project Planning and Development

Capital transit projects are ordinarily developed initially from a comprehensive transportation planning process conducted in metropolitan areas (see 23 CFR § 450.300).⁽⁴⁾ The metropolitan planning process often includes some early consideration of social, economic, and environmental effects of proposed major infrastructure improvements. At this stage, environmental effects are usually considered on a broad scale—for example, overall development patterns, impacts on green space, and regional air quality. Noise and vibration assessments are not typically performed at this stage because the proposed infrastructure improvements lack the necessary detail.

Once the need for a capital transit project in a corridor is established in the metropolitan transportation plan, the transit mode and general alignment best suited for the corridor are identified. The Screening and General noise assessment procedures and the vibration screening procedure described in this manual may be used to compare noise and vibration effects among different transit modes and alignments at an early stage of the project planning. The analysis that results is documented through the environmental review process.

NEPA establishes a broad policy regarding mitigation as a means of accomplishing its environmental objectives. Other Federal laws, such as Section 4(f) (49 U.S.C. 303) and Section 404 (33 U.S.C. 1344), have explicit mitigation requirements for certain resources. The decision to include noise or vibration mitigation for a project is made by FTA and the project sponsor after public review of the environmental document, as appropriate. If mitigation measures are deemed necessary to protect the environment or to satisfy statutory requirements, they will be incorporated as an integral part of the project and subsequent grant documents will reference these measures as contractual obligations on the part of the project sponsor. Through that process, FTA

ensures that the project sponsor complies with all design and mitigation commitments contained in the environmental record.

Once the project enters construction, noise or vibration may need to be reassessed in some circumstances. Some large construction projects in densely populated residential areas may require noise monitoring to ensure agreed-upon noise limits are not exceeded. Vibration testing may be needed in the final stages of construction to determine whether vibration control measures have the predicted effect.

Considering that transit projects must be located amid or very close to concentrations of people, noise and vibration impacts can be a concern throughout the environmental review process, design, and construction phases. This manual offers the flexibility to address noise and vibration at different stages in the development of a project and in different levels of detail.

2.3 Mitigation Policy Considerations

Because noise is frequently among the greatest environmental concerns of planned transit projects, FTA and the project sponsor should make reasonable efforts to reduce predicted noise to levels considered acceptable for affected noise-sensitive land uses. The need for noise mitigation is determined based on the magnitude of impact and consideration of factors specifically related to the proposed project and affected land uses.

The goal of providing noise mitigation is to gain substantial noise reduction, not simply to reduce the predicted levels to just below the “severe” impact threshold. For FTA to determine whether the mitigation is reasonable, the evaluation of specific mitigation measures should include the noise reduction potential, the cost, the effect on transit operations and maintenance, and any other relevant factors, such as any new environmental impacts that may be caused by the implementation of a noise reduction measure. A thorough evaluation enables FTA to make the findings required by NEPA and other statutes, such as Section 4(f) or Section 106 requirements and their implementing regulations.

Severe impacts have the greatest adverse impact on the community, and mitigation should be strongly considered. Areas with “moderate” impacts also have potential for effects on the community and therefore should also include consideration and possible adoption of mitigation measures when considered reasonable.

Since reasonableness is not strictly defined, FTA recommends that project sponsors work with the affected public and FTA staff during the environmental review process to decide appropriate mitigation strategies. A project sponsor may also consider developing and formally adopting a mitigation policy to aid in the determination of appropriate and applicable mitigation measures for current and proposed projects and anticipated impacts. Having such a policy in place can aid in the project planning up front and help to expedite mitigation decisions.

The following considerations can assist in determining circumstances that trigger the need for mitigation and include examples of how they can be applied in a noise mitigation policy:

- **Number of Noise-Sensitive Sites Affected**

A row or cluster of residences adjacent to a rail transit line establishes a greater need for mitigation than one or several isolated residences in a mixed-use area. Single residences may not be able to meet a cost-effectiveness criterion for mitigation.

Example Mitigation Policy Consideration: Set a minimum number of noise-sensitive sites as a threshold, combined with a reference to a cost-effectiveness criterion.

- **Increase over Existing Noise Levels**

Since the noise impact criteria are delineated as bands or ranges, project noise can vary 5 to 7 decibels (dB) within the band of moderate impact at any specific ambient noise level. If the project and ambient noise plot falls just below the severe range, the need for mitigation is strongest for a moderate impact. Similarly, if the plot falls within the moderate range just above the no impact threshold, the impacts are expected to be less, so the justification for mitigation would not be as strong.

Example Mitigation Policy Consideration: Set a strong need for mitigation when a moderate impact is 2 dB (for example) over the no impact threshold.

- **Noise Sensitivity of the Property**

Section 4.1 includes a comprehensive list of noise-sensitive land uses, yet there can be differences in noise sensitivity depending on individual circumstances. For example, parks and recreational areas vary in their sensitivity depending on the type of use they experience (active vs. passive recreation) and the settings in which they are located.

Example Mitigation Policy Consideration: Cite the use of the property as a determination of sensitivity for parks and recreational areas.

- **Effectiveness of the Mitigation Measure(s)**

Determine the magnitude of the noise reduction that can be achieved, and consider whether there are conditions that limit effectiveness, such as noise barrier effectiveness for a multi-story apartment building.

Example Mitigation Policy Consideration: Set a minimum reduction in noise level to be considered effective. A 5-dB reduction is typically considered an effective reduction from mitigation.

- **Feasibility of the Mitigation Measure(s)**

Determine if the mitigation measure is feasible from an engineering, operations or safety perspective. In some cases, it may not be possible to construct mitigation (noise barriers) due to physical or structural limitations

or because of safety concerns, especially related to sight lines for pedestrians and vehicles.

Example Mitigation Policy Consideration: State that the engineering design of the mitigation must be feasible, that it must be implementable in light of operations, and that mitigation must not compromise safety.

- **Fairness and Equity of the Mitigation Measure(s)**

Ensure that mitigation measures are applied in a fair and equitable manner. In many cases, small differences in distances or operations can result in small differences in projected noise levels. For example, all the residences in a row could have a projected moderate impact except for one residence at the end of the row that falls just under the moderate criteria due to being set slightly further back from the alignment. In a case like this, mitigation should be applied for the entire row of residences if possible.

Example Mitigation Policy Consideration: State that mitigation should be applied equitably.

- **Existing Transportation Noise**

Neighborhoods with ambient noise levels already heavily influenced by transportation noise, especially the same type of noise source as the project, should be considered. Often adding a new similar noise source will not add to the ambient noise levels or only slightly increase it to within acceptable levels. Whereas, impacts would be more likely, if the new noise was added to a neighborhood with minimal transportation noise. However, it is important to note that per (Section 4.1, Step 3) the higher the existing noise, the lower the allowable noise increase from new sources. A new cumulative noise environment may be very objectionable because people will not be compartmentalizing the existing noise versus the new noise and reacting only to the new noise. In this circumstance, impacts predicted in the moderate range could be treated as if they were severe.

Example Mitigation Policy Consideration: Set a policy that moderate impacts under these circumstances be treated as severe and cite the potential for reducing noise from existing transportation noise, as well as from project noise.

- **Community Views**

This manual provides the methodology to make an objective assessment of the need for noise mitigation. However, the views of the community should be considered where there are potential noise impacts predicted through this manual. The NEPA compliance process provides the framework for hearing the community's concerns about a proposed project and then making a good-faith effort to address those concerns. Many projects can be expected to have projected noise levels within the moderate impact range and, where possible, decisions regarding mitigation should be made after considering input from the affected public, relevant government agencies, and community organizations. There have been cases where the solution to the noise problem, a noise barrier, was not preferable to community members because of perceived adverse visual effects.

Example Mitigation Policy Consideration: State that community input in determining the need for mitigation will be included whenever possible.

- **Implementation Cost**

Cost is an important consideration in reaching decisions about noise mitigation measures. One guideline for gauging the reasonableness of the cost of mitigation is the state DOT's procedures on the subject. Many states have established their own cost threshold per benefited residence for determining whether installation of noise barriers for noise reduction is a reasonable expenditure. Several airport authorities have placed limits on the costs they will incur for sound insulation per residence for homes, and FTA assesses cost in a similar manner by benefited residence. Higher costs may be justified depending on the specific set of circumstances of a project.

Example Mitigation Policy Consideration: State the adopted cost threshold per benefited receiver for typical circumstances.

SECTION

3

Transit Noise

This section presents the basic concepts of transit noise as background for computation methods and transit noise assessment procedures presented in Section 4. An overview of fundamental noise topics, including amplitude, frequency, time pattern, and decibel addition, is presented in Appendix B.

The Source-Path-Receiver framework for noise illustrated in Figure 3-1 is central to all environmental noise studies. Each transit source generates noise that depends upon the type of source and its operating characteristics. Along the propagation path, between all sources and receivers, noise levels can be reduced (attenuated) by distance depending on ground type, intervening obstacles, and other factors. Finally, noise combines from multiple sources at each receiver and potentially interferes with activities at that location.

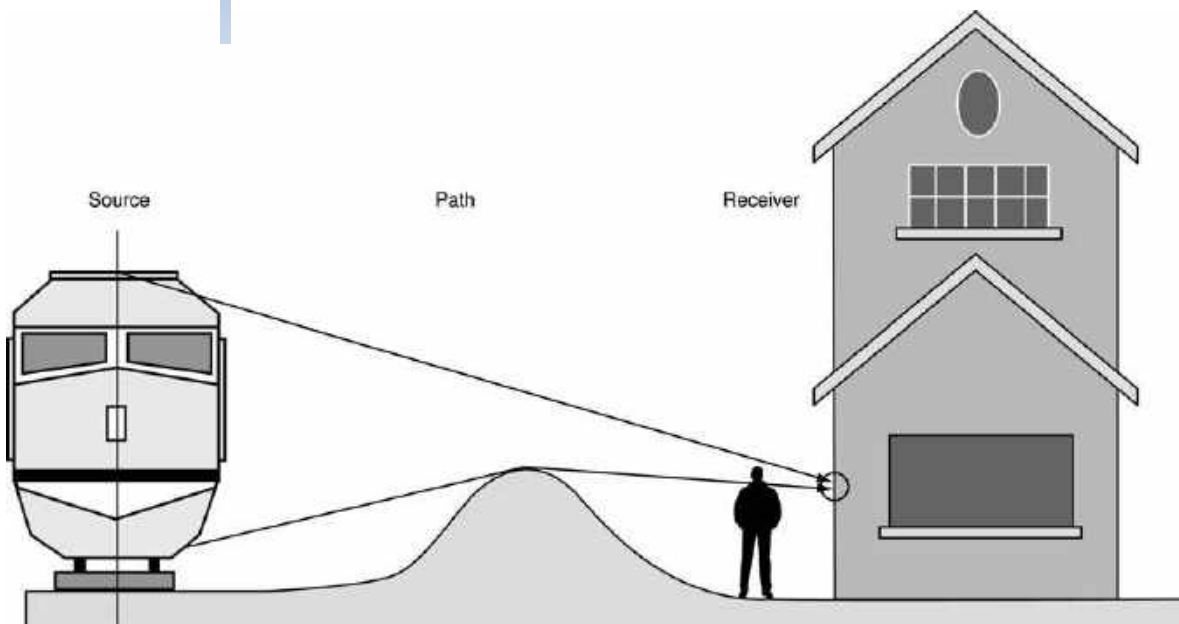


Figure 3-1 Source-Path-Receiver Framework

This section contains the following:

- Section 3.1 presents the noise metrics used in this manual.
- Section 3.2 provides an overview of transit noise sources, including a listing of major sources and a discussion of noise-generation mechanisms.
- Section 3.3 provides an overview of noise paths, including a discussion of the various attenuating mechanisms on the path between source and receiver.
- Section 3.4 provides an overview of receiver response to transit noise, including a discussion of the technical background for transit noise criteria and the distinction between absolute and relative noise impact.

3.1 Noise Metrics

This manual uses the noise metrics outlined in Table 3-1 for transit noise measurements, computations, and assessment. The terminology is consistent with common usage in the United States. All of these noise metrics are expressed in units of A-weighted decibels (dBA). A-weighted sound levels represent the overall noise at a receiver that is adjusted in frequency to approximate typical human hearing sensitivity. This is the basic noise unit for transit noise analyses.

Table 3-1 Noise Metrics

Metric	Abbreviation	Definition
A-weighted Sound Level	dBA	A-weighted sound levels represent the overall noise at a receiver that is adjusted in frequency to approximate typical human hearing sensitivity. This is expressed as A-weighted decibels (dBA), the basic noise unit for transit noise analyses.
Sound Exposure Level	SEL	SEL is the cumulative noise exposure from a single noise event, normalized to one second. SEL contains the same overall sound energy as the actual varying sound energy during the event. It is the primary metric for the measurement of transit vehicle noise emissions, and is an intermediate metric in the measurement and calculation of both $L_{eq(t)}$ and L_{dn} .
Equivalent Sound Level	$L_{eq(t)}$	The equivalent sound level $L_{eq(t)}$ describes a receiver's cumulative noise exposure from all events normalized to a specified period of time "t". $L_{eq(t)}$ represents a hypothetical, constant sound level and contains the same overall sound energy as the actual varying sound energy during the time period "t". For transit noise impact assessments, the equivalent sound level metric is A-weighted and all events are normalized over a one-hour time period, $L_{eq(1hr)}$. For transit noise assessments, this metric is appropriate for non-residential land uses and is computed for the loudest hour of project related activity during hours of noise sensitivity.
Day-Night Sound Level	L_{dn}	L_{dn} describes a receiver's cumulative noise exposure from all events over 24 hours. Events between 10 p.m. and 7 a.m. are increased by 10 dB to account for humans' greater nighttime sensitivity to noise. L_{dn} is used to assess transit noise for residential land uses.
Maximum Sound Level	L_{max}	The maximum level describes the maximum noise level reached during a single noise event. For transit noise impact assessments, it is appropriate to consider the A-weighted maximum level (L_{max}) to understand the full context of the scenario. It is not appropriate to use this metric for transit noise impact assessments. This metric is commonly used in vehicle noise specifications and commonly measured for individual vehicles.

The noise metrics, including their application to transit noise and vibration impact assessment, are described in more detail in Appendix B.1.4. Mathematical definitions and graphic illustrations are presented to facilitate understanding and the interrelationships among metrics.

3.2 Sources of Transit Vehicle Noise

This section discusses major characteristics of the sources of transit noise. Transit noise can be generated by transit vehicles in motion, stationary transit

vehicles, and fixed-transit facilities. Procedures for computing nearby noise levels for major sources as a function of operating parameters such as vehicle speed are given in Sections 4.4 and 4.5.

Transit Vehicles in Motion

Transit vehicles most noticeably create noise when in motion. Noise from transit vehicles in motion can come from multiple sources, including the propulsion unit (i.e., the engine and engine components), the interaction of the wheels and/or tires and the running surface, and warning bells and horns.

Vehicle propulsion units generate:

- Whine from electric control systems and traction motors that propel rapid transit cars
- Diesel-engine exhaust noise from both diesel-electric locomotives and transit buses
- Air-turbulence noise generated by cooling fans
- Gear noise

Noise is also generated by the interaction of wheels and/or tires with their running surfaces. Tire noise from rubber-tired vehicles is generated at normal operating speeds. The interaction of steel wheels and rails generates:

- Rolling noise due to continuous rolling contact
- Impact noise when a wheel encounters a discontinuity in the running surface such as a rail joint, turnout or crossover (where the train or rail vehicle switches off one track and onto another)
- Impact noise from the wheel and running surface if the wheel is not completely round (wheel flat) or if the running surface is not completely flat
- Squeal generated by friction between wheels and rail on tight curves

Transit vehicles are equipped with horns and bells for use in emergency situations and as a general audible warning to track workers and trespassers within the ROW, pedestrians, and motor vehicles at highway grade crossings. Horns and bells on the moving transit vehicle combined with stationary bells at-grade crossings can generate high noise levels for nearby residents and are often sources of complaints.

For many noise sources, such as transit vehicles, the sound level is dependent on the speed of the noise source. In other cases, such as for stationary sources or horns mounted on vehicles, the sound level is not dependent on speed. Figure 3-2 illustrates sound level dependence on speed for a diesel-powered commuter rail train and an electric-powered transit train assuming all other parameters, such as weight, are equal. Plotted vertically in this figure is a notional indication of the maximum sound level during a passby. Speed dependence is strong for electric-powered transit trains because wheel/rail noise is the dominant noise source and noise from this type of source increases strongly with speed. Diesel-powered commuter rail train noise is dominated by the locomotive exhaust noise at slower speeds. As speed increases, wheel-rail

noise becomes the dominant noise source and diesel- and electric-powered trains generate similar noise levels. Similarly, speed dependence is also strong for automobiles, city buses (two-axle), and non-accelerating highway buses (three-axle), because tire/pavement noise is the dominant noise source for these vehicles. Accelerating highway bus noise is dominated by exhaust noise.

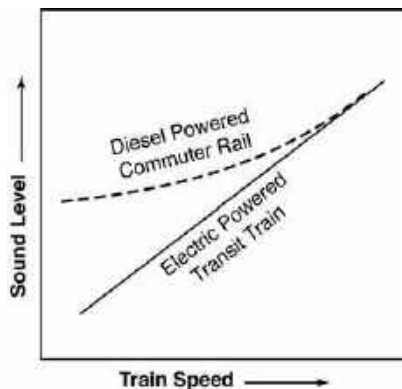


Figure 3-2 Sound Level Dependence on Speed

Sound levels close to the source are also dependent on vehicle acceleration, vehicle length, running surface type, and running surface condition. For high-speed rail vehicles (vehicles with an operating speed of 90–250 mph are typically beyond the scope of this manual), air turbulence can also be a source of noise. In addition, for an elevated structure, the guideway can radiate noise as it vibrates in response to the dynamic loading of the moving vehicle.

Stationary Transit Vehicles

Noise can be generated by transit vehicles even when they are stationary. For example, auxiliary equipment such as cooling fans on motors, radiator fans, plus hydraulic, pneumatic, and air-conditioning pumps, often continue to run when vehicles are stationary. Transit buses are also often left idling in stations or storage yards.

Fixed-transit Facilities

Noise can also be generated by sources at fixed-transit facilities. Such sources include ventilation fans in transit stations, subway tunnels, and electric power substations, as well as equipment in chiller plants, and many activities within maintenance facilities and shops.

Common Noise Sources

Table 3-2 summarizes common sources of transit noise by vehicle and facility type.

Table 3-2 Sources of Transit Noise

Vehicle or Facility*	Dominant Components	Comments
RRT or Light Rail Transit (LRT) on exclusive ROW	Wheel/rail interaction and guideway amplification	Depends on condition of wheels and rails
	Propulsion system	When accelerating and at higher speeds
	Brakes	When stopping
	Auxiliary equipment	When stopped
	Wheel squeal	On tight curves
	<i>In general</i>	Noise increases with speed and train length
LRT in Mixed Traffic	Wheel squeal	On tight curves
	Auxiliary equipment	When stopped
	Horns and crossing bells	At-grade crossings and stations
	<i>In general</i>	Traveling at lower speeds in mixed traffic produces less noise than when traveling at higher speeds in exclusive ROW
Commuter Rail	Diesel exhaust	On diesel-hauled trains
	Cooling fans	On both diesel and electric-powered trains
	Wheel/rail interaction	Depends on condition of wheels and rails
	Horns and crossing gate bells	At-grade crossings and stations
	<i>In general</i>	Noise is usually dominated by locomotives and horns/bells at-grade crossings
Low and Intermediate Capacity Transit	Propulsion systems, including speed controllers	At low speeds
	Ventilation systems	At low speeds
	Tire/guideway interaction	For rubber-tired vehicles, including monorails
	Wheel/rail interaction	Depends on condition of wheels and rails
	<i>In general</i>	Wide range of vehicles: monorail, rubber-tired, steel-wheeled, linear induction. Noise characteristics depend upon type
Diesel Buses	Cooling fans	While idling
	Engine casing	While idling
	Diesel exhaust	At low speeds and while accelerating
	Tire/roadway interaction	At moderate and high speeds
	<i>In general</i>	Includes city buses (generally two-axle) and commuter buses (generally three-axle)
Electric Buses and Trackless Trolleys	Tire/roadway interaction	At moderate speeds
	Electric traction motors	At moderate speeds
	<i>In general</i>	Much quieter than diesel buses
Bus Storage Yards	Buses starting up	Usually most disruptive in the early morning
	Buses accelerating	Usually near entrances/exits and/or locations that require buses to accelerate (tight turns)
	Buses idling	Warm-up areas
	<i>In general</i>	Site specific: often peak periods with considerable noise
Rail Transit Storage Yards	Wheel squeal	On tight curves
	Wheel impacts	On joints and switches
	Wheel rolling noise	On tangent track
	Auxiliary equipment	Throughout day and night; includes air-break release noise
	Coupling/uncoupling	On storage tracks
	Signal horns	Throughout yard site
	<i>In general</i>	Site specific: often early morning and peak periods with considerable noise

Maintenance Facilities	Signal horns	Throughout facility
	Intercoms	Throughout facility
	Impact tools	Shop buildings
	Car/bus washers/driers	Wash facility
	Vehicle activity	Throughout facility
	<i>In general</i>	Site specific: considerable activity throughout day and night, some outside.
Stations	Automobiles	Patron arrival/departure, especially in early morning
	Buses idling	Bus loading zone
	Intercoms	Platform area
	Locomotive idling	At commuter rail terminal stations
	Auxiliary systems	At terminal stations and layover facilities
	Horns	At stations, if applicable
	<i>In general</i>	Site specific, with peak activity periods
Subways	Fans	Noise through vent shafts/structures
	Buses/trains in tunnels	Noise through vent shafts/structures
	<i>In general</i>	Noise is not a problem, except in the immediate vicinity of vent shafts/structures.

* Refer to Appendix A for additional information.

3.3 Paths of Transit Noise from Source to Receiver

This section contains a qualitative overview of noise-path characteristics from source to receiver, including attenuation along these paths. Equations for specific noise-level attenuations along source-receiver paths are included in Sections 4.4 and 4.5.

Sound paths from source to receiver are predominantly through the air. Along these paths, sound reduces with distance due to divergence, absorption/diffusion, and shielding. These mechanisms of sound attenuation are discussed below.

Divergence

Sound levels naturally attenuate with distance, as shown in Figure 3-3. The plot shows attenuation at the receiver relative to the sound level 50 ft from the source. This type of attenuation is called divergence and is dependent upon source configuration (line or point source) or other source-emission characteristics. Localized sources (point sources) grouped closely together attenuate greatly with distance at a rate of approximately 6 dB per doubling of distance. Examples of point sources include highway grade-crossing signals along rail corridors, intercoms in maintenance yards and other closely grouped sources of noise. Vehicles passing along a track or roadway forming a line are called line sources. Line sources attenuate less than point sources with distance. Rate of attenuation for line sources varies depending on the noise metric. $L_{eq}(1hr)$ and L_{dn} noise levels attenuate at a rate of 3 dB per doubling of distance and L_{max} noise levels attenuate at a rate of 3 to 6 dBs per doubling of distance.

Figure 3-3 illustrates approximate attenuation with distance between the source and receiver for point and line sources. The line source curve for the L_{max} noise

metric separates into three curves because it is dependent on the length of the line source. Equations for the curves in Figure 3-3 are included in Section 4.5.

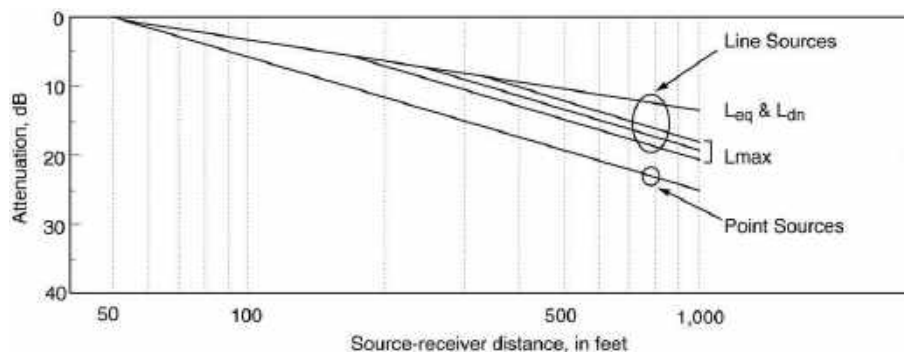


Figure 3-3 Attenuation Due to Distance (Divergence)

Absorption/Diffusion

In addition to distance, sound levels can be attenuated depending on the type of ground between the source and receiver. A portion of the sound energy is absorbed by the ground and only the remaining energy travels to the source. How much energy the ground absorbs is dependent on the ground type (characterized as acoustically “hard” or “soft”) and geometry. Example absorptive ground types include freshly-plowed or vegetation-covered ground. Figure 3-4 illustrates approximate attenuation due to ground type by source to receiver path distance and height. Ground attenuation can be as large as 5 dB over a path distance of several hundred ft. At very large distances, wind and temperature gradients could modify the expected ground attenuation. However, these variable atmospheric effects are not included in this manual because they generally occur beyond the range of typical transit-noise impact. Equations for the curves in this figure are included in Section 4.5.

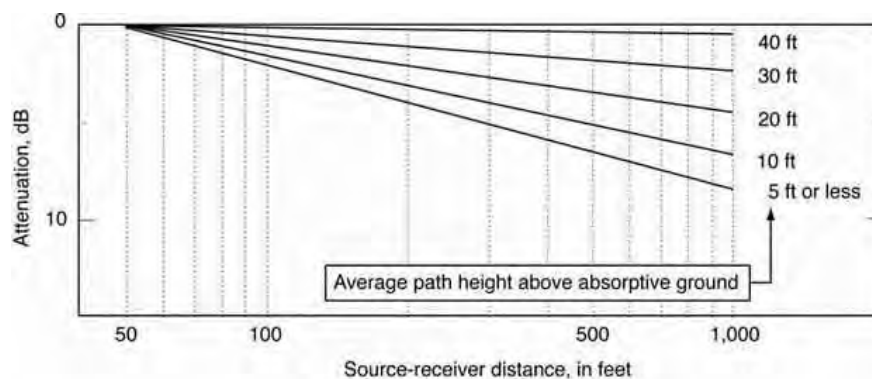


Figure 3-4 Attenuation due to Soft Ground

Shielding

Sound paths are sometimes interrupted by terrain, human-constructed noise barriers, rows of buildings, or other objects. Noise barriers are one of the most effective means of mitigating noise (Section 4.5, Step 7). A noise barrier reduces sound levels at a receiver by breaking the direct line-of-sight between source and receiver with a solid wall (in contrast to vegetation which hides the source from view but does not reduce sound levels substantially over short distances). Sound energy reaches the receiver only by bending (diffracting) over the top of

the barrier, as shown in Figure 3-5. This diffraction over the barrier reduces the sound level that reaches the receiver. One important consideration in using noise barriers to mitigate noise impacts is safety. Noise barriers, if not designed and sited carefully, can reduce visibility of trains for pedestrians and motorists, leading to less safe conditions. It is important to consult with safety experts when choosing and siting a noise barrier.

Noise barriers for transportation systems are typically used to attenuate noise at the receiver, potentially reducing received sound levels by 5 to 15 dB, depending upon barrier height, length, and distance from both source and receiver. Barriers on structures close to the transportation noise source may provide less attenuation than barriers located farther from the source due to reverberation (multiple reflections) between the barrier and the body of the vehicle or noise source. This reverberation can be offset by increased barrier height and/or acoustical absorption on the source side of the barrier. Further discussion and equations on acoustical absorption and barrier attenuation is provided in Section 4.5.

Source-to-receiver sound paths may not always travel through the air, but rather through the ground or through structural components of the receiver's building. Discussion of such ground-borne and structure-borne propagation is included in Section 5.

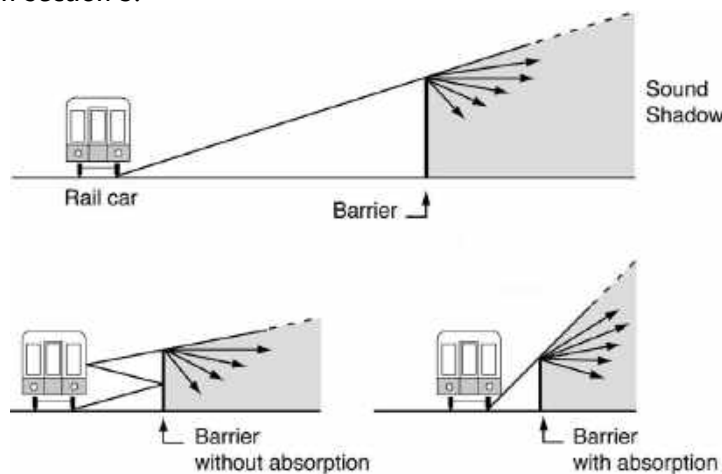


Figure 3-5 Noise Barrier Geometry

3.4 Receiver Response to Transit Noise

This section contains an overview of human receiver response to noise. It serves as background information for the noise impact criteria in Section 4.1.

Noise can interrupt ongoing activities causing community annoyance, especially in residential areas. In general, most residents become highly annoyed when noise interferes considerably with activities such as sleeping, talking, noise-sensitive work, and audio entertainment. In addition, some land uses, such as outdoor concert pavilions, are inherently incompatible with high noise levels.

Annoyance from noise has been investigated and approximate dose-response relationships have been quantified by the U.S. Environmental Protection Agency (EPA).⁽⁵⁾ The selection of noise metrics in this manual is largely based upon this EPA work. Beginning in the 1970s, the EPA undertook a number of research and synthesis studies relating to community noise of all types. Results of these studies have been widely published, discussed, and refereed by many professionals in acoustics. Basic conclusions of these studies have been adopted by the Federal Interagency Committee on Noise (FICON),⁽ⁱⁱ⁾ the U.S. Department of Housing and Urban Development (HUD), the American National Standards Institute, and even internationally⁽⁶⁾⁽⁷⁾⁽⁸⁾⁽⁹⁾. Conclusions from this seminal EPA work remain scientifically relevant today.

Figure 3-6 contains a synthesis of actual case studies of community reaction to newly introduced sources of noise in a residential urban neighborhood.⁽¹⁰⁾ Plotted horizontally in the figure is the increase in noise from new sources above existing noise levels expressed as Day-Night Sound Levels, L_{dn} , discussed in Appendix B.1.4.5. Plotted vertically is the community reaction to this newly introduced noise. As shown in the figure, community reaction varies from no reaction to vigorous action for newly introduced noises averaging from 10 dB below existing to 25 dB above existing. Note the assumptions included in the graphic are associated with the specific data points from the study. These assumptions are generally appropriate to give context to most transit projects, but community reaction may differ for conditions specific to each project.

In many community attitudinal surveys, transportation noise has been ranked among the greatest causes of community dissatisfaction. A synthesis of many such surveys on annoyance is shown in Figure 3-7.⁽¹¹⁾⁽¹²⁾ Noise exposure levels are plotted against the percentage of people who are highly annoyed by the particular level of neighborhood noise. As shown in the figure, the percentage of high annoyance is approximately 0 percent at 45 dB, 10 percent around 60 dB, and increases quite rapidly to approximately 70 percent around 85 dB. The scatter about the synthesis line is due to community variation and wording differences in the surveys. An update of the original research containing additional railroad, transit and street traffic noise surveys generally follows the shape of the original response curve shown in Figure 3-7.⁽¹²⁾⁽¹³⁾

As indicated by Figure 3-6 and Figure 3-7, introduction of certain levels of transit noise into a community may have two undesirable effects. First, it may substantially increase noise levels above existing noise levels in a community. This effect is called a relative noise impact. Evaluation of this effect compares new noise levels to the existing levels. Criteria for a relative noise impact evaluation are based upon noise increases above existing levels. Second, newly introduced transit noise may interfere with community activities independent of existing noise levels. For example, it may be too loud to converse or sleep. This effect is called absolute noise impact and is expressed as a fixed level threshold that is not to be exceeded. The fixed level threshold is determined independently of existing noise levels. Relative and absolute noise impacts are discussed in terms of transit noise criteria in Section 4.1, Step 3.

ⁱⁱ The Federal Interagency Committee on Aviation Noise (FICAN) is the current version of this group.

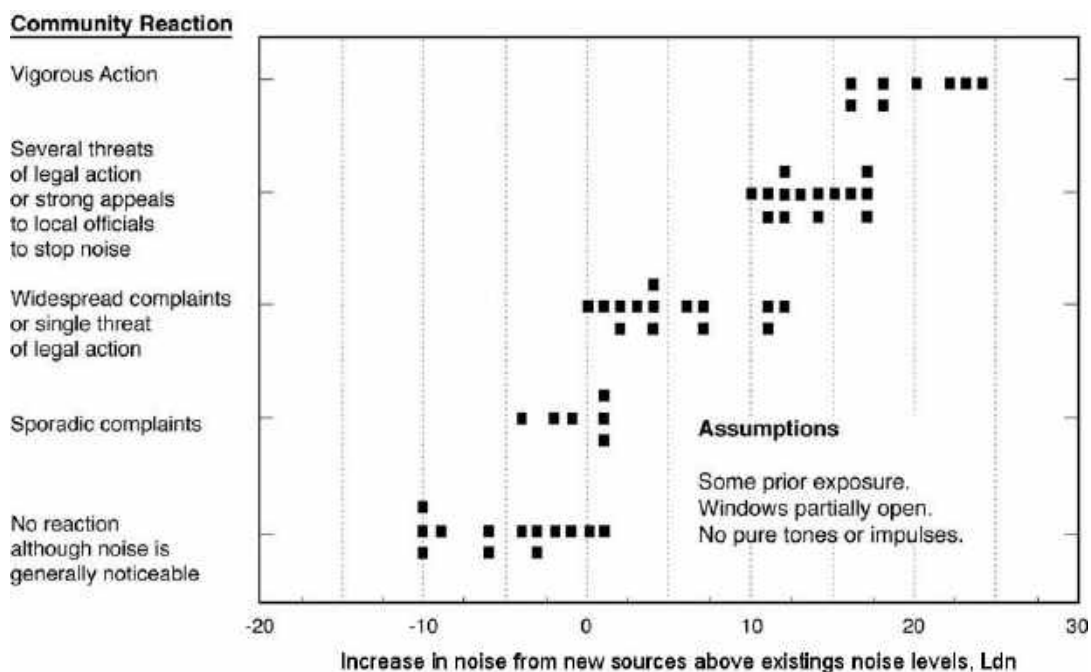


Figure 3-6 Community Reaction to New Noise, Relative to Existing Noise in a Residential Urban Environment

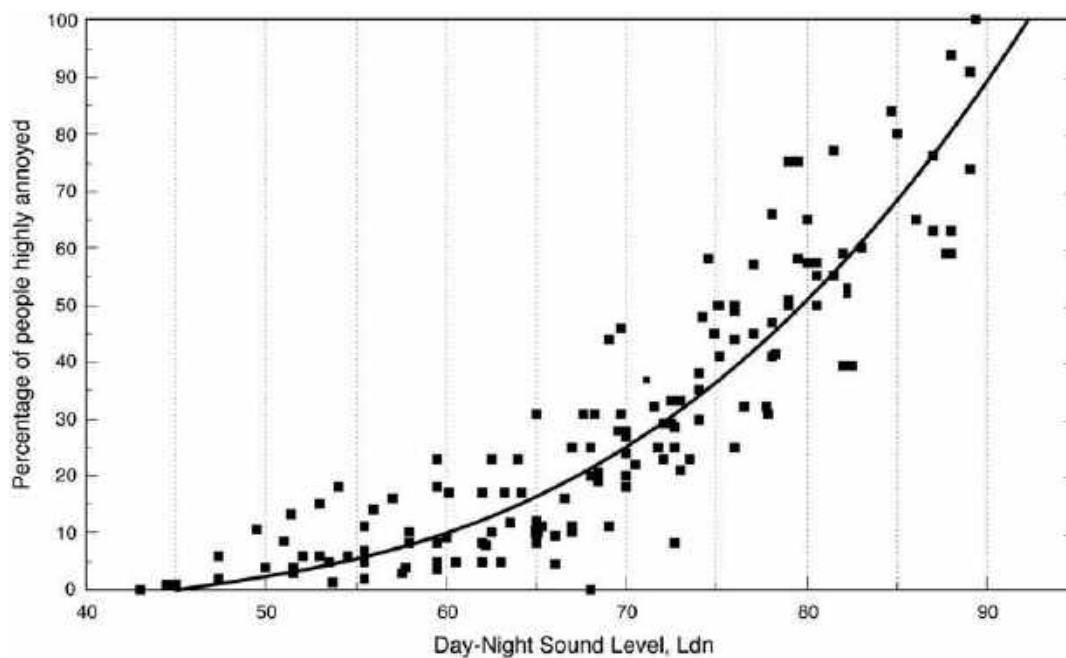


Figure 3-7 Community Annoyance Due to Noise

SECTION

4

Noise Impact Analysis

The FTA noise impact analysis process is a multi-step process used to evaluate the project for potential noise impacts for FTA NEPA approvals. If impact is determined, measures necessary to mitigate adverse impacts must be considered for incorporation into the project.⁽⁴⁾ It is recommended that project sponsors develop and formally adopt a policy for determining the need for mitigation for situations that are loosely covered by the impact criteria. Considerations for mitigation policies are included in Section 2.3. The FTA noise impact analysis steps are summarized as follows and are described in the subsequent subsections:

4.1: Determine noise impact criteria.

Step 1: Identify the type of project/dominant noise source (transit or multimodal).

Step 2: Choose land use category for FTA criteria.

4.2: Determine the highest appropriate level of noise analysis for the current stage of project planning or development.

4.3: Evaluate for the potential of impact according to the Noise Screening Procedure.

Step 1: Identify project type.

Step 2: Determine the screening distance.

Step 3: Identify the study area.

Step 4: Locate noise-sensitive land uses.

4.4: Evaluate impact according to the General Noise Assessment and evaluate preliminary mitigation options if impact is found.

Step 1: Identify noise-sensitive receivers.

Step 2: Determine the project noise source reference levels.

Step 3: Estimate project noise exposure by distance.

Step 4: Combine noise exposure from all sources.

Step 5: Measure existing noise exposure.

Step 6: Inventory noise impacts.

Step 7: Determine noise mitigation needs.

4.5: Evaluate for impact according to the Detailed Noise Analysis and evaluate mitigation options if impact is found.

Step 1: Identify noise-sensitive receivers.

Step 2: Determine noise source levels for detailed analysis.

Step 3: Calculate project noise exposure by distance.

Step 4: Combine noise exposure from all sources.

Step 5: Determine existing noise exposure.

Step 6: Assess noise impact.

Step 7: Determine noise mitigation measures.

In addition to analyzing for potential noise impacts, analyze the project for potential vibration impacts according to the process presented in Section 6. After both the noise and vibration analyses have been completed, assess

construction noise and vibration according to Section 7 and document findings according to Section 8.

4.1 Determine Noise Impact Criteria

This section describes the procedure for determining the appropriate criteria for assessing project noise impact based on the type of project and project noise source. Project noise is the new noise or change in noise introduced by the project. Noise impact criteria may vary for different segments of the project. Project segments can be portions of a project with similar characteristics.

The procedure to determine the appropriate impact criteria is described in this section and shown more simply as a flow chart in Figure 4-1. If there is uncertainty in how to determine the appropriate criteria, contact the FTA Regional office.

The selected criteria are used in the analysis procedures discussed in Sections 4.3, 4.4, and 4.5 to identify potential impacts and the level of impact.

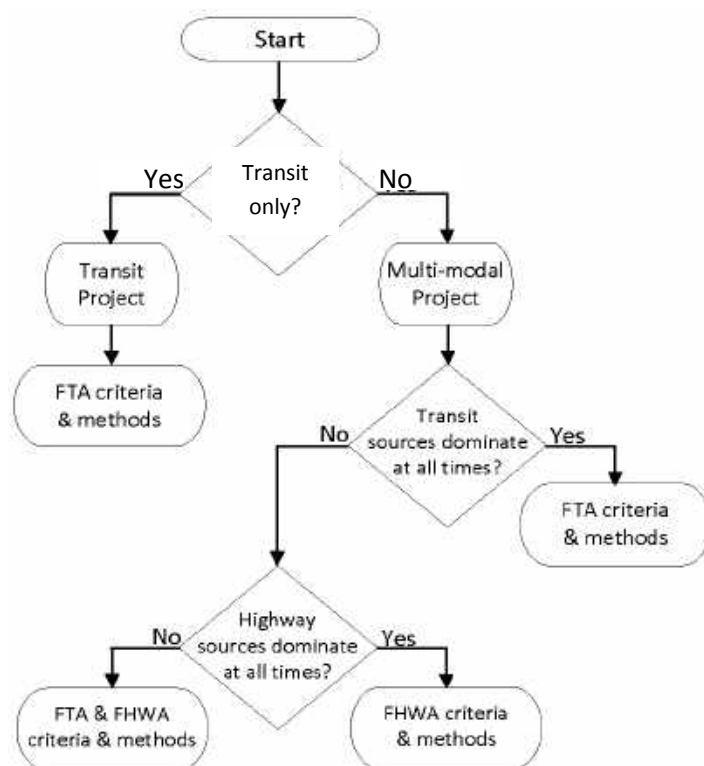


Figure 4-1 Noise Impact Criteria Flow Chart by Project Segment

Step 1: Identify Project Type

Identify the type of project as transit, multimodal (transit and highway), or other multimodal according to the dominant noise source.

Option A: Transit Project (Transit Noise Only) – The transit project category includes all transit projects where the project noise is exclusively due to new transit sources, no changes are made to the highway or to existing highway noise barriers, and the existing noise levels generated by roadway sources will not change because of the project. For these transit projects, FTA is the lead agency conducting the environmental review in cooperation with the transit agency.

Typical examples of transit projects include:

- RRT, LRT, commuter rail, and AGT
- Rail projects built within an existing highway or railroad corridor that do not alter the existing noise levels generated by roadway sources
- Bus facility projects with operations on local streets and highways used to access the facility, where the project does not include roadway construction or modification that changes roadway capacity substantially
- Fixed facilities including storage and maintenance yards, passenger stations and terminals, parking facilities, and substations
- Portions of transit projects not adjacent to highway corridors

FTA impact criteria are appropriate for transit projects, proceed to Step 2.

Option B: Multimodal Project (Transit and Highway Noise) – In this manual, “multimodal” refers to projects that include changes to both transit and highway components, resulting in project noise comprised of both highway and transit noise sources.

Typical examples of multimodal projects include:

- New highway construction providing general-purpose lanes as well as dedicated bus and high occupancy vehicle (HOV) lanes
- Rail transit projects that involve changes to the highway travel lanes or existing highway noise barriers

Evaluate multimodal projects for impact according to the project noise source by project segment. FHWA’s noise assessment methods are used to inform FTA’s NEPA evaluation only for segments where highway noise levels change due to the transit project. These projects are not necessarily subject to FHWA’s procedures at 23 CFR part 772 (see *call out box below*). For segments of the project outside the highway corridor, use FTA’s criteria and methods. Use Table 4-1 to determine multimodal project noise.

Once the project noise source(s) is identified, determine the appropriate assessment method according to Table 4-2.

Note that a separate noise analysis may be required for FHWA approval of a multimodal project pursuant to 23 CFR part 772. For these projects, it is important to work with FHWA early in the environmental review process to determine how a noise assessment will be completed where FHWA approval is needed for the project.

The determination of whether a project is subject to FHWA procedures at 23 CFR part 772 depends upon the specific circumstances of a project. A proposed transit project that would share an existing highway ROW is not necessarily a FHWA-defined multimodal project. A transit project that meets all three of the following criteria is not considered a multimodal project subject to 23 CFR part 772:

- FTA is the lead agency in the NEPA process and FHWA's limited participation is as a cooperating agency.
- The main transportation purpose of the project, as stated in the purpose and need statement of the environmental document, is transit-related and not highway-related.
- No Federal-aid highway funds are being used to fund the project.

Table 4-1 Multimodal Project Noise Factors

Factor	Description
Volume of Traffic	Major freeways and interstate highways often carry large volumes of traffic throughout the day and night such that the highway noise dominates at all times. Transit noise in this case may be unimportant by comparison, but must still be evaluated using FTA's noise criteria for a potential impact.
Traffic Patterns	Some highways and arterials serve primarily as commuter routes such that nighttime traffic diminishes considerably, while transit systems continue to operate well into the late hours. Here the dominant noise source at times of maximum sensitivity may be transit.
Type of Traffic	Some highways and arterials may serve commuters during the daytime hours, but provide access to business centers by trucks at night. In this case, the roadway noise would likely continue to dominate.
Alignment Configuration	Elevation of the transit mode in the median or beside a busy highway may result in transit noise contributing more noise to nearby neighborhoods than a highway that may be partially shielded by rows of buildings adjacent to the ROW. In this case, both transit and highway noise may be considered dominant.

Table 4-2 Multimodal Project Assessment Methods

Dominant Noise Source	Assessment Method
Transit, at All Times	Use FTA criteria and methods. <i>Proceed to Step 2.</i>
Highway, at All Times	Use FHWA criteria and methods to inform FTA's NEPA evaluation. <i>Contact FHWA directly for assistance using FHWA noise analysis methods and FHWA noise impact criteria.</i>
Transit and Highway at Different Times	Use both the FHWA and FTA methods to determine if one, both, or neither method determines impact due to the project noise for these segments. Note that the project noise includes both highway and transit sources associated with the project. Both methods are used because the FTA methods consider nighttime sensitivity while the FHWA methods consider the peak traffic hour. <i>Proceed to Step 2 for FTA criteria. Contact FHWA directly for assistance using FHWA noise analysis methods and FHWA noise impact criteria.</i>

Option C: Other Multimodal Projects – For projects with components from other modes, contact the FTA Regional office. Additional information on high-speed rail vibration and noise can be found in the Federal Railroad Administration (FRA) “High-Speed Ground Transportation Noise and Vibration Impact Assessment” guidance manual.⁽¹⁴⁾

Step 2: Choose Land Use Category for FTA Criteria

Determine the appropriate noise-sensitive land use category for the project segment using Table 4-3 and the descriptions below then, proceed to Step 3. FTA criteria are presented by land use.

Table 4-3 Land Use Categories and Metrics for Transit Noise Impact Criteria

Land Use Category	Land Use Type	Noise Metric, dBA	Description of Land Use Category
1	High Sensitivity	Outdoor $L_{eq(1hr)}$ *	Land where quiet is an essential element of its intended purpose. Example land uses include preserved land for serenity and quiet, outdoor amphitheatres and concert pavilions, and national historic landmarks with considerable outdoor use. Recording studios and concert halls are also included in this category.
2	Residential	Outdoor L_{dn}	This category is applicable all residential land use and buildings where people normally sleep, such as hotels and hospitals.
3	Institutional	Outdoor $L_{eq(1hr)}$ *	This category is applicable to institutional land uses with primarily daytime and evening use. Example land uses include schools, libraries, theaters, and churches where it is important to avoid interference with such activities as speech, meditation, and concentration on reading material. Places for meditation or study associated with cemeteries, monuments, museums, campgrounds, and recreational facilities are also included in this category.

* $L_{eq(1hr)}$ for the loudest hour of project-related activity during hours of noise sensitivity.

Noise-sensitive land use categories are described in in order of sensitivity. Most commercial or industrial uses are not considered noise-sensitive because activities within these buildings are generally compatible with higher noise levels. Business can be considered noise-sensitive if low noise levels are an important part of operations, such as sound and motion picture recording studios.

For residential land use (category 2), apply the noise criteria at the nearest façade of the occupied portion of the building, e.g., not at a garage or porch. The residential criteria should be applied at locations with nighttime sensitivity. For major noise-sensitive outdoor use at non-residential locations, apply the noise criteria at the point of noise-sensitive use nearest the noise source.

Land use categories are evaluated using noise metrics that reflect the noise-sensitive time of day:

- **Categories 1 and 3** – The noise metric, $L_{eq(1hr)}$ is used for all category 1 and 3 land uses where nighttime sensitivity is not a factor. Category 3 land uses are considered less noise-sensitive than category 1 land uses. For transit analyses, $L_{eq(1hr)}$ is computed for the noisiest hour of transit-

related activity during which human activities occur at the noise-sensitive location. See Appendix B.I.4.4 for more information on this metric.

- **Category 2** – The noise metric L_{dn} is used for all category 2 land uses where nighttime sensitivity is a factor. This noise metric includes a 10-dB penalty for nighttime noise. See Appendix B.I.4.5 for more information on this metric.

Land Use Categories: Special Cases

Historic sites, parks, indoor-only land use, and undeveloped land require special consideration. In addition to NEPA, noise impacts may need to be considered under other environmental laws such as Section 106⁽¹⁵⁾ or Section 4(f).⁽¹⁶⁾ Indoor-only use and undeveloped land should be evaluated on a case-by-case basis to determine noise sensitivity based on how each facility is used or the reason it is protected under the applicable requirement.

Historic Sites – Section 106 requires Federal agencies to evaluate potential effects from projects on historic properties. Per the regulations at 36 CFR part 800,⁽¹⁷⁾ historic properties are defined as any prehistoric or historic district, site, building, structure, or object included in, or eligible for the National Register of Historic Places (NRHP). An adverse effect determination under Section 106 is made when a project may alter, directly or indirectly, any of the characteristics of a historic property that qualify the property for inclusion in the National Register in a manner that would diminish the integrity of the property's location, design, setting, materials, workmanship, feeling, or association.

Under FTA environmental reviews, some structures may be evaluated as noise-sensitive resources per this noise manual and evaluated as historic properties under Section 106. However, because this manual and Section 106 regulations have different criteria for effect, identifying a severe noise impact for a structure under this manual does not necessarily mean there would be an adverse effect under Section 106. It is important to thoroughly document the characteristics of historic properties that qualify for inclusion in the NRHP for evaluation of effect under Section 106.

If a property, for example, is listed on the NRHP under criterion C because the structure possesses high artistic values, but lacks integrity of setting, feeling, or association, it is unlikely that a change in the noise environment would affect the features that qualify the property for listing or eligibility for inclusion in the NRHP.

In the assessment of effects on historic properties, consideration should be given to not just the proposed transit project, but any associated mitigation measures with the transit project. For example, if a transit project would involve noise walls or berms as mitigation, the effect of those structures on the visual setting may need to be considered in a Section 106 analysis.

Parks – Most parks used primarily for active recreation such as sports complexes and bike or running paths are not considered noise-sensitive.

However, some parks (even some in dense urban areas) are primarily used for passive recreation such as reading, conversation, or meditation. These places, which may be valued as havens from the noise and rapid pace of everyday city life, are treated as noise-sensitive, and are included in land use category 3. Consult the state or local agency with jurisdiction over the park on questions about how the park is used, and visit the park to observe its use, if possible.

Indoor-Only Use – The land use categories described in this section correspond with noise impact criteria that provide protection for both outdoor and indoor land uses. For locations where noise impact will be evaluated but there is no outdoor land use such as apartment buildings, hotels or upper levels of multi-story buildings, indoor criteria can be used. In these cases, the criterion for indoor noise levels from project sources is a L_{dn} of 45 dBA.⁽¹⁸⁾ This criterion is consistent with the Federal Aviation Administration (FAA). See Section 4.5 for more information on how indoor criteria apply to noise mitigation consideration.

Undeveloped Land – Undeveloped land may also need to be considered for noise impact assessment and mitigation if plans are under way to develop the land for noise-sensitive use. The policy for considering such land for assessment and mitigation should be determined on a project-specific basis by the project sponsor in consultation with the FTA Regional office.

Step 3: Determine Appropriate FTA Criteria Presentation

FTA criteria for noise impact were developed specifically for transit noise sources operating on fixed-guideways or at fixed facilities in urban areas. These criteria are based on well-documented research on human response to community noise and represent a reasonable balance between community benefit and project costs. These criteria do not reflect specific community attitudinal factors. See Appendix C for additional background information on the development of FTA noise criteria.

The criteria specify a comparison of future project noise with existing noise. Note that projections of future noise exposure without the project (no-build scenario) are not included in this analysis. The criteria also consider land use which is an important factor that reflects noise sensitivity based on activity and time period of concern. The criteria are defined with the expectation that communities already exposed to high levels of noise can only tolerate a small increase. In contrast, if the existing noise levels are low, it is reasonable to allow a greater change in the community noise.

The levels of impact are described in Table 4-4. The criteria at which the levels of impact occur are presented in two ways depending on the relationship of project and existing noise sources.

If the project noise source is a new source of transit noise in the community, such as a new project in an area currently without transit, use the criteria as presented in Option A. If the project noise adds to or changes existing transit noise in the community, use the criteria as presented in Option B.

Table 4-4 Levels of Impact

Level of Impact	Description
No Impact	Project-generated noise is not likely to cause community annoyance. Noise projections in this range are considered acceptable by FTA and mitigation is not required.
Moderate Impact	Project-generated noise in this range is considered to cause impact at the threshold of measurable annoyance. Moderate impacts serve as an alert to project planners for potential adverse impacts and complaints from the community. Mitigation should be considered at this level of impact based on project specifics and details concerning the affected properties.
Severe Impact	Project-generated noise in this range is likely to cause a high level of community annoyance. The project sponsor should first evaluate alternative locations/alignments to determine whether it is feasible to avoid severe impacts altogether. In densely populated urban areas, evaluation of alternative locations may reveal a trade-off of affected groups, particularly for surface rail alignments. Projects that are characterized as point sources rather than line sources often present greater opportunity for selecting alternative sites. This guidance manual and FTA's environmental impact regulations both encourage project sites which are compatible with surrounding development when possible. If it is not practical to avoid severe impacts by changing the location of the project, mitigation measures must be considered.

Option A: Project Noise Impact Criteria Presentation – The impact criteria presentation for evaluating existing noise independently to project noise is presented in this option.

The noise levels at which impacts occur are presented in Figure 4-2 and Table 4-5. Equations for the impact criteria are presented in Appendix C. If impact is determined, measures necessary to mitigate impacts are to be considered for incorporation into the project.⁽³⁾

Figure 4-2 presents the existing noise exposure on the horizontal axis and project noise on the vertical axis. Category 1 and 2 land uses have the same criteria for project noise and are on the primary vertical axis. Category 3 land use criteria are presented on the secondary vertical axis. Note that project noise for category 1 and 3 land uses is expressed as $L_{eq(1hr)}$, whereas project noise for category 2 land use is expressed as L_{dn} . Also, note that project noise criteria are 5 dB higher for category 3 land uses in Figure 4-2 since these types of land use are less noise-sensitive than those in categories 1 and 2.

Note that for projects in locations with existing noise levels below 55 dBA, the project noise exposure is allowed some increase over the existing noise exposure before it is considered to cause impact. For category 1 and 2 land uses, the maximum project noise level to be considered to cause no impact is 65 dBA ($L_{eq(1hr)}$ or L_{dn}) regardless of the existing noise. Note that no impact at 65 dBA aligns with other Federal agencies in that a L_{dn} of 65 dBA is a standard limit for an acceptable living environment among some Federal agencies.^{(19) (20)} Project noise levels above the top curve are considered to cause severe impact. The upper limit of the severe impact range is 75 dBA for category 1 and 2 land uses. The upper limit of 75 dBA is associated with an unacceptable living environment. Project noise between the two curves is considered to have moderate impact on the community.

The criteria are also tabulated in Table 4-5. Figure 4-2 and the equations that correspond with this figure in Appendix C are the precise definition of the criteria. The values in Table 4-5 can be used for illustrative purposes and should only be used if all numbers are rounded up to the nearest decibel.

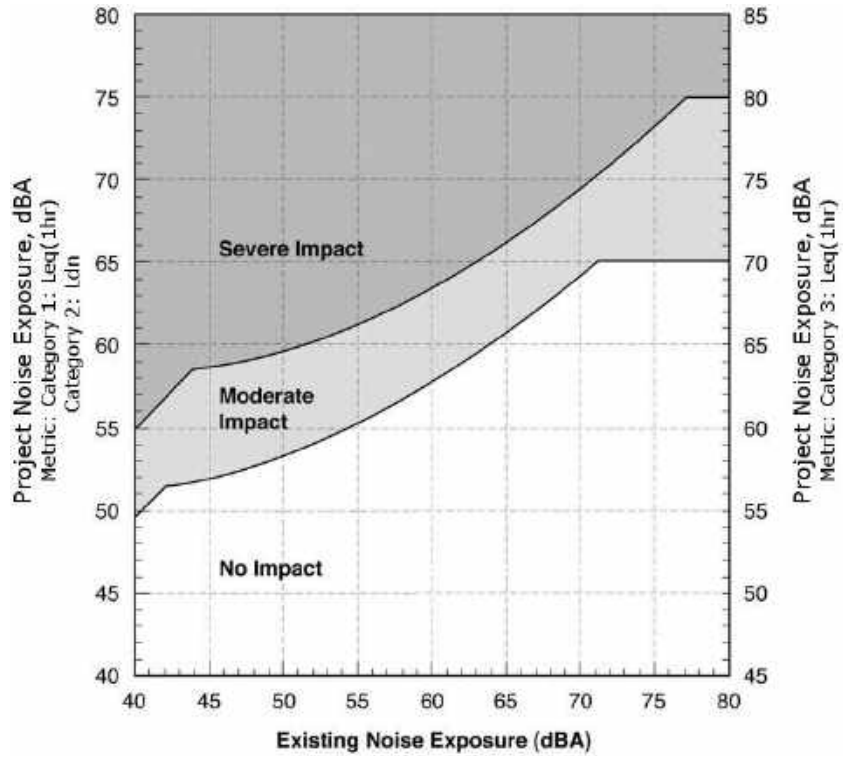


Figure 4-2 Noise Impact Criteria for Transit Projects

Table 4-5 Noise Levels Defining Impact for Transit Projects

Existing Noise Exposure, dBA	Project Noise Impact Exposure, dBA					
	Category 1 ($L_{eq}(1hr)$) or 2 (L_{dn}) Sites			Category 3 Sites ($L_{eq}(1hr)$)		
$L_{eq}(1hr)$ or L_{dn}	No Impact	Moderate Impact	Severe Impact	No Impact	Moderate Impact	Severe Impact
<43	< Ambient+10	Ambient +10 to 15	> Ambient+15	< Ambient+15	Ambient +15 to 20	> Ambient+20
43	<52	52-58	>58	<57	57-63	>63
44	<52	52-58	>58	<57	57-63	>63
45	<52	52-58	>58	<57	57-63	>63
46	<53	53-59	>59	<58	58-64	>64
47	<53	53-59	>59	<58	58-64	>64
48	<53	53-59	>59	<58	58-64	>64
49	<54	54-59	>59	<59	59-64	>64
50	<54	54-59	>59	<59	59-64	>64
51	<54	54-60	>60	<59	59-65	>65
52	<55	55-60	>60	<60	60-65	>65
53	<55	55-60	>60	<60	60-65	>65
54	<55	55-61	>61	<60	60-66	>66
55	<56	56-61	>61	<61	61-66	>66
56	<56	56-62	>62	<61	61-67	>67
57	<57	57-62	>62	<62	62-67	>67
58	<57	57-62	>62	<62	62-67	>67
59	<58	58-63	>63	<63	63-68	>68
60	<58	58-63	>63	<63	63-68	>68
61	<59	59-64	>64	<64	64-69	>69
62	<59	59-64	>64	<64	64-69	>69
63	<60	60-65	>65	<65	65-70	>70
64	<61	61-65	>65	<66	66-70	>70
65	<61	61-66	>66	<66	66-71	>71
66	<62	62-67	>67	<67	67-72	>72
67	<63	63-67	>67	<68	68-72	>72
68	<63	63-68	>68	<68	68-73	>73
69	<64	64-69	>69	<69	69-74	>74
70	<65	65-69	>69	<70	70-74	>74
71	<66	66-70	>70	<71	71-75	>75
72	<66	66-71	>71	<71	71-76	>76
73	<66	66-71	>71	<71	71-76	>76
74	<66	66-72	>72	<71	71-77	>77
75	<66	66-73	>73	<71	71-78	>78
76	<66	66-74	>74	<71	71-79	>79
77	<66	66-74	>74	<71	71-79	>79
>77	<66	66-75	>75	<71	71-80	>80

Option B: Cumulative Noise Impact Criteria Presentation

The impact criteria presentation for evaluating existing noise to project noise cumulatively is presented in this option.

In certain cases, the cumulative form of the noise criteria shown in Figure 4-3 can be used. These cases involve projects where changes are proposed to an existing transit system, as opposed to a new project in an area previously without transit. Such changes might include operations of a new type of vehicle, modifications of track alignments within existing transit corridors, or changes in facilities that dominate existing noise levels. In these cases, the existing noise

sources change because of the project, and so it is not possible to define project noise separately from existing noise. An example would be a commuter rail corridor where the existing noise along the alignment is dominated by diesel locomotive-hauled trains, and where the project involves electrification with the resulting replacement of some of the diesel-powered locomotives with electric trains operating at increased frequency of service and higher speeds on the same tracks. In this case, the existing noise can be determined and a new future noise can be calculated, but it is not possible to describe what constitutes the “project noise.” For example, if the existing noise dominated by trains was measured to be an L_{dn} of 63 dBA at a particular location, and the new combination of diesel and electric trains is projected to be an L_{dn} of 65 dBA, the change in the noise exposure due to the project would be 2 dB. Referring to Figure 4-3, a 2-dB increase with an existing noise exposure of 63 dBA would be rated as a moderate impact. Normally the project noise is added to the existing noise to come up with a new cumulative noise, but in this case, the existing noise was dominated by a source that changed due to the project, so it would be incorrect to add the project noise to the existing noise. Consequently, the existing noise determined by measurement is compared with a new calculated future noise, but a description of what constitutes the actual project is complex.

Another example would be a rail corridor where a track is added and grade crossings are closed, potentially resulting in a change in train location and horn operation. Here the “project noise” results from moving some trains closer to some receivers, away from others, and elimination of horns. In this case, the change in noise level is more readily determined than the noise from the actual project elements. In all cases, Figures 4-3 and 4-4 for changes in a transit system results in the same assessment of impact as Figure 4-2 for development of transit facilities in a new area.

The noise impact criteria in Figure 4-3 and Figure 4-4 are presented as an increase in cumulative noise level between the existing and project conditions. The horizontal axis represents the existing noise exposure and the vertical axis is the increase in cumulative noise level due to the transit project. Note that noise exposure is expressed as $L_{eq(1hr)}$ for category 1 and 3 land uses and L_{dn} for category 2 land use. Since $L_{eq(1hr)}$ and L_{dn} are measures of total acoustic energy, any new noise sources in a community will cause an increase, even if the new source level is the same or less than the existing noise level (refer to decibel addition in Appendix B). As shown in Figure 4-3, the criterion for moderate impact is a noise exposure increase of 10 dB for an existing noise exposure level of 42 dBA or less, but only a 1-dB increase when the existing noise exposure is 70 dBA.

As the existing level of ambient noise increases, the allowable level of transit noise increases, but the total amount that community noise exposure is allowed to increase is reduced. This accounts for the unexpected result that a project exposure which is less than the existing noise exposure can still cause impact. This is clearer from the examples listed in Table 4-6 which indicate the level of transit noise allowed for different existing levels of exposure. Any increase greater than shown in the table will cause moderate impact.

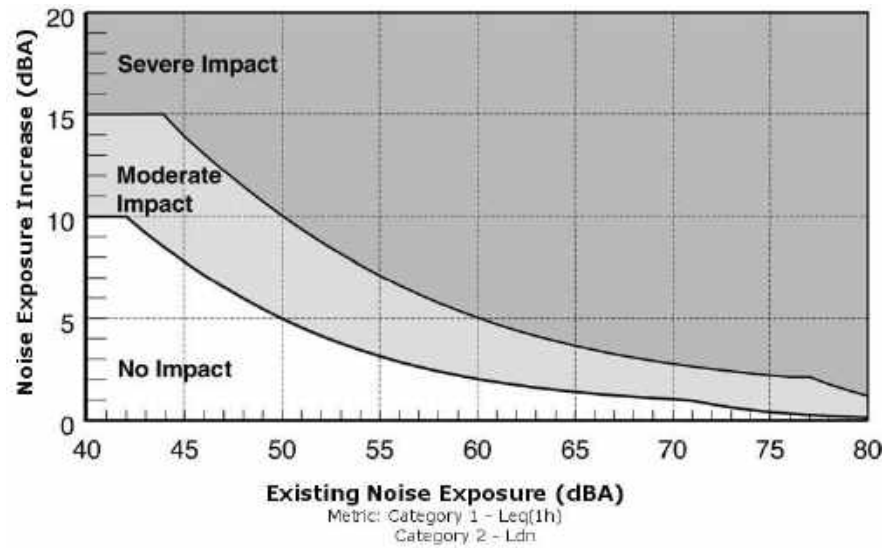


Figure 4-3 Increase in Cumulative Noise Levels Allowed by Criteria (Land Use Cat. 1 & 2)

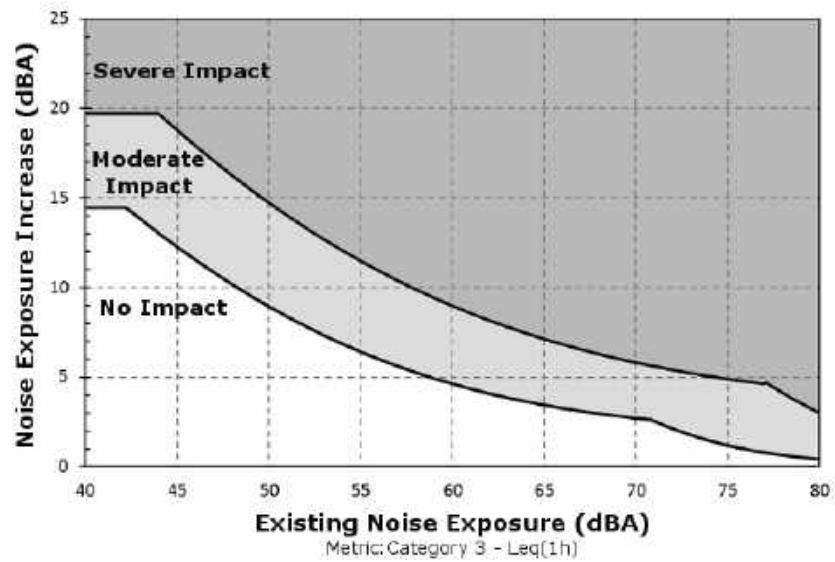


Figure 4-4 Increase in Cumulative Noise Levels Allowed by Criteria (Land Use Cat. 3)

This table shows that as the existing noise exposure increases from 45 dBA to 75 dBA, the allowed project noise exposure increases from 51 dBA to 65 dBA. However, the allowed increase in the cumulative noise level decreases from 7 dB to 0 dB (rounded to the nearest whole decibel). The justification for this is that people already exposed to high levels of noise should be expected to tolerate only a small increase in the amount of noise in their community. In contrast, if the existing noise levels are quite low, it is reasonable to allow a greater change in the community noise for the equivalent difference in annoyance.

Note that Table 4-6 was developed for illustrative purposes and the official criteria are included in Figure 4-3 and Figure 4-4 and the associated equations.

Table 4-6 Noise Impact Criteria: Effect on Cumulative Noise Exposure

L_{dn} or L_{eq(1hr)} in dBA (rounded to nearest whole decibel)			
Existing Noise Exposure	Allowable Project Noise Exposure Before Moderate Impact	Allowable Combined Total Noise Exposure	Allowable Noise Exposure Increase Before Moderate Impact
45	51	52	7
50	53	55	5
55	55	58	3
60	57	62	2
65	60	66	1
70	64	71	1
75	65	75	0

4.2 Determine Noise Analysis Level

There are three levels of analysis to evaluate noise on a transit project based on the type and scale of the project, stage of project development, and environmental setting. These levels, described below, are the Noise Screening Procedure, the General Noise Assessment and the Detailed Noise Analysis.

The Noise Screening Procedure, conducted first, defines the study area of any subsequent noise impact assessment. Where there is potential for noise impact, the General Noise Assessment and Detailed Noise Analysis procedures are used to determine the extent and severity of impact. In some cases, a General Noise Assessment may be all that is needed. However, if the proposed project is near 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.

Conduct the noise screening procedure and then determine the appropriate noise analysis option.

Noise Screening Procedure – The Noise Screening Procedure is a simplified method of identifying study area receivers or locations where a project may have the potential for noise impacts from transit projects. This procedure accounts for impact criteria, the type of project, and noise-sensitive land uses. If no noise-sensitive land uses or receivers are present in the analysis area, then no further noise assessment is needed. If noise-sensitive receivers are identified, then proceed to conduct a General Assessment and/or a Detailed Assessment.

The Noise Screening Procedure steps are provided in Section 4.3.

General Noise Assessment – The General Noise Assessment is used to examine potentially impacted areas identified in the screening step by examining the location and estimated severity of noise impacts. This procedure considers noise source and land use information likely to be available at an early stage in the project development process. Estimates are made of project noise levels and of existing noise conditions to model the location of a noise impact contour

that defines the outer limit of an impact corridor or area. This modeling method uses transit-specific noise and adjustment data (in tabular and graphical form) for the noise computations.

For many smaller projects, this assessment may be sufficient to define impacts and determine whether noise mitigation is necessary. The procedure can be used in conjunction with established highway noise prediction procedures to compare highway, transit, and multimodal alternatives. If an assessment is needed to inform the decision on transit mode and general alignment in a corridor, the General Noise Assessment procedures should be used, and not the Detailed Noise Analysis, which requires more detailed information.

The General Noise Assessment procedure is provided in Section 4.4. FTA has also developed an Excel spreadsheet to more simply conduct the General Noise Assessment. It is on FTA's website at http://www.fta.dot.gov/12347_2233.html.

Detailed Noise Analysis – The Detailed Noise Analysis procedure is a comprehensive assessment method that produces the most accurate estimates of noise impacts for a proposed project. It is important to recognize that use of the Detailed Noise Analysis methods will not provide more accurate results than the General Noise Assessment unless more detailed and case-specific input data are used.

The project must be defined to the extent that location, alignment, transit mode, hourly operational schedules during day and night, speed profiles, plan and profiles of guideways, locations of access roads, and landform topography (including terrain and building features) are determined. A detailed Noise Analysis is often accomplished at the development of the final environmental impact statement (FEIS), record of decision (ROD), or combined FEIS/ROD in the NEPA process, when the preferred alternative is undergoing refinements to mitigate its adverse impacts. However, these project details may not be available until the final design phase, requiring that the detail noise analysis be conducted after the NEPA process is complete. However, it is recommended that the detailed analysis be conducted earlier for controversial projects or projects with highly noise-sensitive sites close to tracks.

A Detailed Noise Analysis may be warranted as part of the development of an environmental assessment (EA) if there are potentially severe impacts due to the proximity of noise-sensitive land uses.

In some cases, decisions on appropriate noise mitigation measures can be made based on the results of the General Noise Assessment. But if costly measures may be needed, it is generally recommended that a Detailed Noise Analysis be conducted to verify the need and design of the noise mitigation. The Detailed Noise Analysis is always appropriate under two sets of circumstances:

- For a major transit project with likely noise impacts after the preferred alternative has been selected.
- For any other transit project where potentially severe impacts are identified at an early stage.

Noise impacts may occur for relatively minor transit projects when the project is near noise-sensitive sites, particularly residences. In this case, completing a Detailed Noise Analysis is recommended. Some examples include:

- A terminal or station sited adjacent to a residential neighborhood
- A maintenance facility located near a school
- A storage yard adjacent to residences
- An electric substation located adjacent to a hospital

The Detailed Noise Analysis procedure is provided in Section 4.5.

4.3 Evaluate Impact: Noise Screening Procedure

Identify the potential for impact using the Noise Screening Procedure described below.

Step 1: Identify Project Type

Identify the project type using Table 4-7 and confirm the assumptions in Table 4-8 are appropriate for the project.

The noise screening procedure is intended to be conservative to broadly capture the potential for impact with minimal effort. To make the procedure conservative, the project system must be assumed to be operating under relatively high-capacity conditions, which would produce more noise than normal operating conditions. In addition, the assumptions in Table 4-8 were made using the lowest threshold of impact (50 dBA) from the criteria curves in Figure 4-2. Clarification can be obtained from FTA on special cases that are not represented in this section.

If the assumptions in Table 4-8 are not appropriate for the project, make adjustments to the screening distances in Table 4-8 according to the methodology in Section 4.4 or the FTA spreadsheet model.

Step 2: Determine the Screening Distance

Determine the appropriate screening distance considering the type of project and shielding from intervening buildings.

2a. Determine the appropriate screening distance column in Table 4-7.

Option A: Buildings in the Sound Paths – Use the screening distances in the “Intervening Buildings” column.

Option B: Buildings Not in the Sound Paths – Use the distances in the “Unobstructed” column.

2b. Adjust these distances according to the methodology in Section 4.4, or the FTA spreadsheet model, if the assumptions in Table 4-8 are not appropriate for the project. The appropriate screening distance is where the project noise reaches 50 dBA for the appropriate metric. If the assumptions in Table 4-8 are not appropriate for a commuter rail grade crossing project where horns and

warning bells are used, use the FRA horn noise model available from the FRA website to develop the screening distance (49 CFR § 222).⁽²¹⁾

Step 3: Identify Study Area

Apply the screening distances as follows to identify the study area. The study area is intended to be sufficiently large to encompass all potentially impacted locations.

Option A: Fixed Guideway Transit Sources – Apply the screening distance from the guideway centerline.

Option B: Highway/Transit Sources (e.g., Bus) – Apply the screening distance from the nearest ROW line on both sides of a highway or access road.

Option C: Small Stationary Facilities – Apply the screening distance from the center of the noise-generating activity.

Option D: Stationary Facility Spread Over a Large Area – Apply the screening distance from the outer boundary of the proposed project site.

Step 4: Locate Noise-Sensitive Land Uses

Locate all noise-sensitive land uses within the study area using Table 4-3.

See Section 4.1 for more information on noise-sensitive land uses. Include all categories of noise-sensitive land uses in this step.

If no noise-sensitive land uses are identified, no further noise analysis is needed. If one or more of the noise-sensitive land uses are in the study area, proceed to Section 4.4 and complete a General Noise Assessment.

Table 4-7 Screening Distance for Noise Assessments

Project Systems		Screening Distance, ft*	
		Unobstructed	Intervening Buildings
Fixed-Guideway Systems			
Commuter Rail Mainline		750	375
Commuter Rail Station	With Horn Blowing	1,600	1,200
	Without Horn Blowing	250	200
Commuter Rail Road Crossing with Horns and Bells		1,600	1,200
RRT		700	350
RRT Station		200	100
LRT		350	175
Streetcar		200	100
Access Roads to Stations		100	50
Low and Intermediate Capacity Transit	Steel Wheel	125	50
	Rubber Tire	90	40
	Monorail	175	70
Yards and Shops		1000	650
Parking Facilities		125	75
Access Roads to Parking		100	50
Ancillary Facilities: Ventilation Shafts		200	100
Ancillary Facilities: Power Substations		250	125
Bus Systems			
Busway		500	250
Bus Rapid Transit (BRT) on exclusive roadway		200	100
Bus Facilities	Access Roads	100	50
	Transit Mall	225	150
	Transit Center	225	150
	Storage & Maintenance	350	225
	Park & Ride Lots w/Buses	225	150
Ferry Boat Terminals		300	150

*Measured from centerline of guideway for fixed-guideway sources, from the ROW on both sides of the roadway for highway/transit sources, from the center of noise-generating activity for stationary sources, or from the outer boundary of the proposed project site for fixed facilities spread out over a large area.

Table 4-8 Assumptions for Screening Distances for Noise Assessments

Type of Project		Operations	Speeds*	Metric**
Fixed-Guideway Systems				
Commuter Rail Mainline		66 day / 12 night; 1 loco, 6 cars	55 mph	L_{dn}
Commuter Rail Station	With Horn Blowing	22 day / 4 night	N/A	L_{dn}
	Without Horn Blowing	22 day / 4 night	N/A	L_{dn}
Commuter Rail-Highway Crossing with Horns and Bells		22 day / 4 night	55 mph	L_{dn}
RRT		220 day / 24 night; 6-car trains	50 mph	L_{dn}
RRT Station		220 day / 24 night	20 mph	L_{dn}
LRT		150 day / 18 night; 2 artic veh.	35 mph	L_{dn}
Streetcar		150 day / 18 night	25 mph	L_{dn}
Access Roads to Stations		1000 cars, 12 buses	35 mph	$L_{eq}(1hr)$
Low and Intermediate Capacity Transit	Steel Wheel	220 day / 24 night	30 mph	L_{dn}
	Rubber Tire	220 day / 24 night	30 mph	L_{dn}
	Monorail	220 day / 24 night	30 mph	L_{dn}
Yards and Shops		20 train movements	N/A	$L_{eq}(1hr)$
Parking Facilities		1000 cars	N/A	$L_{eq}(1hr)$
Access Roads to Parking		1000 cars	35 mph	$L_{eq}(1hr)$
Ancillary Facilities: Ventilation Shafts		Rapid Transit in Subway	50 mph	L_{dn}
Ancillary Facilities: Power Substations		Sealed shed, air conditioned	N / A	L_{dn}
Bus Systems				
Busway		30 buses, 120 automobiles	50 mph	$L_{eq}(1hr)$
BRT on exclusive roadway		30 buses	35 mph	$L_{eq}(1hr)$
Bus Facilities	Access Roads	1000 cars	35 mph	$L_{eq}(1hr)$
	Transit Mall	20 buses	N/A	$L_{eq}(1hr)$
	Transit Center	20 buses	N/A	$L_{eq}(1hr)$
	Storage & Maintenance	30 buses	N/A	$L_{eq}(1hr)$
	Park & Ride Lots w/Buses	1000 cars, 12 buses	N/A	$L_{eq}(1hr)$
Ferry Boat Terminals		8 boats with horns used in normal docking cycle	N/A	$L_{eq}(1hr)$

*N/A = not applicable

** $L_{eq}(1hr)$ = the loudest hour of project related activity during hours of noise sensitivity.

4.4 Evaluate Impact: General Noise Assessment

The General Noise Assessment should be completed after the Noise Screening Procedure (Section 4.3), through which noise-sensitive receivers have been identified. This can be completed either by using the General Noise Assessment Procedure described below or using the FTA General Noise Assessment Spreadsheet found on the following FTA website:
http://www.fta.dot.gov/12347_2233.html.

Assumptions are used throughout the General Noise Assessment. If the listed assumptions are not appropriate for the project and good engineering judgement cannot be used by following the General Noise Assessment procedure, proceed to a Detailed Noise Analysis or consult with the FTA Regional office.

Major steps in the General Noise Assessment procedure and recommended workflow are shown in Figure 4-5 and listed below. Four examples of General Noise Assessments are given at the end of this section. Many of these concepts are explained in greater detail in the context of a Detailed Noise Analysis in Section 4.5.

Step 1: Identify Noise-Sensitive Receivers – Identify noise-sensitive receivers (Section 4.3) and their proximity to the project and major noise sources.

Step 2: Determine Project Noise Source Reference Levels – Determine the project noise sources and reference levels. Then, estimate the project noise exposure at the reference distance of 50 ft considering operational characteristics with preliminary estimations of the effect of mitigation.

Step 3: Estimate Project Noise Exposure by Distance – Estimate project noise exposure at distances beyond 50 ft considering propagation characteristics using a simplified procedure.

Step 4: Combine Noise Exposure from All Sources – Combine all sources associated with the project to predict the total project noise at the receivers.

Step 5: Measure Existing Noise Exposure – Measure the existing noise or estimate the existing noise exposure using a simplified procedure.

Step 6: Inventory Impacts

Option A: Tabulate the change in noise (existing vs. estimated project noise) at each noise-sensitive receiver or cluster, identifying all moderate and severe impacts.

Option B: Take inventory of noise-sensitive receivers that fall within the moderate and severe noise contours.

Step 7: Determine Noise Mitigation Needs – Evaluate the need for mitigation and repeat the General Noise Assessment with proposed mitigation.

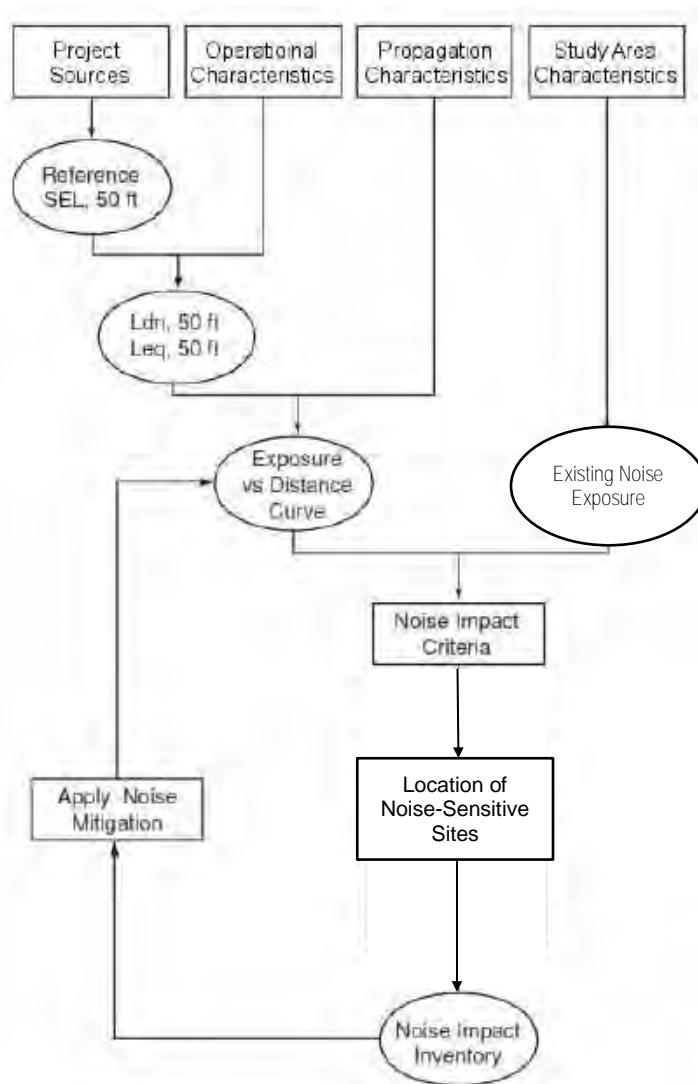


Figure 4-5 Procedure for General Noise Assessment

Step 1: Identify Noise-Sensitive Receivers

Determine the proximity of noise-sensitive land uses identified in Section 4.3 to the project and to the nearest major roadways and railroad lines.

- 1a.** When necessary, use windshield surveys or detailed land use maps to confirm the location of noise-sensitive land uses.
- 1b.** For land uses more than 1,000 ft from major roadways or railroad mainlines, obtain an estimate of the population density in the immediate area, expressed in people per square mile. Distances to roadways or railroads, or population density, will be used later to estimate the existing

noise level. Coordinate with the Metropolitan Planning Organization (MPO) for population densities at an appropriate level of detail.

Step 2: Determine Project Noise Source Reference Levels

Determine the general source reference level for each project noise source.

Classify all project noise sources as fixed-guideway transit, highway/transit, or stationary facility and determine the source reference levels. Note that a major fixed-guideway system will have stationary facilities associated with it and that a stationary facility may have highway/transit elements associated with it.

Option A: Fixed-guideway Transit Sources – For this manual, fixed-guideway transit sources include commuter rail, RRT, LRT, streetcar, AGT, monorail, and magnetically levitated vehicles (maglev). For commuter railroads and LRT systems, the crossing of streets and highways at-grade is likely, and in that case, warning devices should be included in the assessment. At an early project stage, the information available for a General Noise Assessment 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 ROW. Therefore, use conservative estimates (e.g., maximum (expected) design speeds and operations at design capacities) to estimate worst-case noise levels.

First choose the appropriate fixed-guideway transit source reference level and then predict the noise exposure at 50 ft in terms of $L_{eq(1hr)}$ and L_{dn} .

A.i. Choose the reference source noise levels 50 ft from the track for one vehicle in terms of Sound Exposure Level (SEL) using Table 4-9. See Appendix B for a detailed explanation of SEL. Note that the SEL reference speed is 50 mph, unless otherwise noted.

Table 4-9 Reference SEL's 50 ft from Track and at 50 mph, One Vehicle

Source	Type	Reference Conditions	Reference SEL (SEL_{ref}), dBA
Commuter Rail, At-Grade	Locomotives	Diesel-electric, 3000 hp, throttle 5	92
		Electric	90
	Diesel Multiple Unit (DMU)	Diesel-powered, 1200 hp	85
	Horns	Within 1/4 mile of grade crossing	110
	Cars	Ballast, welded rail	82
Rail Transit and Streetcars at 50 mph		At-grade, ballast, welded rail	82
Rail Transit and Streetcars at 25 mph		At-grade, ballast, welded rail	76
Transit whistles / warning devices		Within 1/8 mile of grade crossing	93
AGT	Steel Wheel	Aerial, concrete, welded rail	80
	Rubber Tire	Aerial, concrete guideway	78
Monorail		Aerial straddle beam	82
Maglev		Aerial, open guideway	72

A.ii. Collect the following data:

- Number of train passbys during the day (7 a.m. to 10 p.m.) and night (10 p.m. to 7 a.m.) for category 2 land uses
- Maximum number of train passbys during hours that category 1 or category 3 land uses are normally in use (typically the peak hour train volume)
- Number of vehicles per train for each time period for category 2 land uses (if this number varies during the day or night, take the average)
- Maximum number of vehicles per train during hours that category 1 or category 3 land uses are normally in use (typically the peak hour train volume)
- Train speed in mph (maximum expected)
- Guideway configuration
- Location of highway and street grade crossings, if any
- If this process is repeated to estimate the effect of proposed noise mitigation, include the noise barrier location

A.iii. Calculate the noise exposure at 50 ft in terms of $L_{eq(1hr)}$:

- Calculate $L_{eq(1hr)}$ for each source using the appropriate equations in Table 4-10.
- Compute $L_{eq(1hr), Combo}$ using Eq. 4-6. It may be necessary to compute the combined totals with and without warning horns. Some neighborhoods along the corridor may be exposed to horn noise, but some may not.

A.iv. Calculate the noise exposure at 50 ft in terms of L_{dn} :

- If the project noise will affect any residential receivers, calculate the L_{dn} using the combined $L_{eq(1hr)}$ for both the daytime and nighttime periods separately, using the appropriate equations in Table 4-10.
- It may be necessary to calculate L_{dn} with and without warning horns, as in the previous step.

Note that the equations in Table 4-10 include terms to account for a difference in speed from the 50 mph reference speed and a numerical adjustment to account for the one-hour time period for this metric. For

more information on the numerical adjustment to represent the time period of interest, see Appendix B.1.4.4.

Table 4-10 presents an estimate of the noise reduction potentially provided by wayside noise barriers that can be used when assessing mitigation options in a General Noise Assessment. If impact is determined during the General Noise Assessment, repeat the procedure and include proposed mitigation according to Section 4.4, Step 7. See Section 4.5, Step 7 for a complete description of the benefits resulting from various noise mitigation measures that can be evaluated with a Detailed Noise Analysis.

Table 4-10 Computation of Noise Exposure at 50 ft for Fixed-Guideway General Noise Assessment

Locomotives* $L_{eq(1hr)}$ at 50 ft	$L_{eq.Loco(1hr)} = SEL_{ref} + 10 \log(N_{Loco}) + K \log\left(\frac{S}{50}\right) + 10 \log(V) - 35.6$	Eq. 4-1
Locomotive Warning Horns** $L_{eq(1hr)}$ at 50 ft	$L_{eq.LHorns(1hr)} = SEL_{ref} + 10 \log(V) - 35.6$	Eq. 4-2
Rail Vehicles† $L_{eq(1hr)}$ at 50 ft	$L_{eq.RCars(1hr)} = SEL_{ref} + 10 \log(N_{Cars}) + 20 \log\left(\frac{S}{50}\right) + 10 \log(V) - 35.6 + Adj_{track}$	Eq. 4-3
Streetcars (25 mph or slower) $L_{eq(1hr)}$ at 50 ft	$L_{eq.SCars(1hr)} = SEL_{ref} + 10 \log(N_{Cars}) + 20 \log\left(\frac{S}{25}\right) + 10 \log(V) - 35.6 + Adj_{track}$	Eq. 4-4
Transit Warning Horns $L_{eq(1hr)}$ at 50 ft	$L_{eq.THorns(1hr)} = SEL_{ref} - 10 \log\left(\frac{S}{50}\right) + 10 \log(V) - 35.6$	Eq. 4-5
Combined Locomotive and transit†† $L_{eq(1hr)}$ at 50 ft	$L_{eq.Combo(1hr)} = 10 \log\left(10^{(L_{eq.Loco(1hr)})/10} + 10^{(L_{eq.RCars(1hr)})/10} + 10^{(L_{eq.SCars(1hr)})/10} + 10^{(L_{eq.LHorns(1hr)})/10} + 10^{(L_{eq.THorns(1hr)})/10}\right)$	Eq. 4-6
Daytime L_d at 50 ft	$L_d = L_{eq(1hr)}$ where $V = V_d$, $N_{Loco} = N_d$ (loco events), and $N_{Cars} = N_d$ (car events)	Eq. 4-7
Nighttime L_n at 50 ft	$L_n = L_{eq(1hr)}$ where $V = V_n$, $N_{Loco} = N_d$ (loco events), and $N_{Cars} = N_d$ (car events)	Eq. 4-8
Day/Night L_{dn} at 50 ft	$L_{dn} = 10 \log(15 \times 10^{(L_d/10)} + 9 \times 10^{(L_n+10)/10}) - 13.8$	Eq. 4-9
<p> N_{Loco} = average number of locomotives per train K = constant -10 for passenger diesel 0 for DMUs +10 for electric S = train speed, mph V = average hourly volume of train traffic, trains per hour N_{Cars} = average number of cars per train Adj_{track} = constant +5 for jointed track or for a crossover within 300 ft +4 for aerial structure with slab track (except AGT and monorail) +3 for embedded track on grade -5 if a noise barrier blocks the line of sight V_d = average hourly daytime volume of train traffic, trains per hour = $\frac{\text{number of trains, 7 a.m. to 10 p.m.}}{15}$ N_d = average hourly number of events that occur during daytime (7 a.m. to 10 p.m.) = $\frac{\text{number of events between 7 a.m. to 10 p.m.}}{15}$ V_n = average hourly nighttime volume of train traffic, trains per hour = $\frac{\text{number of trains, 10 p.m. to 7 a.m.}}{9}$ N_n = average hourly number of events that occur during nighttime (10 p.m. to 7 a.m.) = $\frac{\text{number of events between 10 p.m. to 7 a.m.}}{9}$ </p>		

* Assumes a diesel locomotive power rating at approximately 3000 hp.

** Based on FRA's horn noise model (<http://www.fra.dot.gov/eLib/Details/L04091>).

† Includes all commuter rail cars, transit cars, streetcars above 25 mph, AGT and monorail.

† † Only include appropriate terms.

Option B: 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 buses, commuter vanpools and carpools. Use the instructions below to estimate source noise levels for projects that involve these types of vehicles and are using FTA’s environmental review procedures. At an early project stage, the information available for a General Noise Assessment includes:

- 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 ROW; therefore, use of conservative estimates (e.g., maximum (expected) design speeds and operations at design capacities) to estimate worst-case noise impact levels is recommended. The procedure is consistent with FHWA’s highway noise prediction method. The reference SEL levels in Table 4-11 correspond to FHWA’s source emission levels and speed coefficients for buses and automobiles.⁽²²⁾

B.i. Using Table 4-11, choose the appropriate reference source noise levels 50 ft from the roadway in terms of SEL. Note that the SEL reference speed is 50 mph, unless otherwise noted.

Table 4-11 Source Reference Levels at 50 ft from Roadway, 50 mph

Source*	Reference SEL, dBA
Automobiles and Vans	74
Buses (diesel-powered)	82
Buses (electric)	80
Buses (hybrid)	83**

* Assumes normal roadway surface conditions.

** For hybrid buses, determine Reference SEL on a case-by-case basis because they vary, and data are scarce.

B.ii. Collect the following data:

- Number of vehicle passbys during the day (7 a.m. to 10 p.m.) and night (10 p.m. to 7 a.m.) for each vehicle type in Table 4-11, if a category 2 land use is present
- Number of vehicle passbys during hours that category 1 or category 3 land uses are normally in use, each vehicle type in Table 4-11
- Speed (maximum expected)
- Transitway configuration (with or without noise barrier)

B.iii. Calculate the noise exposure at 50 ft in terms of $L_{eq(1hr)}$. Calculate $L_{eq(1hr)}$ for each source using the appropriate equations in Table 4-12.

B.iv. Calculate the noise exposure at 50 ft in terms of L_{dn} . If the project noise will affect any residential receivers, calculate the L_{dn} using the combined $L_{eq(1hr)}$ for both the daytime and nighttime periods separately, using the appropriate equations in Table 4-12.

Note that the equations in Table 4-12 include terms to account for a speed other than the 50 mph reference speed and a numerical adjustment to account for the one-hour time period for this metric. For more information on the numerical adjustment to represent the time period of interest, see Appendix B.1.4.4.

Table 4-12 presents an estimate of noise reduction potentially provided by wayside noise barriers. This is considered illustrative given that barriers are the most common noise mitigation measure. See Section 4.5, Step 7 for a complete description of the benefits resulting from noise mitigation. If impact is determined during the General Noise Assessment without mitigation, repeat the procedure and include proposed mitigation.

Table 4-12 Computation of $L_{eq(1hr)}$ and L_{dn} at 50 ft for Highway/Transit General Noise Assessment

L_{eq(1hr)} at 50 ft	$L_{eq(1hr)} = SEL_{ref} + 10 \log(V) + C_S \log(\frac{S}{50}) - 35.6$	Eq. 4-10
Daytime L _d at 50 ft	$L_d = L_{Aeq(1hr)}$ where V = V _d	Eq. 4-11
Nighttime L _n at 50 ft	$L_n = L_{Aeq(1hr)}$ where V = V _n	Eq. 4-12
L_{dn} at 50 ft	$L_{dn} = 10 \log(15 \times 10^{(L_d/10)} + 9 \times 10^{((L_n+10)/10)}) - 13.8$	Eq. 4-13
Barrier Adjustment	= -5 for noise barriers	
	<p>V = hourly volume of vehicles, vehicles per hour</p> <p>C_s = Speed constant 15 for diesel buses 28 for electric buses 21 for hybrid buses⁽²³⁾ 30 for automobile and van pools</p> <p>S = average vehicle speed, mph</p> <p>V_d = average hourly daytime volume of vehicles, vehicles per hour = $\frac{\text{total number of vehicles, 7 a.m. to 10 p.m.}}{15}$</p> <p>V_n = average hourly nighttime volume of vehicles, vehicles per hour = $\frac{\text{total number of vehicles, 10 p.m. to 7 a.m.}}{9}$</p>	

Option C: Stationary Sources – Stationary sources include fixed transit system facilities. New transit facilities undergo a site review for best location that considers 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, ferry 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. Noise from access roads is treated according to the procedures described in the Highway/Transit Sources category. In a General Noise Assessment, only the prominent features of each fixed facility are considered in the noise analysis.

C.i. For small facilities, using Table 4-13, determine the reference source noise levels 50 ft from the center of the site in terms of SEL. The source reference levels given in the table are based on measurements for the peak hour of operation of a typical stationary source of the noted type and size.

A large facility, such as a rail yard, is spread out over considerable area with various noise sources with different noise levels depending on the layout of the facility. Specifying a single reference SEL for the facility at 50 ft from the center of the site could be misleading if all of these different noise sources are not represented. Therefore, the reference distance should be the equivalent distance of 50 ft, which is determined by estimating the noise levels from the center of the site at a distance far enough to capture all noise sources and projecting back to 50 ft from the center of the site. This approach allows for a conservative estimate of noise for all surrounding areas and the equivalent noise can be considered as 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 (e.g., the dock in the case of ferry boat operations) instead of the center of the site.

Table 4-13 Source Reference Levels at 50 ft 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)	109	1 train with diesel locomotive idling for 1 hour
Crossing signals	109	3600 second duration
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
Ferry Terminal		
Ferry boat (no fog horn sounded)	97	4 ferry boat landings in 1 hour
Ferry boat (fog horn sounded)	100	
Parking Garage	92	1000-car capacity in peak activity hour
Park & Ride Lot	101	12 buses, 1000 cars in peak activity hour

C.ii. Collect the following data:

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

C.iii. Calculate $L_{eq(1hr)}$ at 50 ft. Calculate $L_{eq(1hr)}$ for each source using the appropriate equations in Table 4-14.

C.iv. Calculate L_{dn} at 50 ft. If the project noise will affect any residential receivers, calculate the L_{dn} using the combined $L_{eq(1hr)}$ for both the daytime and nighttime periods separately, using the appropriate equations in Table 4-14.

The equations in Table 4-14 include a numerical adjustment to account for the one-hour time period for this metric. See Appendix B.1.4.4 for more information on the numerical adjustment.

Table 4-14 presents an estimate of noise reduction potentially provided by noise barriers at the property line. Only approximate locations and lengths for barrier or other noise mitigation measures are developed during a General Noise Assessment to provide a preliminary indication of the costs and benefits of mitigation. A Detailed Noise Analysis of the preferred alternative is usually warranted following the General Noise Assessment (if it predicts any impacts) to verify impacts and design the mitigation.

Table 4-14 Computation of $L_{eq(1hr)}$ and L_{dn} at 50 ft for Stationary Source General Noise Assessment*

$L_{eq(1hr)}$ at 50 ft	$L_{eq(1hr)} = SEL_{ref} + C_N - 35.6$	Eq. 4-14
Daytime L_d at 50 ft	$L_d = 10\log\left(\frac{1}{15}\right) \sum_{7am-10pm} 10^{(L_{Aeq(1hr)}/10)}$	Eq. 4-15
Nighttime L_n at 50 ft	$L_n = 10\log\left(\frac{1}{9}\right) \sum_{10pm-7am} 10^{(L_{Aeq(1hr)}/10)}$	Eq. 4-16
L_{dn} at 50 ft	$L_{dn} = 10\log(15 \times 10^{(L_d/10)} + 9 \times 10^{(L_n+10)/10}) - 13.8$	Eq. 4-17
Barrier Adjustment	= -5 for noise barrier at property line	
Volume Adjustment	$= C_N$ $= 10\log\left(\frac{N_T}{20}\right)$ Rail yards and shops $= 10\log(N_T)$ 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 $= 10\log\left(\frac{N_F}{4}\right)$ Ferry terminal $= 10\log\left(\frac{N_A}{1000}\right)$ Parking garage $= 10\log\left(\frac{N_A}{2000} + \frac{N_B}{24}\right)$ Park & ride lot $= 10\log\left(\frac{E}{3600}\right)$ Crossing signals N_T = average number of trains per hour during the day (7AM to 10PM) or night (10PM to 7AM) N_B = average number of buses per hour during the day or night N_F = average number of ferry boat landings per hour during the day or night N_S = average number of buses serviced and cleaned per hour during the day or night N_A = average number of automobiles per hour during the day or night E = average hourly duration of events, sec during the day or night	

* If any of these numbers is zero, omit that term.

Step 3: Estimate Project Noise Exposure by Distance

Estimate the project noise exposure for locations beyond the reference distance, such as for noise-sensitive land uses.

In the previous step, noise exposure at the reference distance of 50 ft was calculated for the various noise sources. This step describes how to estimate the project noise exposure beyond (or, if needed, closer than) the reference distance, such as at noise-sensitive land uses locations. This procedure estimates the source's noise exposure as a function of distance. Adjustments are provided to account for shielding attenuation from rows of buildings.

3a. Select the appropriate distance correction curve (Fixed-Guideway & Highway or Stationary) from Figure 4-6. The Fixed-Guideway & Highway curve refers to line sources while the Stationary curve refers to point sources. The distance correction factor (C_{distance}) is 0 dB at 50 ft.

3b. Choose a distance other than 50 ft, such as the distance to a receiver. Determine the correction factor using Figure 4-6 or calculate using the equations in Table 4-15.⁽ⁱⁱⁱ⁾ For distances beyond 1,000 ft, the equations in Table 4-15 can be used; however, ground effects have an upper limit and atmospheric conditions may affect propagation characteristics. More detailed calculation methods may be required to account for those effects beyond 1,000 ft.

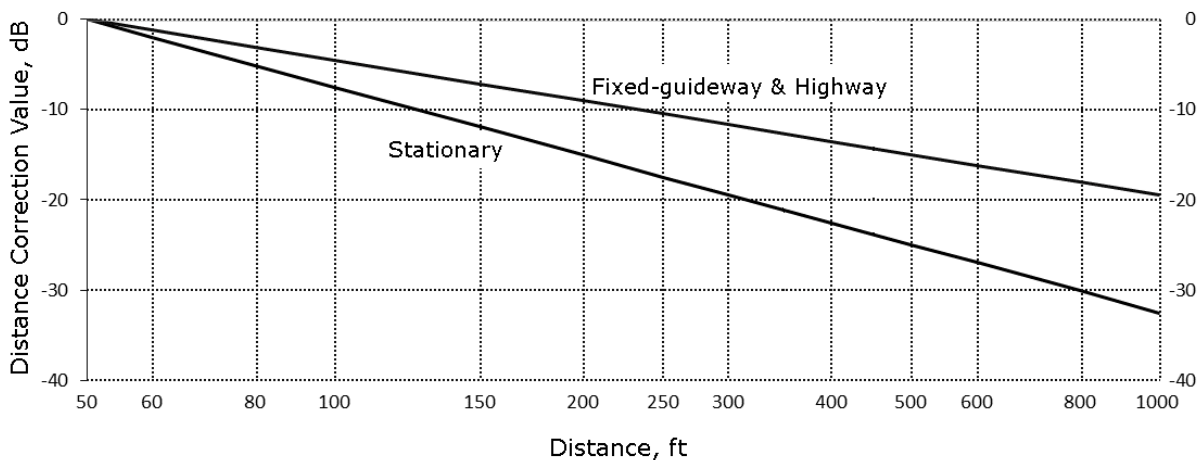


Figure 4-6 Curves for Estimating Exposure vs. Distance in General Noise Assessment

ⁱⁱⁱ Note that the curves and equations assume acoustically soft ground beyond a distance of 50 ft. See Table 4-27 for more detailed calculation of ground attenuation.

Table 4-15 Distance Correction Factor Equations for General Noise Assessment

Source	Equation	
Stationary Sources	$C_{distance} = -25\log\left(\frac{D}{50}\right)$	Eq. 4-18
Fixed-guideway and Highway	$C_{distance} = -15\log\left(\frac{D}{50}\right)$	Eq. 4-19
D = distance, ft		

3c. Apply the distance correction ($C_{distance}$) to the project noise exposure at 50 ft (Section 4.4, Step 2) using the following equation:

$$L_{distance} = L_{50} + C_{distance} \quad \text{Eq. 4-20}$$

where:

$$L_{distance} = L_{dn} \text{ or } L_{eq(1hr)} \text{ at the new distance in feet}$$

$$L_{50} = L_{dn} \text{ or } L_{eq(1hr)} \text{ at 50 ft}$$

3d. Repeat Step 3c for each source-receiver distance from the project. A noise exposure vs. distance curve can be created, if desired, by calculating the noise exposure for all distances of interest and plotting a curve. This curve can be used to assist in determining 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 to assess the potential benefits from mitigation measures.

For second row receivers and beyond, it is necessary to account for shielding attenuation from rows of intervening buildings. Without accounting for shielding, impacts may be substantially overestimated. Use the following general rules to account for 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.

Step 4: Combine Noise Exposure from All Sources

Combine all sources to predict the total project noise at the receivers using the equations in Table 4-16, once propagation adjustments have been made for the noise exposure from each source separately (fixed-guideway, highway/transit, and stationary).

Table 4-16 Computing Total Noise Exposure

Total $L_{eq(t)}$ from all sources for the hour of interest:	$L_{eq.total(1hr)} = 10\log(\sum_{all\ sources} 10^{L_{eq}/10})$	Eq. 4-21
Total L_{dn} from all sources	$L_{dn.total} = 10\log(\sum_{all\ sources} 10^{L_{dn}/10})$	Eq. 4-22

Step 5: Estimate Existing Noise Exposure

Measure the existing noise or estimate the existing noise exposure using a simplified procedure.

Existing noise in the project vicinity must be quantified and compared to the project noise to determine the potential noise impact. It is generally recommended to measure existing noise, especially at locations known to be noise-sensitive, but if measurement results are not available then they must be estimated. In the Detailed Noise Analysis, the existing noise exposure is usually based on noise measurements at representative locations in the community.

It is not necessary or recommended that existing noise exposure be determined by measuring at every noise-sensitive location in the project area. Rather, the recommended approach is to characterize the noise environment for "clusters" of sites based on measurements or estimates at representative locations in the community. Because of the sensitivity of the noise criteria to the existing noise exposure, careful characterization of pre-project ambient noise is important. Guidelines for selecting representative receiver locations and determining ambient noise are provided in Appendix D and Appendix E, respectively.

Changes to Existing Transit

For projects that propose changes to an existing transit system, such as a rehabilitation project, the project noise can include changes to the existing noise because of the project, and so it is not possible to define project noise separately.

For these projects, refer to Section 4.1, Step 3 – Option B, on using the cumulative noise criteria.

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 4-17, where a neighborhood's existing noise exposure is based on proximity to nearby major roadways or railroads, or on population density. For areas near major airports, published aircraft noise contours can also be used to estimate the existing noise exposure. The process is as follows:

5a. Obtain scaled mapping and aerial photographs showing the project location and alternatives. A scale of 1 inch = 200 or 400 ft 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 ft from the center of the alignment or property center, depending on whether the project is a line source (fixed guideway/roadway) or a stationary facility. These data are commonly available from local transit agencies and a number of publicly available online tools.

5b. Estimate the existing noise exposure by estimating the noise from major roads and railroad lines or by population density. First, evaluate the site's proximity to major roads and railroad lines including those that are included in the project. If these noise sources are far enough away that ambient noise is dominated by local streets and community activities, estimate the existing noise based on population density. To choose the appropriate existing noise exposure, compare noise levels from each of the three categories—Roadways, Railroads, and Population Density—and select the lowest level. In case of a

lightly used railroad (one train per day or less) select the Population Density category. Existing noise levels are presented in Table 4-17. Refer to Section 4.1, Step 3 – Option B, on using the cumulative noise criteria for projects that propose changes to an existing transit system, such as a rehabilitation project.

Option A: Roadways – Major roadways are separated into two categories for a general noise assessment. Roadways that cannot be described by these two categories are not considered major roadways and would use the Population Density method described below. The roadway categories are as follows:

- Interstate highway—roadways with 4 or more lanes that allow trucks
- Other roadway—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 in Table 4-17 are based on data for light to moderate traffic on typical highways and parkways using FHWA highway noise prediction procedures. Where a range of distances is given, the noise exposure estimates are given at the larger distance (note that the traffic noise at the smaller distance is underestimated). 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:

$$D_{GM} = \sqrt{(D_N)(D_F)} \quad \text{Eq. 4-23}$$

where:

- D_{GM} = distance to the geometric mean in feet
- D_N = distance to the nearest lane centerline in feet
- D_F = distance to the farthest lane centerline in feet

Option B: Railroad Lines – 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 $L_{eq(1hr)}$ only during certain hours of the day, and these hours may vary from day to day. Therefore, to avoid underestimating noise impact when using $L_{eq(1hr)}$, it is recommended that sites near rail lines are estimated based on nearby roadways or population density unless very specific train information is available.

Option C: Population Density – In areas away from major roadways, noise from local streets or in neighborhoods is estimated using a relationship determined during a research program by EPA.⁽²⁴⁾ 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:

$$L_{dn} = 22 + 10\log(p) \quad \text{Eq. 4-24}$$

where:

$$L_{dn} = \text{in dBA}$$

$$p = \text{population density in people per square mile}$$

In areas near major airports, published noise contours can be used to estimate the existing noise exposure. The L_{dn} from such contours should be applied if greater than the estimates of existing noise from other sources at a given location.

Table 4-17 Estimating Existing Noise Exposure for General Noise Assessment

Dominant Existing Noise Source	Distance from Major Noise Source, ft*	Population Density, people per sq. mi.	Noise Exposure Estimates			
			L_{eq} Day	L_{eq} Evening	L_{eq} Night	L_{dn}
Interstate Highway**	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
Other Roadway†	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
Railway††	10–30		--	--	--	75
	30–60		--	--	--	70
	60–120		--	--	--	65
	120–240		--	--	--	60
	240–500		--	--	--	55
	500–800		--	--	--	50
	800 and up		--	--	--	45
Population		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

* Distances do not include shielding from intervening rows of buildings. Generally, for estimating shielding attenuation in populated areas, assume 1 row of buildings every 100 ft, 4.5 dB for the first row, and 1.5 dB for every subsequent row up to a maximum of 10 dB attenuation.

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

† 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.

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

Step 6: Inventory Noise Impacts

Inventory the potential noise impacts either by comparing the project and existing noise at each noise-sensitive land use or by developing noise impact contours.

Use land use information and assumptions for shielding attenuation from rows of buildings. 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. If the objective is to compare major alignment options, it may not be necessary to identify every different type of noise-

sensitive land use. The inventory may include a subset of land uses, including residential and public institutional uses.

Option A is the preferred method as it quantifies the noise impact at each noise-sensitive land use indicating the severity of the impact. Option B may be useful for comparing and narrowing down major alignment options with numerous noise-sensitive land uses.

Option A: Compare existing noise to project noise at each noise-sensitive land use.

A1. Tabulate each individual noise-sensitive land use building and site within the identified screening distance (Section 4.3).

A2. Determine for each noise-sensitive land use the existing noise (Section 4.4, Step 5), the project noise (Section 4.4, Step 3) and the resulting change in noise.

A3. Designate each noise-sensitive land use with either a no, moderate, or severe noise impact based on the criteria in Section 4.1.

A4. Identify all moderate and severe impacts on a project map.

Option B: Develop noise impact contours.

B1. Determine the noise level thresholds at which the project noise would cause moderate and severe impacts using the estimated existing noise exposure from Section 4.4, Step 5 and the noise impact criteria in Figure 4-2.

B2. Determine the distances from the project boundary to the two impact levels using the noise exposure vs. distance curves or equations in Section 4.4, Step 3.

B3. Plot points on a project land use map that correspond to the distances determined in Section 4.4, Step 3. Continue this process for all areas surrounding the project. Connect the plotted points to represent the noise impact contours.

B4. Tabulate all noise-sensitive land use buildings and sites that lie between the impact contours and the project boundary. For residential buildings, an estimate of the number of dwelling units is satisfactory.

B5. Prepare summary tables showing the number of buildings (and estimated dwelling units, if available) within both impact categories.

Specific decibel level noise contours, for example, 65 dBA, can also be plotted if desired. The distances can be determined using the procedure in Section 4.4, Step 3 by substituting the desired decibel level for the impact threshold.

Locations of points will change with respect to the project boundary as the existing ambient exposure changes, the project source levels change, and as shielding effects change. It is recommended to plot points close together to

draw a smooth curve. For a General Noise Assessment, the contours may be drawn through buildings and 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. Example 4-1 and Example 4-4 describe the development of noise contours with illustrations.

Step 7: Determine Noise Mitigation Needs

Apply estimates of the noise reduction from proposed mitigation measures (Section 4.4, Step 2), where the assessment shows either severe or moderate impact, and repeat the tabulation of noise impacts.

Note that noise barriers are the only form of mitigation available in a General Noise Assessment. The other mitigation measures are available for a Detailed Noise Analysis. The approximate noise barrier lengths and locations developed in a General Noise Assessment provide a preliminary basis for evaluating the costs and benefits of impact mitigation. This evaluation will provide a conservative estimate of the effect of the mitigation on the identified impacts.

In general, it is recommended to complete a Detailed Noise Analysis for final mitigation measures. However, if impact is identified through a General Noise Assessment and can be mitigated to a level of no impact using the noise reduction estimates included in the General Noise Assessment, a Detailed Noise Analysis may not be needed. Mitigation assumed in the assessment used for the NEPA evaluation must be included in the project as a commitment. Consult with the FTA Regional office to determine if a Detailed Noise Analysis is required for final mitigation measures.

The following examples illustrate how to complete general noise assessments for varying project types including commuter rail, highway/transit, BRT system, and a transit center.

Example 4-1 General Noise Assessment – Commuter Rail

General Noise Assessment for a Commuter Rail System in an Existing Abandoned Railroad Right-of-Way

The following example illustrates the General Noise Assessment procedure for a new fixed-guideway project. The hypothetical project is a commuter rail system to be built within the abandoned ROW of a railroad. The example covers a segment of the corridor that passes through a densely developed area with population density of 25,000 people per square mile in mixed single- and multi-family residential land uses as shown in Figure 4-7. The example is presented in two parts: first, a segment where the rail line is grade-separated and a horn is not sounded; and second, an at-grade street-rail crossing where the horn is sounded.

Assumptions

- **Project Corridor**
Existing population density is 25,000 people per square mile.
- **Commuter Rail System**
Commuter train with one locomotive and a three-car consist on a double-track at-grade system with welded rail. Trains operate with 20-minute headways during peak hours and 1-hour headways during off-peak. Speeds are approximately 40 mph along the corridor.

Operating Schedule

	Period	Headway (minutes)		Trains per hour			Period Total
		Inbound	Outbound	Inbound	Outbound	Total	
Daytime	7 a.m. – 8 a.m.	20	20	3	3	6	6
	8 a.m. – 4 p.m.	60	60	1	1	2	16
	4 p.m. – 6 p.m.	20	20	3	3	6	12
	6 p.m. – 10 p.m.	60	60	1	1	2	8
Nighttime	10 p.m. – 11 p.m.	60	60	1	1	2	2
	11 p.m. – 5 a.m.	--	--	--	--	--	--
	5 a.m. – 6 a.m.	60	60	1	1	2	2
	6 a.m. – 7 a.m.	20	20	1	1	2	2

Part I: Grade-Separated Street Crossing**Determine Project Source Reference Levels at 50 ft**

Classify the noise source: Fixed-Guideway Transit

Determine noise source reference level from Table 4-9:

Locomotive: 92 dBA

Cars: 82 dBA

Estimate Project Noise Exposure at 50 ft

Determine average hourly daytime and nighttime volumes of train traffic.

Daytime (7 a.m. – 10 p.m.)

$$V_d = \frac{42 \text{ trains}}{15 \text{ hours}} = 2.8 \text{ trains/hour}$$

Nighttime (10 p.m. – 7 a.m.)

$$V_n = \frac{6 \text{ trains}}{9 \text{ hours}} = 0.7 \text{ trains/hour}$$

Use Eq. 4-1 and Eq. 4-3 to calculate the daytime $L_{eq(1hr)}$ at 50 ft for the locomotives and rail cars.

$$\begin{aligned}
 L_{d.Locos} &= SEL_{ref} + 10\log(N_{Locos}) + K\log\left(\frac{S}{50}\right) + 10\log(V_d) - 35.6 \\
 &= 92 + 10\log(1) - 10\log\left(\frac{40}{50}\right) + 10\log(2.8) - 35.6 \\
 &= 61.8 \text{ dBA at 50 ft}
 \end{aligned}$$

$$\begin{aligned}
 L_{d.RCars} &= SEL_{ref} + 10\log(N_{Cars}) + 20\log\left(\frac{S}{50}\right) + 10\log(V_d) - 35.6 \\
 &= 82 + 10\log(3) + 20\log\left(\frac{40}{50}\right) + 10\log(2.8) - 35.6 \\
 &= 53.7 \text{ dBA at 50 ft}
 \end{aligned}$$

Calculate the total daytime L_d for the locomotive and rail cars using Eq. 4-7.

$$\begin{aligned}
 L_{d.Combo} &= 10\log(10^{L_{d.Loco}/10} + 10^{L_{d.RCars}/10}) \\
 &= 10\log(10^{61.8/10} + 10^{53.7/10}) \\
 &= 62.4 \text{ dBA at 50 ft}
 \end{aligned}$$

Calculate the nighttime $L_{eq(1hr)}$ at 50 ft for the locomotives and rail cars.

$$\begin{aligned} L_{n,Locos} &= SEL_{ref} + 10 \log(N_{Locos}) + K \log\left(\frac{S}{50}\right) + 10 \log(V_n) - 35.6 \\ &= 92 + 10 \log(1) - 10 \log\left(\frac{40}{50}\right) + 10 \log(0.7) - 35.6 \\ &= 55.8 \text{ dBA at 50 ft} \end{aligned}$$

$$\begin{aligned} L_{n,RCars} &= SEL_{ref} + 10 \log(N_{Cars}) + 20 \log\left(\frac{S}{50}\right) + 10 \log(V_n) - 35.6 \\ &= 82 + 10 \log(3) + 20 \log\left(\frac{40}{50}\right) + 10 \log(0.7) - 35.6 \\ &= 47.7 \text{ dBA at 50 ft} \end{aligned}$$

Calculate the total nighttime L_n for the locomotive and rail cars using Eq. 4-8.

$$\begin{aligned} L_{n,Combo} &= 10 \log(10^{L_{n,Locos}/10} + 10^{L_{n,RCars}/10}) \\ &= 10 \log(10^{55.8/10} + 10^{47.7/10}) \\ &= 56.4 \text{ dBA at 50 ft} \end{aligned}$$

Calculate L_{dn} at 50 ft for the project using Eq. 4-9.

$$L_{dn,Combo} = 10 \log(15 \times 10^{(L_{n,Combo}/10)} + 9 \times 10^{((L_{n,Combo}+10)/10)}) - 13.8$$

Estimate Existing Noise Exposure

Estimate existing noise at noise-sensitive sites. Since the existing alignment is on an abandoned railroad, the dominant existing noise source can be described by a generalized noise level to characterize a large area. Use Table 4-17 and population density of 25,000 people per square mile to determine the existing noise level. Unobstructed residences range from 100 to 200 ft from the rail line.

According to Table 4-17: $L_{dn} = 60$ dBA

Determine Noise Level and Distance for the Onset Of Impact

Determine the noise level for the onset of moderate and severe impact using Figure 4-2 and the existing noise level of 60 dBA. Note that this project is land use category 2 and the appropriate metric is L_{dn} .

Existing Noise L_{dn}	Onset of Moderate Impact L_{dn}	Onset of Severe Impact L_{dn}
60 dBA	58 dBA	64 Dba

Determine the distance from the project noise sources to the noise impact contours using the fixed-guideway curve in Figure 4-6 (or the equations in Table 4-15) and the project impact thresholds obtained above. The project noise level at 50 ft is approximately 64 dBA.

Moderate impact (58 dBA)

$$58 - 64 = -6 \text{ dB}$$

According to Figure 4-6, the distance correction is approximately -6 dB at 120 ft.

Severe Impact (64 dBA)

$$64 - 64 = 0 \text{ dB}$$

According to Figure 4-6, the distance correction is less than 0 dB at approximately 51 ft.

Project Level L_{dn}	Onset of Moderate Impact Distance	Onset of Severe Impact Distance
64 dBA	120 ft	51 ft

Develop Noise Impact Contours

Draw contours for each affected land use, based on the above table and its distance from the rail line (Figure 4-7). Note that the impact distances listed are in terms of distance to the centerline of the Commuter Rail corridor.

Inventory of Noise Impact

There are six residential buildings within the contours defining moderate impact (shaded in Figure 4-7).

Noise Mitigation

The procedure is repeated assuming a noise barrier to be placed at the railroad ROW line. The barrier serves to reduce project noise from the commuter rail by at least 5 dB. Note that the barrier does not affect the project criteria to be used in determining impact, and the same existing noise levels (as the case without a barrier) are used to determine these thresholds.

In this example, the noise barrier decreases the distance to moderate impact from 120 to 60 ft and eliminates all residential noise impact for this segment of the project area.

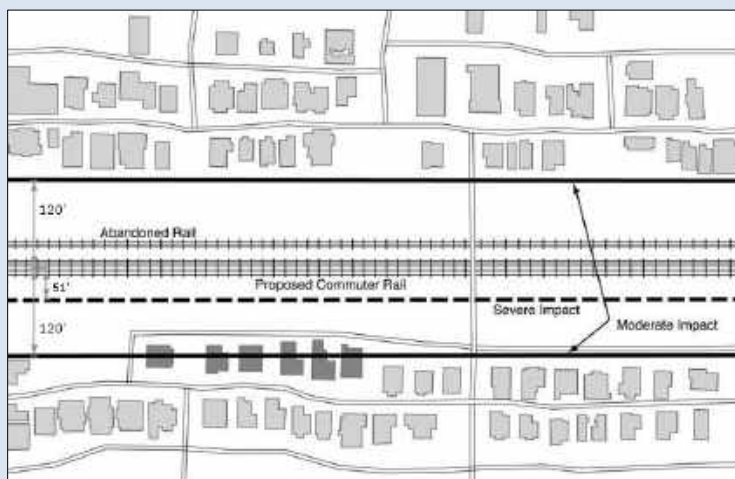


Figure 4-7 Noise Impacts of Hypothetical Commuter Rail

Part 2: At-Grade Crossing with Horn Blowing

Now consider the case of an active street crossing of the commuter railroad tracks. The General Noise Assessment method includes source reference levels for horns on moving trains and warning bells (crossing signals) at the street crossing. According to Table 4-9, the horn noise applies to track segments within ¼ mile of the grade crossing.

Estimate Project Noise Exposure at 50 ft

Using the train volumes from Part I and the information in Table 4-9 and Table 4-10, determine the day and nighttime $L_{eq(1hr)}$ from sounding the horns at 50 ft.

$$\begin{aligned}
 L_{d.LHorns} &= SEL_{ref} + 10 \log(V_d) - 35.6 \\
 &= 110 + 10 \log(2.8) - 35.6 \\
 &= 78.9 \text{ dBA}
 \end{aligned}$$

$$\begin{aligned}
 L_{n.LHorns} &= SEL_{ref} + 10 \log(V_n) - 35.6 \\
 &= 110 + 10 \log(0.7) - 35.6 \\
 &= 72.9 \text{ dBA}
 \end{aligned}$$

Calculate the L_{dn} at 50 ft from train horns using Eq. 4-9 :

$$\begin{aligned}
 L_{dn.LHorns} &= 10 \log(15 \times 10^{(L_{d.LHorns}/10)} + 9 \times 10^{(L_{n.LHorns}+10)/10}) - 13.8 \\
 &= 81 \text{ dBA}
 \end{aligned}$$

At-grade street crossings will have warning bells, typically sounding for 20 seconds for every train passby. The total daytime and nighttime durations are as follows:

$$\begin{aligned}
 E_d &= \text{average daytime hourly duration} \\
 &= 20 \text{ seconds} \times 2.8 \text{ trains/hour} = 56 \text{ seconds/hour} \\
 E_n &= \text{average nighttime hourly duration} \\
 &= 20 \text{ seconds} \times 0.7 \text{ trains/hour} = 14 \text{ seconds/hour}
 \end{aligned}$$

From Table 4-14:

$$\begin{aligned}
 L_{d.WBell} &= SEL_{ref} + 10 \log\left(\frac{E_d}{3600}\right) - 35.6 \\
 &= 109 + 10 \log\left(\frac{56}{3600}\right) - 35.6 \\
 &= 55.3 \text{ dBA}
 \end{aligned}$$

$$\begin{aligned}
 L_{n.WBell} &= SEL_{ref} + 10 \log\left(\frac{E_n}{3600}\right) - 35.6 \\
 &= 109 + 10 \log\left(\frac{14}{3600}\right) - 35.6 \\
 &= 49.3 \text{ dBA}
 \end{aligned}$$

Calculate L_{dn} at 50 ft. from the warning bells using Eq. 4-17:

$$\begin{aligned}
 L_{dn.WBell} &= 10 \log(15 \times 10^{(L_{d.WBell}/10)} + 9 \times 10^{(L_{n.WBell}+10)/10}) - 13.8 \\
 &= 57.3 \text{ dBA}
 \end{aligned}$$

Compared to horn blowing, the crossing signal warning bell noise is negligible, but still must be included in the evaluation.

Estimate Existing Noise Exposure

From Part I, the existing noise level is 60 dBA.

Determine Noise Level and Distance for the Onset Of Impact

As in Part I, the existing noise level (60 dBA) is used to determine the onset of moderate and severe impacts:

Existing Noise L_{dn}	Onset of Moderate Impact L_{dn}	Onset of Severe Impact L_{dn}
60 dBA	58 dBA	64 dBA

Determine the distance from the project noise sources to the impact contours using the fixed-guideway curve in Figure 4-6 (or the equations in Table 4-15) and the project impact thresholds obtained above. The project noise at 50 ft is approximately 81 dBA. However, there are at least two intervening rows of buildings, which will provide 6 dB (4.5 dB for the first row and 1.5 dB for the second row) of shielding.

Moderate impact (58 dBA)

$$58 - (81 - 6) = -17 \text{ dB}$$

According to Figure 4-6, the distance correction is approximately -17 dB at 715 ft.

Severe Impact (64 dBA)

$$64 - (81 - 6) = -11 \text{ dB}$$

According to Figure 4-6, the distance correction is approximately -11 dB at 265 ft.

Project Level L_{dn}	Onset of Moderate Impact Distance	Onset of Severe Impact Distance
81 dBA	715 ft	265 ft

Draw Noise Impact Contours

Contours can be drawn as in Part I for 1/4 mile on either side of the grade crossing.

Example 4-2 General Noise Assessment – Highway/Transit

General Noise Assessment Example of Highway/Transit Corridor Projects

This example illustrates a highway/transit project where the highway noise dominates and the FHWA assessment methods should be used to inform the FTA process according to the impact criteria in Section 4.1.

Case 1: Highway Dominates

A new LRT system is planned for the median of a major highway that carries heavy traffic both day and night. The noise levels at the first row of houses along the highway were measured during peak hour, mid-day and nighttime with hourly $L_{eq(1hr)}$ readings of 65 dBA, 63 dBA, and 60 dBA, respectively. The LRT tracks will be 125 ft from the first row of houses. The LRT operations during peak hour will be 4-car trains at 45 mph, with 5-minute headways in both directions. Nighttime service decreases to 2-car trains and 20 minute headways.

FTA is providing a share of the funding for the LRT project, but the State DOT and the FHWA are co-lead agencies because the median requires considerable preparation for the tracks, including replacing bridge piers of street crossings and moving some highway lanes.

Assumptions

$$\begin{aligned} SEL_{ref} &= 82 \text{ dBA} \\ Nd &= 4 \text{ cars per train} \\ Nn &= 2 \text{ cars per train} \\ S &= 45 \text{ mph} \\ V_d &= 24 \text{ trains per hour} \\ V_n &= 6 \text{ trains per hour} \end{aligned}$$

Estimate Project Noise Exposure at 50 ft

Use Table 4-9 and Table 4-10 to determine the peak hour $L_{eq(1hr)}$ for the rail vehicles.

Use Eq. 4-3 to calculate the LRT peak-hour noise level.

$$\begin{aligned} L_{d,RCars}(h) &= SEL_{ref} + 10 \log(N_{cars}) + 20 \log\left(\frac{S}{50}\right) + 10 \log(V) - 35.6 \\ &= 82 + 10 \log(4) + 20 \log\left(\frac{45}{50}\right) + 10 \log(24) - 35.6 \\ &= 65 \text{ dBA at 50 ft} \end{aligned}$$

Use Eq. 4-3 to calculate the LRT late evening hourly noise level.

$$\begin{aligned}
 L_{n.RCars}(h) &= SEL_{ref} + 10 \log(N_{cars}) + 20 \log\left(\frac{S}{50}\right) + 10 \log(V) - 35.6 \\
 &= 82 + 10 \log(2) + 20 \log\left(\frac{45}{50}\right) + 10 \log(6) - 35.6 \\
 &= 56 \text{ dBA at 50 ft}
 \end{aligned}$$

Estimate Project Noise Exposure at 125 ft

Since the LRT tracks will be 125 ft from the first row of houses, use Figure 4-6 to determine the level at 125 ft.

At 125 ft, the distance correction is 5 dB.

Peak hour:

$$65 - 5 = 60 \text{ dBA at 125 ft}$$

Night hourly:

$$56 - 5 = 51 \text{ dBA at 125 ft}$$

In this case, the highway dominates the noise environment in the area both day and night, by 5 dB during peak hour and 9 dB at night. According to Section 4.1 and Table 4-2, use the FHWA assessment methods.

Example 4-3 General Noise Assessment – BRT System

General Noise Assessment for a BRT System in an Existing Railroad Right-of-Way

This example for a simple BRT project illustrates using the FTA procedures for a new BRT corridor planned in an existing abandoned railroad ROW.

Assumptions

SEL_{ref}	= 82 for buses
S	= 25 mph
V_d	= (344 buses) / (15 hours) = 22.9 buses per hour
V_n	= (116 buses) / (9 hours) = 12.9 buses per hour

Estimate Project Noise Exposure

Use the information and equations in Table 4-12 to calculate the daytime and nighttime $L_{eq(1hr)}$ at 50 ft.

$C_S = 15$ for buses

$$\begin{aligned}
 L_{d.Bus} &= SEL_{ref} + 10 \log(V_d) + C_S \log\left(\frac{S}{50}\right) - 35.6 \\
 &= 82 + 10 \log(22.9) + 15 \log\left(\frac{25}{50}\right) - 35.6 \\
 &= 55 \text{ dBA at 50 ft}
 \end{aligned}$$

$$\begin{aligned}
 L_{n.Bus} &= SEL_{ref} + 10 \log(V_n) + C_S \log\left(\frac{S}{50}\right) - 35.6 \\
 &= 82 + 10 \log(12.9) + 15 \log\left(\frac{25}{50}\right) - 35.6 \\
 &= 53 \text{ dBA at 50 ft}
 \end{aligned}$$

Calculate L_{dn} at 50 ft for the project using Eq. 4-13.

$$\begin{aligned}
 L_{dn.Bus} &= 10 \log(15 \times 10^{(L_{d.Bus}/10)} + 9 \times 10^{(L_{n.Bus}+10)/10}) - 13.8 \\
 &= 60 \text{ dBA at 50 ft}
 \end{aligned}$$

Estimate Existing Noise Exposure

The surrounding area is residential with 2,500 people per square mile starting approximately 100 ft away from the proposed alignment. Determine the existing noise using Table 4-17.

$$L_{dn} = 50 \text{ dBA}$$

Determine Noise Level and distance for the Onset of Impact

Determine the noise level for the onset of moderate and severe impact using Figure 4-2 and the existing noise level of 50 dBA. Note that this project is land use category 2 and the appropriate metric is L_{dn} .

Existing Noise L_{dn}	Onset of Moderate Impact L_{dn}	Onset of Severe Impact L_{dn}
50 dBA	54 dBA	59 dBA

Determine the distance to the noise impact contours using the fixed-guideway & highway curve in Figure 4-6 (or the equations in Table 4-15) and the project impact thresholds obtained above. The project noise level at 50 ft is approximately 60 dBA.

Moderate impact (54 dBA)

$$54 - 60 = -6 \text{ dB}$$

According to Figure 4-6, the distance correction is approximately -6 dB at 125 ft.

Severe Impact (59 dBA)

$$59 - 60 = -1 \text{ dB}$$

According to Figure 4-6, the distance correction is less than -1 dB at approximately 60 ft.

Project Level L_{dn}	Onset of Moderate Impact Distance	Onset of Severe Impact Distance
60 dBA	125 ft	60 ft

Inventory of Noise Impact

Since there are residential land uses approximately 100 ft away from the proposed alignment and the onset of moderate impact is at 125 ft, there are possible moderate impacts to the residences.

Noise Mitigation

A barrier is proposed for mitigation between the BRT system and the residences. The analysis is repeated and results in a predicted new project level of 55 dBA and the following impact distances:

Mitigated Project Level L_{dn}	Onset of Moderate Impact Distance	Onset of Severe Impact Distance
55 dBA	60 ft	N/A

With a noise barrier in place between the BRT system and the residences, it is predicted that the onset of moderate impact would occur approximately 60 ft away from the BRT system. Since the residential area begins approximately 100 ft away from the BRT system, which is beyond the distance of moderate impact (60 ft), a noise barrier would provide the appropriate noise mitigation for the predicted moderate impact. The onset of severe impact is listed as N/A because with a noise barrier, the severe impact criterion is not exceeded by the project.

Example 4-4 General Noise Assessment – Transit Center

General Noise Assessment for a Transit Center

The following example illustrates the procedure for performing a General Noise Assessment for a stationary source. 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 4-8.

Assume that the Noise Screening Procedure has already been done for this project and the nearest residence has been identified approximately 140 ft from the center of the proposed transit center. Recall that if any residential or other noise-sensitive land use is identified within 150 ft of a transit center during the Noise Screening Procedure, additional analysis is required.

Assumptions

- **Main Street Traffic**
Peak hour traffic of 1200 autos, 20 heavy trucks, 300 medium trucks.
- **Population Density**
12 houses per block, single family homes, 3 people per family.
 - Block area 78,750 square ft.
 - Population density = 9,750 people/square mile.
- **Bus Traffic**

Period	Hours	Buses per Hour
Peak, Morning	7 a.m.–9 a.m.	30
Peak, Afternoon	4 p.m.–6 p.m.	30
Mid-day	9 a.m.–4 p.m.	15
Evening	6 p.m.–10 p.m.	12
Early Morning (Night)	6 a.m.–7 a.m.	15
Late Night	10 p.m.–1 a.m.	4

Estimate Project Noise Exposure at 50 ft

Determine the hourly volume of buses during day and night.

Daytime (7 a.m. – 10 p.m.)

$$V_d = \frac{273 \text{ buses}}{15 \text{ hours}} = 18.2 \text{ buses/hour}$$

Nighttime (10 p.m. – 7 a.m.)

$$V_n = \frac{27 \text{ buses}}{9 \text{ hours}} = 3 \text{ buses/hour}$$

Calculate the daytime and nighttime $L_{eq(1hr)}$ at 50 ft for the bus transit center using the reference levels in Table 4-13 and the equations in Table 4-14.

$$\begin{aligned}
 L_{d,BTCenter} &= SEL_{ref} + C_N - 35.6 \\
 &= 101 + 10\log\left(\frac{18.2}{20}\right) - 35.6 \\
 &= 65 \text{ dBA at 50 ft}
 \end{aligned}$$

$$L_{n,BTCenter} = SEL_{ref} + C_N - 35.6$$

$$= 101 + 10\log\left(\frac{3}{20}\right) - 35.6$$

$$= 57 \text{ dBA at 50 ft}$$

Calculate L_{dn} at 50 ft for the project using Eq. 4-17.

$$L_{dn.BTCenter} = 10\log(15 \times 10^{(L_{d.BTCenter}/10)} + 9 \times 10^{((L_{n.BTCenter}+10)/10)}) - 13.8$$

$$= 66 \text{ dBA at 50 ft}$$

Estimate Existing Noise Exposure

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

Roadway Noise Estimate – The traffic on Main Street qualifies this street for the Other Roadway category in Table 4-17. According to the map, the nearest residence is 275 ft from the edge of Main Street. The table shows existing $L_{dn} = 55$ dBA at this distance for representative busy city street traffic.

Population Density Noise Estimate – Noise from local streets is estimated from the population density of 9,750 people/square mile. Table 4-17 confirms that the L_{dn} is approximately 55 dBA.

In this example, the existing noise level by both the roadway and population density estimates are the same, but that is not always the case. If the levels are different, use the lower noise level. The existing noise level associated with the residential neighborhood in this example is $L_{dn} = 55$ dBA.

Determine Noise Level and Distance for the Onset of Impact

Determine the noise level for the onset of moderate and severe impact using Figure 4-2 and the existing noise level of 55 dBA. Note that this project is land use category 2 and the appropriate metric is L_{dn} .

Existing Noise L_{dn}	Onset of Moderate Impact L_{dn}	Onset of Severe Impact L_{dn}
55 dBA	56 dBA	62 dBA

Determine the distances from the center of the property to the noise impact contours using the stationary curve in Figure 4-6. The project noise level at 50 ft is 66 dBA.

Moderate impact (56 dBA)

$$56 - 66 = -10 \text{ dB}$$

According to Figure 4-6, the distance correction is approximately -10 dB at 125 ft.

Severe impact (62 dBA)

$$62 - 66 = -4 \text{ dB}$$

According to Figure 4-6, the distance correction is -4 dB at approximately 70 ft.

Project Noise L_{dn}	Onset of Moderate Impact Distance	Onset of Severe Impact Distance
66 dBA	125 ft	70 ft

Draw Noise Impact Contours

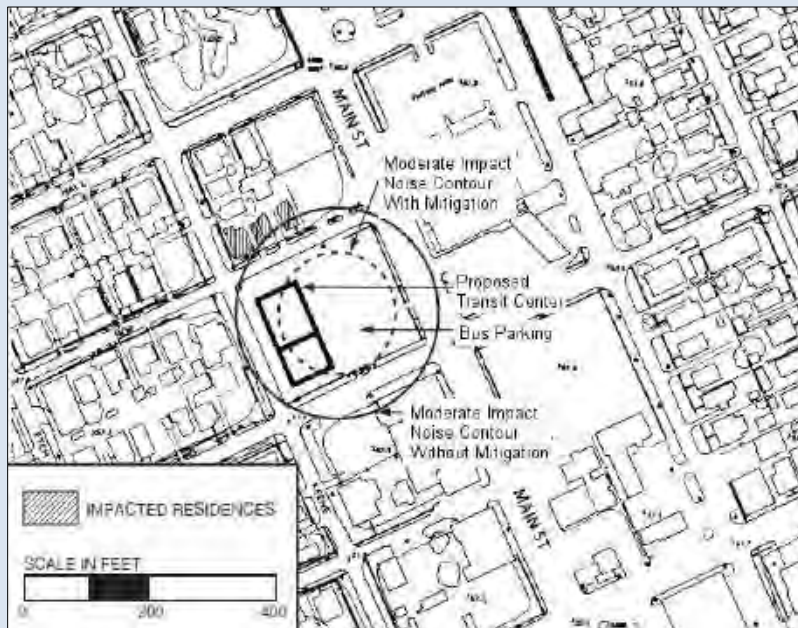
Draw lines at 70 ft and 125 ft from the center of the property of the proposed transit center. These lines represent the noise impact contours. (Note that in Figure 4-8 the severe impact contour is not drawn for clarity. The contour is just within the dashed line representing the moderate impact contour after mitigation).

Inventory of Noise Impact

Within, or touching, the contour defining moderate impact are three residential buildings (shaded in Figure 4-8). No residences are within the severe impact contour.

Noise Mitigation

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 ft high partially enclosing the transit center, sufficient to screen the residences but not the commercial block facing Main Street. According to Table 4-14, the approximate noise barrier effect is -5 dB. Repeating the procedure above, the noise barrier will reduce the moderate impact contour to 80 ft and the severe impact contour to 45 ft (note that at 50 ft the distance correction is 0), which in this example eliminates all potential impacts on the residences.



**Figure 4-8 Example of Project for General Noise Assessment:
Siting of Transit Center in Mixed Commercial/Residential Area**

4.5 Evaluate Impact: Detailed Noise Analysis

Evaluate for impact using the Detailed Noise Analysis procedure in this section, if appropriate. For guidelines on when the Detailed Noise Analysis is appropriate, review Section 4.2.

The steps in the Detailed Noise Analysis (Figure 4-9) parallel the steps in the General Noise Assessment, though the Detailed Noise Analysis employs equations for computations rather than graphs or tables. Each step in the Detailed Noise Analysis is more refined in the prediction of project noise and subsequent evaluation of mitigation measures. Noise projections from the project must be determined for each receiver.

- **Step 1: Identify Noise-Sensitive Receivers**

Identify the noise-sensitive receivers of interest in the impact analysis study, including clustering noise-sensitive areas. This identification is usually based

on the Screening Procedure and General Noise Assessment previously conducted.

- **Step 2: Determine Project Noise Source Reference Levels**
Determine the project noise sources and reference levels. Then, estimate the project noise exposure at the reference distance of 50 ft, considering operational characteristics. When appropriate, measurements may be used to determine noise source reference levels.
- **Step 3: Determine Propagation Characteristics**
Estimate project noise exposure as a function of distance, accounting for shielding and propagation along the path.
- **Step 4: Combine Noise Exposure from All Sources**
Combine all sources to predict the total project noise at receivers.
- **Step 5: Determine Existing Noise Exposure**
Determine the existing noise exposure. Measurements are used to determine the existing noise exposure. When measurements are unavailable, a simplified procedure to estimate existing noise exposure may be used with a clear justification to and approval by the FTA Regional office.
- **Step 6: Assess Noise Impact**
Assess the noise impact at each receiver of interest using separate procedures for transit only and multimodal transportation projects.
- **Step 7: Determine Noise Mitigation Measures**
Evaluate the need for mitigation and repeat the Detailed Noise Analysis with proposed mitigation.

When situations arise that are not explicitly covered in the Detailed Noise Analysis, professional judgment, in consultation with the FTA Regional office, may be used to extend these methods to cover these unique cases, when appropriate. Appendix G provides information on developing and using non-standard modeling procedures.

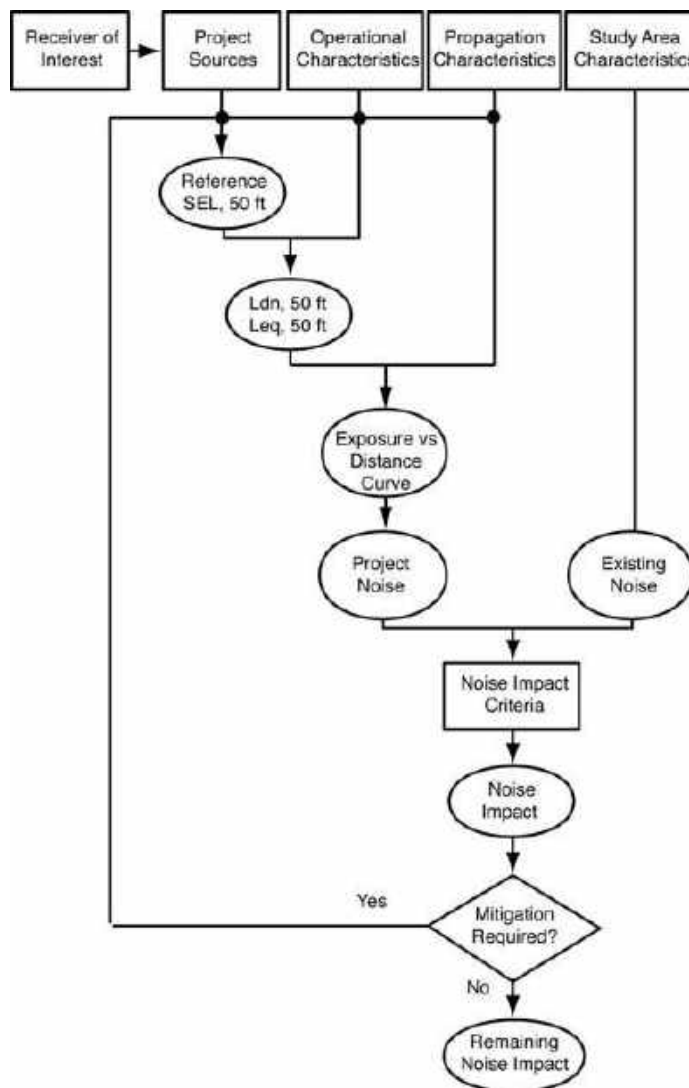


Figure 4-9 Procedure for Detailed Noise Analysis

Step 1: Identify Noise-Sensitive Receivers

Select the noise-sensitive receivers of interest, the number of which will depend upon the land use in the vicinity of the proposed project and the extent of the study area defined by the Noise Screening Procedure in Section 4.3 and the results of the General Noise Assessment in Section 4.4.

The steps in identifying the noise-sensitive receivers of interest, both the number of receivers needed and their locations, shown in Figure 4-10, include:

- Ia.** Identify all noise-sensitive land uses.
- Ib.** Select individual receivers of interest.
- Ic.** Cluster residential neighborhoods and other large noise-sensitive areas.

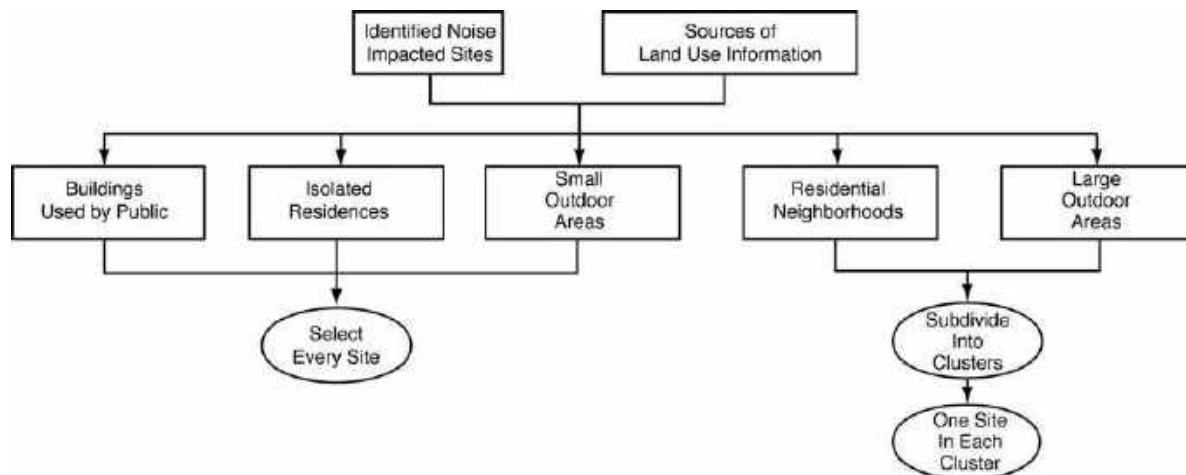


Figure 4-10 Guide to Selecting Noise-Sensitive Receivers of Interest

Ia. Identify all noise-sensitive land uses where impact is identified by the General Noise Assessment in Section 4.4. If a General Noise Assessment has not been done, include all noise-sensitive sites according to the Noise Screening Procedure in Section 4.3. In areas where ambient noise is low, include land uses that are farther from the proposed project than for areas with higher ambient levels.

Recommended materials and methods that can assist in locating noise-sensitive land uses near the proposed project include:

- **Land use maps** prepared by regional or local planning agencies or by the project staff. Area-wide maps often do not have sufficient detail to be of much use. But they can provide broad guidance and may suggest residential pockets hidden within otherwise commercial zones. Of more use are project-specific maps that provide building-by-building detail on the land near the proposed project.
- **Road and town maps** can supplement other maps, are generally more up-to-date, and may be of larger scale.
- **Aerial photographs**, when current, especially those of 400-ft scale or better, are valuable in locating all potential noise-sensitive land uses close to the proposed project. In addition, they can be useful in determining the distances between receivers and the project.
- **Windshield survey**, in which the corridor is driven and land uses are annotated on base maps, may be used for definitive identification of noise-sensitive sites. The windshield survey, supplemented by footwork where needed, is especially useful in identifying newly-constructed sites and in confirming land uses very close to the proposed project. In addition, maps and aerial photos typically reveal only horizontal distances, not vertical distances. Houses on a hill overlooking the project may need a barrier of unacceptable height for its attenuation to be effective, and the greater vertical distance between source and receiver may eliminate the impact entirely. The windshield survey would reveal where vertical contour maps

or other means may be needed so that vertical distances can be determined.

- **Geographic Information Systems (GIS)** provides electronic mapping needed for identifying noise-sensitive land uses. GIS data may include land parcels, building structures, aerial photography, and project-specific information. These data may be obtained during the project study or from local or regional agencies that store and maintain GIS data. Using electronic GIS data has advantages over paper mapping with respect to automating the process of identifying noise-sensitive land uses and accurately being able to determine their distances to the project alignment

Table 4-18 contains three types of *land uses of interest* and provides guidelines as to when receivers should be analyzed individually and when they can be clustered.

Table 4-18 Land Uses of Interest

Land Uses	Specific Use	Selecting Receivers
Residences	Isolated single family residences Neighborhoods (single and multi-family residences, apartment buildings, duplexes, etc.)	Select each isolated residence as a receiver of interest. For residential areas, cluster by proximity to project sources, proximity to ambient-noise sources, and location along project line. Choose one receiver of interest (closest to the project noise source and at an intermediate distance from the predominant sources of existing noise) in each cluster (i.e., Balance the distance between the receiver and the new noise source and the receiver and the existing noise source). Multiple clusters in one location may be needed to fully characterize the area.
Indoor noise-sensitive sites	Places of worship Schools Hospitals/nursing homes Libraries Public meeting halls Concert halls/auditoriums/theaters Recording/broadcast studios Museums and certain historic buildings Hotels and motels Other public buildings with noise-sensitive indoor use	Select noise-sensitive buildings as separate receivers of interest.
Outdoor noise-sensitive areas	Certain parks Historic sites used for interpretation Amphitheaters Passive recreation areas Cemeteries Other outdoor noise-sensitive areas	For relatively small noise-sensitive areas, select noise-sensitive sites as separate receivers of interest. For relatively large areas (e.g. a cemetery, etc.), cluster by proximity to project noise sources, proximity to ambient-noise sources, and location along project line. Choose one receiver of interest (closest to the project noise source and at an intermediate distance from the predominant sources of existing noise) in each cluster.

Ib. Select the following types of noise-sensitive receivers within the noise study area, per Table 4-18, to be evaluated as individual receivers:

- Every major noise-sensitive public building
- Every isolated residence
- Every relatively small outdoor noise-sensitive area

Use judgment to avoid analyzing noise where such analysis is obviously not needed. Areas that are considered particularly noise-sensitive by the community, but do not meet the criteria in Table 4-3, should be considered on a case-by-case basis as discussed in Section 4.1.

Ic. Residential neighborhoods and relatively large outdoor noise-sensitive areas can often be clustered, simplifying the analysis that is required without compromising the accuracy of the analysis. Subdivide all such neighborhoods/areas into clusters of approximately uniform noise, each containing a collection of noise-sensitive sites. Strive to obtain uniformity of both project noise and ambient noise using the following guidelines:

- In general, project noise reduces (drops off) with distance from the project. For this reason, project noise uniformity requires nearly equal distances between the project noise source and all sites within the cluster. Clusters are typically shaped as long narrow strips parallel to the transit corridor and/or circling project point sources such as maintenance facilities. It is suggested to cluster sites where the project noise varies over a range of 5 dB or less.
- Note that noise drops off approximately 3 dB per doubling of distance for line sources and approximately 6 dB per doubling of distance for point sources over open terrain. This reduction in noise will occur over a shorter distance in areas containing obstacles blocking the path of sound propagation, such as rows of buildings.
- Ambient noise usually drops off from non-project sources in the same manner as noise from project sources. For this reason, clustering for uniform ambient noise will usually result in long narrow strips parallel to major roadways or circling major point sources of ambient noise, such as manufacturing facilities. It is suggested to cluster sites where the ambient noise varies over a range of 5 dB or less. Ambient noise levels may be difficult to judge without measurements. In areas without predominant sources of noise, like highways, ambient noise can be considered to vary with population density, which is often uniform along the corridor. In situations where ambient noise tends to be uniform, the clusters can encompass relatively large areas.

After defining clusters, select one representative receiver in each cluster. It is recommended to choose the receiver closest to the project noise source and at an intermediate distance from the predominant sources of existing noise. See Appendix D for additional guidance and examples on clustering receivers, as well as an example.

Assess each identified cluster representative and individual noise-sensitive receiver of interest using the Detailed Noise Analysis as presented in the following steps.

Step 2: Determine Project Noise Source Reference Levels

Identify the major project noise sources near the noise-sensitive receivers of interest, group them by source type, and determine reference levels to compute project noise at 50 ft, as shown in Figure 4-11.

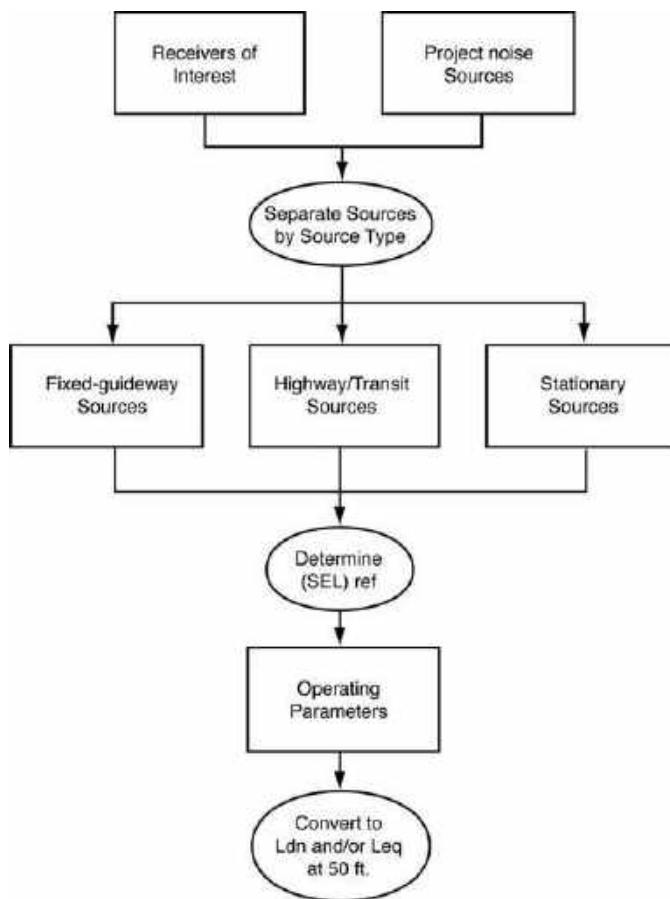


Figure 4-11 Flow Diagram for Determining Project Noise at 50 ft

2a. Identify the major project noise sources near receivers of interest according to Table 4-19. The right-hand column of the table indicates if each source is considered as a major contributor to the overall noise impact. Note that some noise sources can create high noise levels but are not indicated as major contributors. Although such sources are loud, they rarely stay in a neighborhood for more than a day or two; therefore, the overall noise exposure is relatively minor. Computations are required for all major noise sources in this table.

Table 4-19 Sources of Transit Noise

Project Type	Source Type	Actual Source	Major?
Commuter Rail Light Rail Streetcars RRT	Fixed-Guideway	Locomotive and rail car passbys	Yes
		Horns and whistles	Yes
		Crossing signals	Yes
		Crossovers/switches	Yes
		Squeal on tight curves	Yes
	Track-maintenance equipment	No	
	Stationary	Substations	Yes
		Chiller plants	No
Busways Bus Transit Malls	Highway/Transit	Bus passbys	Yes
		Buses parking	No
	Stationary	Buses idling	Yes
AGT Monorail	Fixed-Guideway	Vehicle passbys	Yes
	Miscellaneous	Line equipment	No
Terminals Stations Transit Centers	Fixed-Guideway	Locomotive and rail car passbys	Yes
		Crossovers/switches	Yes
		Squeal on tight curves	Yes
	Highway/Transit	Bus passbys	Yes
		Buses parking	No
		Automobile passbys	No
	Stationary	Locomotives idling	Yes
		Buses idling	Yes
		Ferry boats landing, idling, and departing at dock	Yes
HVAC equipment		No	
	Cooling towers	No	
	P/A systems	No	
Park-and-Ride Lots	Highway/Transit	Bus passbys	Yes
		Buses idling	Yes
		Automobile passbys	No
	Stationary	P/A systems	No
Traffic Diversion Projects	Highway/Transit	Highway vehicle passbys	Yes
Storage Facilities Maintenance Facilities	Fixed-Guideway	Locomotive and rail car passbys	Yes
		Locomotives idling	Yes
		Squeal on tight curves	Yes
		Horns, warning signals, coupling/ uncoupling, auxiliary equipment, crossovers/ switches, brake squeal, and air release	Yes
	Highway/Transit	Bus passbys	Yes
	Stationary	Buses idling	Yes
		Yard/shop activities	No
		Car washes	No
HVAC Equipment		No	
	P/A Systems	No	

2b. Separate the major noise sources by source type: fixed-guideway transit, highway/transit or stationary facility. Note that a major fixed-guideway system will usually have stationary facilities associated with it, and that a stationary facility may have highway/transit elements associated with it. Then use the instructions in the following source type options below to:

2c. Determine the source reference levels for the all project noise sources. Each source reference level pertains to reference operating conditions for stationary sources or one vehicle passby under reference operating conditions.

These reference levels should incorporate source-noise mitigation only if such mitigation will be considered for incorporation into the system specifications. The source levels used in this manual are typical of systems designed according to current engineering practice, but they do not include special noise control features that could be incorporated in the specifications at extra cost. If special features that result in noise reductions are included in any of the predictions, the Federal environmental documents must include a commitment by the project sponsor to adopt such treatments before the project is approved for construction. For example, if the specifications include vehicle noise limits that may not be exceeded, these limits should be used to determine the reference level, and this level should be used in the analysis rather than the standard, tabulated reference level.

2d. Convert the source reference level to noise exposure in terms of $L_{eq}(1hr)$ or L_{dn} under project operating conditions using the appropriate equations depending upon the type of source. The noise exposure is determined at the reference distance of 50 ft.

Option A. Fixed-guideway Sources – Compute project noise at 50 ft for fixed-guideway sources as identified in the second column of Table 4-19.

A.i. Reference SEL Levels

Determine the reference SEL at 50 ft for each major fixed-guideway noise source, either by measurement according to Appendix F or by referencing Table 4-20. The table provides guidance on which method is preferred for each source type. The "NO" designation implies that the source levels given in the table are appropriate to use in the analysis, and the "YES" designation implies that measurements are preferred over the data given in the table. In general, measurements are preferred for source types that vary considerably from project to project, including any emerging technology sources. The data in the table are adequate for source types that do not vary considerably from project to project.

For sources where measurements are preferred, refer to Appendix F for guidance on measurement procedures and methods for conversion of these measurements to the reference conditions of Table 4-20. For projects where source-noise specifications have been defined (e.g., noise limits are usually included in the specifications for purchase of new transit vehicles), these specifications may be used instead of measurements after conversion to reference conditions using the equations in Appendix F. This is only appropriate when there is a firm commitment to adopt the noise specifications in the vehicle

procurement documents during the engineering phase and to adhere to the specifications throughout the procurement, delivery, and testing of the vehicles.

Approximate L_{\max} values are provided in the table for general user information. As discussed in Appendix B.1.4.2, L_{\max} is not used directly in the evaluation of noise impact.

Table 4-20 Source Reference SELs at 50 ft: Fixed-Guideway Sources at 50 mph

Source	Reference SEL, dBA	Approximate L_{\max} , dBA	Prefer Measurements? *
Rail cars	82	80	No
Streetcars**	76	74	No
Locomotives – diesel	92	88	No
Locomotives – electric	90	86	No
Diesel multiple unit (DMU)	85	81	Yes
Agt – steel wheel	80	78	Yes
Agt – rubber tire	78	75	Yes
Monorail	82	80	Yes
Maglev	72	70	Yes
Transit car horns (emergency)	93	90	No
Transit car whistles	81	78	No
Locomotive horns			
At-grade crossing	113	110	No
From crossing to 1/8 mile	†	110	
From 1/8 mile to 1/4 mile	110	110	

* "No" implies that the source levels given in the table are appropriate to use in the analysis and

"Yes" implies that measurements are preferred over the data given in the table.

** The reference speed for streetcars is 25 mph. For streetcar speeds above 25 mph, use the "Rail Cars" reference level and 50 mph for the reference speed.

† Use the following equation for locomotive horns from crossing to 1/8 mile:

$$SEL_{Ref} = 113 - 3 \times \left(\frac{D_P}{660}\right)$$

where:

D_P = distance from grade crossing parallel to tracks

A.ii. Estimate Noise Exposure at 50 ft – Use the reference SELs in Table 4-20, operating conditions, and the equations in Table 4-21 to predict the noise exposure at 50 ft expressed in terms of $L_{eq(1hr)}$ and L_{dn} . Follow the steps below:

1. **Identify operating conditions** – Trains with different numbers of cars or operating conditions produce different noise exposure levels and should be converted from SEL to L_{dn} separately. Use the following guidelines to determine if sources should be converted separately. These differences in operating conditions will produce an approximate 2-decibel change in noise exposure:

- 40 percent change in number of locomotives or cars per train.
- 40 percent change in number of trains per hour.
- 40 percent change in number of trains per day, or per night (for computation of L_{dn}).
- 15 percent change in train speed.
- Change of one notch in diesel locomotive throttle setting (e.g., from notch 5 to notch 6).

2. Establish relevant time periods – For each of these source types and conditions, determine the relevant time periods for all receivers that may be affected by this source.

- For residential receivers, the time periods of interest for computation of L_{dn} are: daytime (7 a.m. to 10 p.m.) and nighttime (10 p.m. to 7 a.m.).
- If the source will affect non-residential receivers, the time period of interest is the loudest hour of project-related activity during hours of noise sensitivity. Several different hours may be of interest for non-residential receivers depending on the hours the facility is used.

3. Collect input data

- Source reference SELs for locomotives, rail cars, and warning horns.
- Number of rail cars in the train (if this number varies during the day, take the average for the daytime and nighttime periods separately for category 2 land uses, and use the maximum number during the period of interest for category 1 or 3 land uses).
- Number of locomotives in the train, if any.
- Train speed, in miles per hour (maximum expected).
- Average throttle setting of the train's locomotive(s) for diesel-powered locomotives and DMU's only.^(iv) If this input is not available, assume a throttle setting of 8 for locations where the vehicle would accelerate and 5 for all other locations.⁽²⁵⁾
- For residential receivers of interest:
 - Average hourly train volume during daytime hours (the total number of train passbys between 7 a.m. and 10 p.m., divided by 15 hours);
 - Average hourly train volume during nighttime hours (the total number of train passbys between 10 p.m. and 7 a.m., divided by 9 hours);
- For non-residential receivers of interest, number of events that occur during each hour of interest in trains per hour; and
- Track type (continuously welded or jointed) and profile (at-grade or elevated).

4. Calculate $L_{eq(1hr)}$ at 50 ft

- Calculate $L_{eq(1hr)}$ using the appropriate equations in Table 4-21 for each hour of interest.
- Compute the combined $L_{eq(1hr)}$. It may be necessary to compute the combined totals with and without the warning horns; some neighborhoods along the corridor may be exposed to the horn noise and some may not.

5. Calculate L_{dn} at 50 ft

- If the project noise will affect any residential receivers, calculate the L_{dn} using the combined day $L_{eq(1hr)}$ and the combined night $L_{eq(1hr)}$.
- It may be necessary to calculate L_{dn} with and without the warning horns, as above.

^{iv} Omit this term if not applicable from the equation in Table 4-21 for other vehicle types.

Note that the equations in Table 4-21 include terms to account for a difference in speed from the reference speed of 50 mph and a numerical adjustment to account for the one-hour time period for this metric. For more information on the numerical adjustment to represent the time period of interest, see Appendix B.1.4.4.

Table 4-21 Computation of $L_{eq(1hr)}$ and L_{dn} at 50 ft: Fixed-Guideway Sources

Locomotives* $L_{eq(1hr)}$ at 50 ft	$L_{eq.Loco(1hr)} = SEL_{ref} + 10 \log(N_{Loco}) + C_T + K \log\left(\frac{S}{50}\right) + 10 \log(V) - 35.6$	Eq. 4-25
Locomotive Warning Horns** $L_{eq(1hr)}$ at 50 ft	$L_{eq.LHorns(1hr)} = SEL_{ref} + 10 \log(V) - 35.6$	Eq. 4-26
Rail Vehicles† $L_{eq(1hr)}$ at 50 ft	$L_{eq.RCars(1hr)} = SEL_{ref} + 10 \log(N_{Cars}) + 20 \log\left(\frac{S}{50}\right) + 10 \log(V) - 35.6$ $+ Adj_{track}$	Eq. 4-27
Streetcar (25 mph or slower) $L_{eq(1hr)}$ at 50 ft	$L_{eq.SCars(1hr)} = SEL_{ref} + 10 \log(N_{Cars}) + 20 \log\left(\frac{S}{25}\right) + 10 \log(V) - 35.6 + Adj_{track}$	Eq. 4-28
Transit Warning Horns** $L_{eq(1hr)}$ at 50 ft	$L_{eq.THorns(1hr)} = SEL_{ref} - 10 \log\left(\frac{S}{50}\right) + 10 \log(V) - 35.6$	Eq. 4-29
Combined Locomotive and transit†† $L_{eq(1hr)}$ at 50 ft	$L_{eq.Combo(1hr)} = 10 \log(10^{(L_{eq.Loco(1hr)}/10)} + 10^{(L_{eq.RCars(1hr)}/10)} + 10^{(L_{eq.SCars(1hr)}/10)} + 10^{(L_{eq.LHorns(1hr)}/10)} + 10^{(L_{eq.THorns(1hr)}/10)})$	Eq. 4-30
Daytime L_d at 50 ft	$L_d = L_{eq(1hr)}$ where $V = V_d$, $N_{Loco} = N_d$ (loco events), and $N_{Cars} = N_d$ (car events)	Eq. 4-31
Nighttime L_n at 50 ft	$L_n = L_{eq(1hr)}$ where $V = V_n$, and $N_{Loco} = N_d$ (loco events), and $N_{Cars} = N_d$ (car events)	Eq. 4-32
Day/Night L_{dn} at 50 ft	$L_{dn} = 10 \log(15 \times 10^{(L_d/10)} + 9 \times 10^{(L_n+10)/10}) - 13.8$	Eq. 4-33
<p>N_{Loco} = average number of locomotives per train</p> <p>C_T = 0 for $T < 6$ $2(T - 5)$ for $T \geq 6$ where T = average throttle setting for diesel-powered locomotives and DMUs only</p> <p>K = -10 for passenger diesel 0 for DMUs[‡] +10 for electric</p> <p>N_{Cars} = average number of cars per train</p> <p>V = average hourly volume of train traffic, trains per hour</p> <p>S = train speed, mph</p> <p>Adj_{track} = constant +5 for jointed track or for a crossover within 300 ft +4 for aerial structure with slab track (except AGT and monorail) +3 for embedded track on grade</p> <p>V_d = average hourly daytime volume of train traffic, trains per hour = $\frac{\text{number of trains, 7 a.m. to 10 p.m.}}{15}$</p> <p>$N_d$ = average hourly number of events that occur during daytime (7 a.m. to 10 p.m.) = $\frac{\text{number of events between 7 a.m. to 10 p.m.}}{15}$</p> <p>$V_n$ = average hourly nighttime volume of train traffic, trains per hour = $\frac{\text{number of trains, 10 p.m. to 7 a.m.}}{9}$</p> <p>$N_n$ = average hourly number of events that occur during nighttime (10 p.m. to 7 a.m.) = $\frac{\text{number of events between 10 p.m. to 7 a.m.}}{9}$</p>		

* Assumes a diesel locomotive power rating at approximately 3000 hp ** Based on FRA's horn noise model (www.fra.dot.gov/Elilib/Document/2681)

† Includes all commuter rail cars, transit cars, streetcars above 25 mph, AGT and monorail. †† Only include appropriate terms.

‡ Because of the wide range of vehicle types that qualify as a DMU, measurements are preferred for the reference level and speed coefficient. If no measurements are conducted, use the reference level in Table 4-20 and a speed coefficient of 0.

Example 4-5 Detailed Noise Analysis – Fixed Guideway Noise Sources**Computation of $L_{eq(1hr)}$ and L_{dn} at 50 ft for Fixed-Guideway Source**

A commuter train with 1 diesel locomotive and 6 cars will pass close to a residential area at a grade crossing. The track is jointed.

Assumptions

$$\begin{aligned}
 SEL_{ref} &= 92 \text{ for diesel locomotives} \\
 &= 82 \text{ for rail cars} \\
 &= 113 \text{ for locomotive warning horns at-grade crossing} \\
 N_{Cars} &= 6 \\
 N_{Loco} &= 1 \\
 S &= 43 \text{ mph} \\
 T &= 8 \\
 V_d &= 40 \text{ trains/15 hours} = 2.667 \text{ trains per hour} \\
 V_n &= 2 \text{ trains/9 hours} = 0.222 \text{ trains per hour}
 \end{aligned}$$

Use the equations in Table 4-2I to determine the daytime $L_{eq(1hr)}$ for each source and the combined daytime $L_{eq(1hr)}$ at 50 ft.

$$\begin{aligned}
 L_{d.Locs(1hr)} &= SEL_{ref} + 10 \log(N_{Loco}) + C_T + K \log\left(\frac{S}{50}\right) + 10 \log(V_d) - 35.6 \\
 &= 92 + 10 \log(1) + 6 + (-10) \log\left(\frac{43}{50}\right) + 10 \log(2.667) - 35.6 \\
 &= 67.3 \text{ dBA at 50 ft}
 \end{aligned}$$

$$\begin{aligned}
 L_{d.RCars(1hr)} &= SEL_{ref} + 10 \log(N_{Cars}) + 20 \log\left(\frac{S}{50}\right) + 10 \log(V_d) - 35.6 + Adj_{track} \\
 &= 82 + 10 \log(6) + 20 \log\left(\frac{43}{50}\right) + 10 \log(2.667) - 35.6 + 5 \\
 &= 62.1 \text{ dBA at 50 ft}
 \end{aligned}$$

$$\begin{aligned}
 L_{d.LHorn(1hr)} &= SEL_{ref} + 10 \log(V_d) - 35.6 \\
 &= 113 + 10 \log(2.667) - 35.6 \\
 &= 81.7 \text{ dBA at 50 ft}
 \end{aligned}$$

$$\begin{aligned}
 L_{d.Combo(1hr)} &= 10 \log \left[10^{(L_{d.Locs(1hr)}/10)} + 10^{(L_{d.RCars(1hr)}/10)} + 10^{(L_{d.LHorn(1hr)}/10)} \right] \\
 \text{With horn:} &= 81.9 \text{ dBA in neighborhoods where the horn is sounded}
 \end{aligned}$$

$$\begin{aligned}
 \text{Without horn:} &= 10 \log \left[10^{(L_{d.Locs(1hr)}/10)} + 10^{(L_{d.RCars(1hr)}/10)} \right] \\
 &= 68.4 \text{ dBA in neighborhoods where the horn is not sounded}
 \end{aligned}$$

Use the same equations as above to determine the nighttime $L_{eq(1hr)}$ at 50 ft. Use V_n instead of V_d .

$$\begin{aligned}
 L_{n.Locs(1hr)} &= 56.5 \text{ for locomotives} \\
 L_{n.RCars(1hr)} &= 51.3 \text{ for cars} \\
 L_{n.LHorn(1hr)} &= 70.9 \text{ for horns} \\
 L_{n.Combo(1hr)} &= 71.1 \text{ in neighborhoods where the horn is sounded} \\
 &= 57.6 \text{ in neighborhoods where the horn is not sounded}
 \end{aligned}$$

Calculate the L_{dn} with and without horns.

$$L_{dn.Combo} = 10 \log \left[15 \times 10^{(L_{d.Combo}/10)} + 9 \times 10^{((L_{n.Combo}+10)/10)} \right] - 13.8$$

With horn: = 81.6 at 50 ft in neighborhoods where horns are sounded
 Without horn: = 68.1 at 50 ft in neighborhoods where horns are not sounded

Note: Computation results should always be rounded to the nearest decibel at the end of the computation. In all examples of this section, however, the first decimal place is retained for readers to precisely match their own computations against the example computations.

Option B. Highway/Transit Sources – Compute project noise at 50 ft for highway/transit noise sources as identified in the second column of Table 4-19. Use the instructions below to estimate source noise levels for projects following FTA's procedures that involve highway vehicles.

This method is based on the original FHWA highway noise prediction model, with updated noise emission levels.⁽²⁶⁾ The vehicle equations are applicable to speeds typical of freely-flowing traffic on city streets and access roads.

B.i. Reference SEL Levels – Determine the reference SEL at 50 ft for each major highway/transit source, either by measurement according to Appendix F or by using Table 4-22.^(v) The table provides guidance on which method is preferred for each source type. "NO" implies that the source levels given in the table are appropriate to use in the analysis, and "YES" implies that measurements are preferred over the data given in the table. For sources where measurements are preferred, refer to Appendix F for guidance on measurement procedures and methods for conversion of measurement data to the reference conditions in Table 4-20.

Approximate L_{max} values are provided in the table for general user information. As discussed in Appendix B.1.4.2, L_{max} is not used directly in the evaluation of noise impact.

Table 4-22 Source Reference SELs at 50 ft: Highway/Transit Sources at 50 mph

Source	Reference SEL, dBA	Approximate L_{max} , dBA	Prefer Measurements?*
Automobiles	74	70	No
Buses (diesel)	82	79	No
Buses (electric trolleybus)	80	77	No
Buses (hybrid)**	83	80	Yes

* "No" implies that the source levels given in the table are appropriate to use in the analysis and "Yes" implies that measurements are preferred over the data given in the table.

** Hybrid bus with full-time diesel engine and electric drive motors.

^v Idling buses are considered stationary sources.

B.ii. Noise Exposure at 50 ft – Use the reference SELs in Table 4-22, operating conditions, and the equations in Table 4-23 to predict the noise exposure at 50 ft expressed in terms of $L_{eq(1hr)}$ and L_{dn} . Follow the steps below:

1. **Identify operating conditions** – Noise emission from most transit buses is not dependent upon whether the buses are accelerating or cruising. However, accelerating suburban buses are substantially louder than cruising suburban buses. For this reason, suburban buses require separate calculation along roadway stretches where they are accelerating. Separate calculation is also needed for all highway/transit vehicles at different speeds, since speed affects noise emissions. Use the following guidelines to determine if sources should be calculated separately. These differences in operating conditions will produce an approximate 2-decibel change in noise exposure:
 - 40 percent change in number of vehicles per hour;
 - 40 percent change in number of vehicles per day, or per night (for computation of L_{dn}); or
 - 15 percent change in vehicle speed.
2. **Establish relevant time periods** – For each of these source types and conditions, determine the relevant time periods for all receivers that may be affected by this source.
 - For residential receivers, the time periods of interest for computation of L_{dn} are: daytime (7 a.m. to 10 p.m.) and nighttime (10 p.m. to 7 a.m.).
 - If the source will affect non-residential receivers, the time period of interest is the loudest hour of project related activity during hours of noise sensitivity. Several different hours may be of interest for non-residential receivers depending on the hours the facility is used.
3. **Collect input data**
 - Source reference SELs for the vehicle types of concern
 - Average running speed in miles per hour
 - For residential receivers of interest:
 - Average hourly vehicle volume during daytime hours (total number of vehicle passbys between 7 a.m. and 10 p.m., divided by 15).
 - Average hourly vehicle volume during nighttime hours (total number of vehicle passbys between 10 p.m. and 7 a.m., divided by 9).
 - For non-residential receivers of interest, number of events that occur during each hour of interest, in vehicles per hour
4. **Calculate $L_{eq(1hr)}$ at 50 ft – Calculate $L_{eq(1hr)}$ using the appropriate equations in Table 4-23 for each hour of interest.**
5. **Calculate L_{dn} at 50 ft** – If the project noise will affect any residential receivers, calculate the L_{dn} using the day $L_{eq(1hr)}$ and night $L_{eq(1hr)}$.

Note that the equations in Table 4-23 include terms to account for a difference in speed from the reference speed of 50 mph and a numerical adjustment to

account for the one-hour time period for this metric. For more information on the numerical adjustment to represent the time period of interest, see Appendix B.I.4.4.

Table 4-23 Computation of $L_{eq(1hr)}$ and L_{dn} at 50 ft: Highway/Transit Sources

$L_{eq(1hr)}$ at 50 ft	$L_{eq(1hr)} = SEL_{ref} + 10 \log(V) + C_{emissions} - 10\log(\frac{S}{50}) - 35.6$	Eq. 4-34
Daytime L_d at 50 ft	$L_d = L_{eq(1hr)}$ where $V = V_d$	Eq. 4-35
Nighttime L_n at 50 ft	$L_n = L_{eq(1hr)}$ where $V = V_n$	Eq. 4-36
L_{dn} at 50 ft	$L_{dn} = 10\log(15 \times 10^{(L_d/10)} + 9 \times 10^{((L_n+10)/10)}) - 13.8$	Eq. 4-37
Adjustments	$= -3$ for automobiles, open-graded asphalt $= +3$ for automobiles, grooved pavement	
<div> V = average hourly volume of vehicles, vehicles per hour </div> <div> $C_{emissions}$ = $25\log(\frac{S}{50})$ for buses $31\log(\frac{S}{50})$ for hybrid buses ⁽²³⁾ 1.6 for accelerating 3-axle commuter buses $40\log(\frac{S}{50})$ for automobiles </div> <div> S = average vehicle speed, mph (distance divided by time, excluding stop time at red lights) </div> <div> V_d = average hourly daytime volume of vehicles of this type, vehicles per hour $= \frac{total\ vehicle\ volume,\ 7\ a.m.\ to\ 10\ p.m.}{15}$ </div> <div> V_n = average hourly nighttime volume of vehicles, vehicles per hour $= \frac{total\ vehicle\ volume,\ 10\ p.m.\ to\ 7\ a.m.}{9}$ </div>		

Example 4-6 Detailed Noise Analysis – Highway Transit Noise Sources

Computation of $L_{eq(1hr)}$ and L_{dn} at 50 ft for Highway/Transit Source

A bus route with city buses will pass close to a school that is in session from 8 a.m. to 4 p.m. on weekdays. Within this time period, the hour of greatest activity for this bus route is 8 a.m. to 9 a.m.

Assumptions

$$\begin{aligned}
 SEL_{ref} &= 82 \text{ dBA} \\
 S &= 40 \text{ mph} \\
 V &= 30 \text{ buses per hour}
 \end{aligned}$$

Use the equations in Table 4-23 to determine the hourly $L_{eq(1hr)}$ at 50 ft.

$$\begin{aligned}
 L_{d,Bus} &= SEL_{ref} + 10 \log(V) + C_{emissions} - 10 \log\left(\frac{S}{50}\right) - 35.6 \\
 &= 82 + 10 \log(30) + 6 + 25 \times \log\left(\frac{40}{50}\right) - 10 \log\left(\frac{40}{50}\right) - 35.6 \\
 &= 59.7 \text{ dBA at 50 ft}
 \end{aligned}$$

This same bus also passes close to a residential area with the following operating conditions:

$$\begin{aligned} V_d &= 200 \text{ buses}/15 \text{ hours} = 13.33 \text{ buses per hour} \\ V_n &= 20 \text{ buses}/9 \text{ hours} = 2.22 \text{ buses per hour} \end{aligned}$$

Calculate the daytime and nighttime $L_{eq(1hr)}$ at 50 ft.

$$\begin{aligned} L_{d.Bus} &= 82 + 10 \log(13.33) + 6 + 25 \times \log\left(\frac{40}{50}\right) - 10 \log\left(\frac{40}{50}\right) - 35.6 \\ &= 56.2 \text{ dBA at 50 ft} \end{aligned}$$

$$\begin{aligned} L_{n.Bus} &= 82 + 10 \log(2.22) + 6 + 25 \times \log\left(\frac{40}{50}\right) - 10 \log\left(\frac{40}{50}\right) - 35.6 \\ &= 48.4 \text{ dBA at 50 ft} \end{aligned}$$

Calculate L_{dn} at 50 ft.

$$\begin{aligned} L_{dn.Bus} &= 10 \log(15 \times 10^{(L_{d.Bus}/10)} + 9 \times 10^{((L_{n.Bus}+10)/10)}) - 13.8 \\ &= 57.2 \text{ dBA at 50 ft} \end{aligned}$$

Note: Computation results should always be rounded to the nearest decibel at the end of the computation. In all examples of this section, however, the first decimal place is retained for readers to precisely match their own computations against the example computations.

Option C. Stationary Sources – Compute project noise at 50 ft for stationary sources as identified in the second column of Table 4-19.

C.i. Determine Reference SEL Levels – Determine the reference SEL at 50 ft for each major stationary source, either by measurement according to Appendix F or by using Table 4-24. The table provides guidance on which method is preferred for each source type. "NO" implies that the source levels given in the table are appropriate to use in the analysis, and "YES" implies that measurements are preferred over the data given in the table. In general, measurements are preferred for source types that vary considerably from project to project. For example, curve squeal is highly variable depending on weather conditions, curve radius, and train speed. The data in the table are adequate for source types that do not vary considerably from project to project (crossing signals, for example). For sources where measurements are preferred, refer to Appendix F for guidance on measurement procedures and methods for conversion of these measurements to the reference conditions of Table 4-24.

Layover facilities and transit centers can be the sources of low-frequency noise from idling diesel engines. Sounds with considerable low-frequency components can cause greater annoyance than would be expected based on their A-weighted levels. Low-frequency sounds often cause windows and walls to vibrate resulting in secondary effects in buildings such as rattling of dishes in cupboards and wall-mounted pictures. The reference levels in Table 4-24 are adjusted to take increased annoyance into account. For a Detailed Noise Analysis at locations where such idling takes place for an extended period, use the method described in ANSI Standard S12.9-Part 4, Annex D.⁽²⁷⁾

Approximate L_{max} values are provided in the table for general user information. As discussed in Appendix B.1.4.2, L_{max} is not used directly in the evaluation of noise impact.

Table 4-24 Source Reference SELs at 50 ft: Stationary Sources

Source	Reference SEL, dBA	Approximate L_{max} , dBA	Prefer Measurements?*
Auxiliary Equipment	101	65	Yes
Locomotive Idling	109	73	No
Rail Transit Idling	106	70	No
Buses Idling	111	75	No
Ferry Boat Landing**, Idling, and Departing	91	78	No
Ferry Boat Fog Horn	90	84	No
Track Curve Squeal	136	100	Yes
Car Washes	111	75	Yes
Crossing Signals	109	73	No
Substations	99	63	No

* "No" implies that the source levels given in the table are appropriate to use in the analysis, and "YES" implies that measurements are preferred over the data given in the table.

**Ferry boat landings are included in the stationary source category because the noise from the landing remains in one area even though the boats move in and out.

C.ii. Estimate Noise Exposure at 50 ft – Use the reference SELs in Table 4-24, operating conditions, and the equations in Table 4-25 to predict the noise exposure at 50 ft expressed in terms of $L_{eq(1hr)}$ and L_{dn} . Follow the steps below:

1. **Identify operating conditions** – Identify actual source durations and numbers of events. Sources with different operating conditions should be converted from SEL to L_{dn} separately. Use the following guidelines to determine if sources should be converted separately. These differences in operating conditions will produce an approximate 2-dB change in noise exposure:
 - 40 percent change in event duration (e.g., from 30 to 42 minutes), or
 - 40 percent change in number of events per hour (e.g., from 10 to 14 events per hour).
2. **Establish relevant time periods** – For each of these source types and conditions, determine the relevant time periods for all receivers that may be affected by this source.
 - For residential receivers, the time periods of interest for computation of L_{dn} are: daytime (7 a.m. to 10 p.m.) and nighttime (10 p.m. to 7 a.m.).
 - If the source will affect non-residential receivers, the time period of interest is the loudest hour of project related activity during hours of noise sensitivity. Several different hours may be of interest for non-residential receivers depending on the hours the facility is used.
3. **Collect input data**
 - Source reference SELs for each relevant source
 - Average duration of one event, in seconds
 - For residential receivers of interest:
 - Average number of events per hour that occur during the daytime (the total number of events between 7 a.m. and 10 p.m., divided by 15).

- Average number of events per hour that occur during the nighttime (the total number of events between 10 p.m. and 7 a.m., divided by 9).
- For non-residential receivers of interest, number of events that occur during each hour of interest in events per hour

4. **Calculate $L_{eq(1hr)}$ at 50 ft** – Calculate $L_{eq(1hr)}$ using the appropriate equations in Table 4-25 for each hour of interest.

5. **Calculate L_{dn} at 50 ft** – If the project noise will affect any residential receivers, calculate the L_{dn} using the day $L_{eq(1hr)}$ and night $L_{eq(1hr)}$.

Note that the equations in Table 4-25 include a numerical adjustment to account for the one-hour time period for this metric. For more information on the numerical adjustment to represent the time period of interest, see Appendix B.I.4.4.

Table 4-25 Computation of $L_{eq(1hr)}$ and L_{dn} at 50 ft: Stationary Sources

$L_{eq(1hr)}$ at 50 ft	$L_{eq(1hr)} = SEL_{ref} + 10 \log(N) + 10 \log\left(\frac{E}{3600}\right) - 35.6$	Eq. 4-38
Daytime L_d at 50 ft	$L_d = L_{eq(1hr)}$ where $N = N_d$	Eq. 4-39
Nighttime L_n at 50 ft	$L_n = L_{eq(1hr)}$ where $N = N_n$	Eq. 4-40
L_{dn} at 50 ft	$L_{dn} = 10 \log(15 \times 10^{(L_d/10)} + 9 \times 10^{((L_n+10)/10)}) - 13.8$	Eq. 4-41
<p>N = number of events of this type that occur during one-hour</p> <p>E^* = duration of one event, sec</p> <p>N_d = average hourly number of events that occur during daytime (7 a.m. to 10 p.m.)</p> <p style="padding-left: 40px;">$= \frac{\text{number of events between 7 a.m. to 10 p.m.}}{15}$</p> <p>$N_n$ = average hourly number of events that occur during nighttime (10 p.m. to 7 a.m.)</p> <p style="padding-left: 40px;">$= \frac{\text{number of events between 10 p.m. to 7 a.m.}}{9}$</p>		

*Omit the term containing E for ferry boat, and fog horn noise sources.

Example 4-7 Detailed Noise Analysis – Stationary Noise Sources

Computation of $L_{eq(1hr)}$ and L_{dn} at 50 ft for Stationary Sources

A signal crossing lies close to a school that is in session from 8 a.m. to 4 p.m. on weekdays. Within this time period, the hour of greatest activity for the signal crossing is 8 a.m. to 9 a.m.

Assumptions

$$\begin{aligned} SEL_{ref} &= 109 \text{ dBA} \\ E &= 25 \text{ seconds (counting both cycles of the signal)} \\ N &= 22 \end{aligned}$$

Use the equations in Table 4-25 to determine the hourly $L_{eq(1hr)}$ at 50 ft.

$$\begin{aligned} L_{d.Cross} &= SEL_{ref} + 10\log(N) + 10\log\left(\frac{E}{3600}\right) - 35.6 \\ &= 109 + 10\log(22) + 10\log\left(\frac{25}{3600}\right) - 35.6 \\ &= 65.2 \text{ dBA at 50 ft} \end{aligned}$$

This same signal crossing lies close to a residential area with the following operating conditions:

$$\begin{aligned} N_d &= 200 / 15 \text{ hours} = 13.3 \text{ events per hour} \\ N_n &= 12 / 9 \text{ hours} = 1.33 \text{ events per hour} \end{aligned}$$

Calculate the daytime and nighttime $L_{eq(1hr)}$ at 50 ft.

$$\begin{aligned} L_{d.Cross} &= 109 + 10\log(13.3) + 10\log\left(\frac{25}{3600}\right) - 35.6 \\ &= 63.1 \text{ dBA at 50 ft} \\ L_{n.Cross} &= 109 + 10\log(1.33) + 10\log\left(\frac{25}{3600}\right) - 35.6 \\ &= 53.1 \text{ dBA at 50 ft} \end{aligned}$$

Calculate L_{dn} at 50 ft.

$$\begin{aligned} L_{dn} &= 10\log\left(15 \times 10^{(L_{d.Cross}/10)} + 9 \times 10^{((L_{n.Cross}+10)/10)}\right) - 13.8 \\ &= 63.1 \text{ dBA at 50 ft} \end{aligned}$$

Note: Computation results should always be rounded to the nearest decibel at the end of the computation. In all examples of this section, however, the first decimal place is retained for readers to precisely match their own computations against the example computations.

Step 3: Determine Propagation Characteristics

Determine the combined propagation characteristics between each source and receiver of interest.

3a. Calculate project noise exposure as a function of distance. Calculate the project noise exposure at distances other than 50 ft, such as at receiver locations, as a function of distance accounting for shielding and ground effects along the path. See Example 4-8 below.

1. Determine the topography of the ground within the transit corridor using the figures in Table 4-26 as a guide. It is not necessary to represent the transit corridor with an extreme number of changes in topography. Often, several typical sections will suffice throughout the transit corridor.
2. Use the equations in Table 4-26 to determine ground factor (G) based on the effective path height (Heff) for each identified terrain feature. Standard source heights are included at the bottom of the table. Assume receiver heights of 5 ft for both outdoor receivers and first-floor receivers. Note that larger ground factors correspond to larger amounts of ground attenuation with increasing distance from the source. For acoustically "hard" (e.g., non-absorptive) ground conditions, G should be taken to be zero.
3. Determine the distance correction factor using the ground factor and another distance, such as the distance to a receiver, and the equations in Table 4-27.
4. Apply the distance correction ($C_{distance}$) to the project noise exposure at 50 ft (Section 4.5, Step 2) using the following equation:

$$L_{distance} = L_{50ft} + C_{distance} \quad \text{Eq. 4-42}$$

where:

$$\begin{array}{ll} L_{distance} & = L_{dn} \text{ or } L_{Aeq(1hr)} \text{ at the new distance, ft} \\ L_{50ft} & = L_{dn} \text{ or } L_{Aeq(1hr)} \text{ at 50 ft} \end{array}$$

5. Plot noise exposure as a function of distance if desired.

Table 4-26 Ground Factor G, for Ground Attenuation


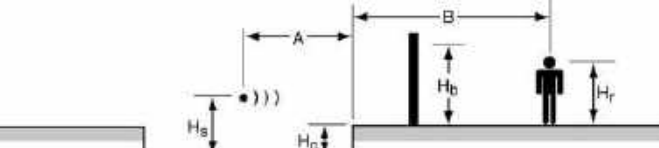
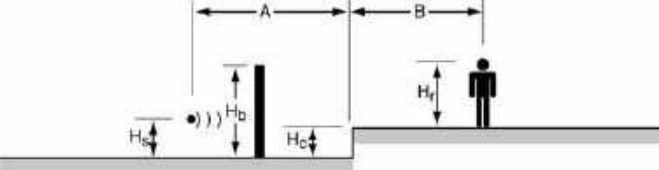
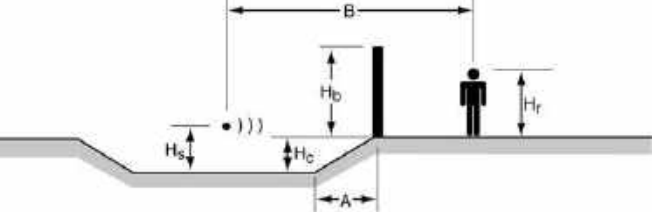
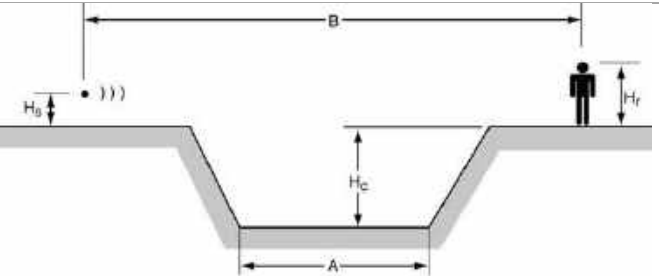
Ground Factor		
Soft Ground:	$G = \begin{cases} 0.66, & H_{eff} \leq 5 \\ 0.75(1 - \frac{H_{eff}}{42}), & 5 < H_{eff} < 42 \\ 0, & H_{eff} \geq 42 \end{cases}$	Eq. 4-43
H_{eff} = sum of average path heights on either side of the barrier, see below.		
Hard Ground:	$G = 0$	
 <p>Figure 4-12 Flat Ground</p>	$H_{eff} = \frac{H_s + 2H_b + H_r}{2}$	Eq. 4-44
 <p>Figure 4-13 Source in Shallow Cut</p>	$H_{eff} = \frac{H_s + 2H_b + H_c + H_r}{2} \quad \text{for } B \leq \frac{A}{2}$ <p>Use Eq. 4-44 $\quad \text{for } B > \frac{A}{2}$</p>	
 <p>Figure 4-14 Elevated Receiver</p>	$H_{eff} = \frac{H_s + H_c + H_r}{2} \quad \text{for } H_b \leq H_c$ $H_{eff} = \frac{H_s + 2H_b - H_c + H_r}{2} \quad \text{for } H_b > H_c$	
 <p>Figure 4-15 Source in Sloped Cut</p>	<p>Use Eq. 4-44 $\quad \text{for } A \leq \frac{B}{2}$</p> $H_{eff} = \frac{H_s + 2H_b + H_c + H_r}{2} \quad \text{for } A > \frac{B}{2}$	
 <p>Figure 4-16 Source and Receiver Separated by Trench</p>	$H_{eff} = \frac{H_s + H_r}{2} \quad \text{for } A \leq \frac{B}{2}$ $H_{eff} = \frac{H_s + 2H_c + H_r}{2} \quad \text{for } A > \frac{B}{2}$	
H_s = 8 ft for trains with diesel-electric locomotives = 2 ft for trains without diesel-electric locomotives = 0 ft for automobiles		
= 3 ft for 2-axle city buses = 8 ft for 3-axle commuter buses		
Note: Equations for H_{eff} remain valid when $H_b = 0$		

Table 4-27 Distance Correction Factor Equations for Detailed Noise Analysis

Source	Equation*
Stationary Sources	$C_{distance} = -20\log\left(\frac{D}{50}\right) - 10G\log\left(\frac{D}{50}\right)$ Eq. 4-45
Fixed-guideway rail car passbys	$C_{distance} = -10\log\left(\frac{D}{50}\right) - 10G\log\left(\frac{D}{42}\right)$ Eq. 4-46
Fixed-guideway locomotive and rubber-tired vehicle passbys, highway vehicle passbys and horns	$C_{distance} = -10\log\left(\frac{D}{50}\right) - 10G\log\left(\frac{D}{29}\right)$ Eq. 4-47
D = distance, ft G = ground factor, see Table 4-26	

*These equations assume the distance between the source and receiver is approximately 300 ft or less. At longer distances, ground effects have an upper limit and atmospheric conditions may affect propagation characteristics. Therefore, more detailed calculation methods may be required to account for those effects.

Example 4-8: Detailed Noise Analysis – Exposure vs. Distance Curve

Exposure vs. Distance Curve for Fixed-Guideway Source

Plot an exposure vs. distance curve for a diesel-electric commuter train that does not sound the horn in this area.

Assumptions

The terrain is flat grassland without a noise barrier.

$$\begin{aligned}
 L_{eq.Loco} (8-9am) &= 72 \text{ dBA at } 50 \text{ ft} \\
 L_{dn.Loco} &= 68 \text{ dBA at } 50 \text{ ft} \\
 H_r &= 5 \text{ ft} \\
 H_b &= 0 \text{ ft (for a "no noise barrier" case)} \\
 H_s &= 8 \text{ ft (for a diesel-electric commuter train)}
 \end{aligned}$$

Calculate H_{eff} using the equations in Table 4-26.

$$\begin{aligned}
 H_{eff} &= \frac{H_s + 2H_b + H_r}{2} \\
 &= \frac{8 + 0 + 5}{2} \\
 &= 6.5 \text{ ft}
 \end{aligned}$$

Determine the ground factor using Eq. 4-43.

$$\begin{aligned}
 G &= 0.75\left(1 - \frac{H_{eff}}{42}\right) \\
 &= 0.63
 \end{aligned}$$

Use Eq. 4-45 to determine noise vs. exposure equations for $L_{d,loco}$ and $L_{dn,loco}$.

$$\begin{aligned}
 L_{eq.Loco} &= 72 - 10\log\left(\frac{D}{50}\right) - 6.3\log\left(\frac{D}{42}\right) \\
 L_{dn.Loco} &= 68 - 10\log\left(\frac{D}{50}\right) - 6.3\log\left(\frac{D}{42}\right)
 \end{aligned}$$

Plot the two equations (see example in Figure 4-17). From these curves, the noise levels due to this train operation can be determined for a receiver of interest at any distance without shielding.

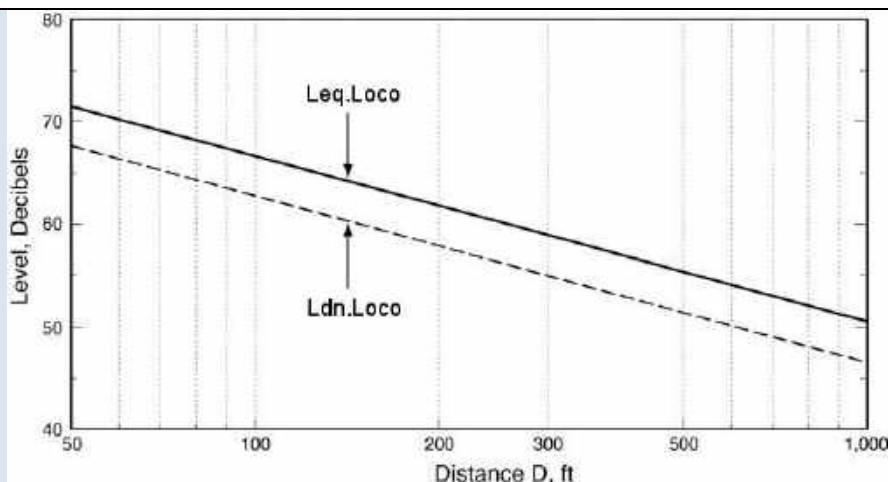


Figure 4-17 Example Exposure vs. Distance Curves

3b. Calculate the attenuation due to shielding for each distance of interest from Step 3a, using the following equation and Tables 4-26 through 4-30 and as illustrated in Example 4-9. If the conditions described in the tables are not met, the attenuation due to shielding is considered zero. Shielding can be due to intervening noise barriers, terrain features, rows of buildings, and dense tree zones.

$$A_{\text{shielding}} = \max\{IL_{\text{barrier}} \text{ or } A_{\text{buildings}} \text{ or } A_{\text{trees}}\} \quad \text{Eq. 4-48}$$

where:

IL_{barrier} = barrier insertion loss, see Table 4-28

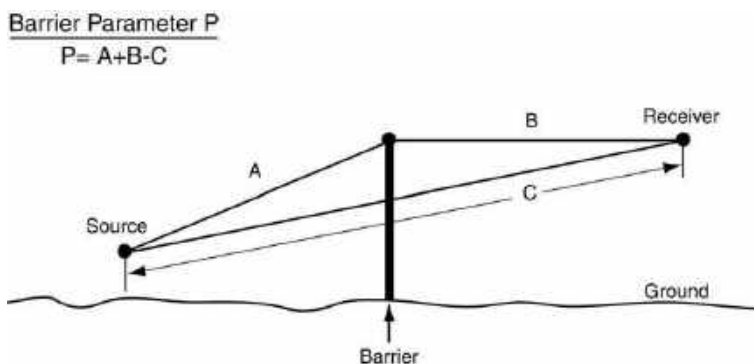
$A_{\text{buildings}}$ = attenuation due to buildings, see Table 4-29

A_{trees} = attenuation due to trees, see Table 4-30

Table 4-28 Barrier Insertion Loss

Barrier Insertion Loss	$IL_{\text{barrier}} = \max\{0 \text{ or } (A_{\text{barrier}} - 10(G_{\text{NB}} - G_{\text{B}}) \log(\frac{D}{50}))\}$	Eq. 4-49
A_{barrier}	$= \min\{12 \text{ or } [5.3 \log(P) + 6.7]\}$	For non-absorptive transit barriers within 5 ft of the rail
	$= \min\{15 \text{ or } (5.3 \log(P) + 9.7)\}$	For absorptive transit barriers within 5 ft of the rail
	$= \min\{15 \text{ or } (20 \log(\frac{2.51\sqrt{P}}{\tanh(4.46\sqrt{P})}) + 5)\}$	For all other barriers, and for protrusion of terrain above the line of sight
<p>P = path length difference, ft (see figure 4-18)*</p> <p>D = closest distance between the receiver and the source, ft</p> <p>G_{NB} = ground factor G computed without barrier (see Table 4-26)</p> <p>G_{B} = ground factor G computed with barrier (see Table 4-26)</p>		

* If the source height (exhaust outlet) for diesel-electric locomotives is not available, assume 15 ft.

**Figure 4-18 Noise Barrier Parameter "P"****Table 4-29 Attenuation due to Buildings**

Condition	Equation	
Gaps in the row of buildings constitute less than 35% of the length of the row	$A_{buildings} = \min\{10 \text{ or } [1.5 (R - 1) + 5]\}$	Eq. 4-50
Gaps in the row of buildings constitute 35 to 65% of the length of the row	$A_{buildings} = \min\{10 \text{ or } [1.5 (R - 1) + 3]\}$	Eq. 4-51
Gaps in the row of buildings constitute more than 65% of the length of the row	$A_{buildings} = 0$	
R = number of rows of houses that intervene between the source and receiver		

Table 4-30 Attenuation due to Trees

Condition	Equation	
At least 100 ft of trees intervene between the source and receiver with no clear line-of-sight between source and receiver, and the trees extend 15 ft or more above the line-of-sight	$A_{trees} = \min\left\{10 \text{ or } \frac{W}{20}\right\} \text{ where } W \geq 100\text{ft}$ $= 0 \text{ where } W < 100\text{ft}$	Eq. 4-52
W = width of tree zone along the line-of-sight between the source and receiver in feet		

Example 4-9: Detailed Noise Analysis – Shielding**Computation of Shielding**

The following features are between the rail corridor and a receiver of interest. Calculate the attenuation due to shielding.

1. A 15-foot high noise barrier is 40 ft from the closest track and 130 ft from the receiver
2. A dense tree zone 100 ft thick that extends 15 ft above the line-of-sight

Assumptions

$$H_s = 8 \text{ ft}$$

$$H_r = 5 \text{ ft}$$

Barrier dimensions

$$A = 40.61 \text{ ft}$$

$$B = 130.38 \text{ ft}$$

$$C = 170.03 \text{ ft}$$

Barrier

Calculate H_{eff} with and without the barrier using the equations in Table 4-26.

$$H_{eff.NoBarrier} = \frac{H_s + 2H_b + H_r}{2}$$

$$\begin{aligned}
 &= 8 + 0 + 5 \\
 &= \frac{2}{2} \\
 &= 6.5 \text{ ft}
 \end{aligned}$$

$$\begin{aligned}
 H_{eff.Barrier} &= H_s + 2H_b + H_r \\
 &= \frac{8 + 15 + 5}{2} \\
 &= 21.5 \text{ ft}
 \end{aligned}$$

Determine the ground factor with and without the barrier using Eq. 4-43.

$$\begin{aligned}
 G_{NoBarrier} &= 0.75(1 - \frac{H_{eff}}{42}) \\
 &= 0.63
 \end{aligned}$$

$$\begin{aligned}
 G_{Barrier} &= 0.75(1 - \frac{H_{eff}}{42}) \\
 &= 0.37
 \end{aligned}$$

Calculate the barrier insertion loss using Table 4-28 and Figure 4-18.

$$\begin{aligned}
 P &= A + B - C \\
 &= 0.96 \text{ ft}
 \end{aligned}$$

$$\begin{aligned}
 A_{barrier} &= \min\{15 \text{ or } (20 \log(\frac{2.51\sqrt{P}}{\tanh(4.46\sqrt{P})}) + 5)\} \\
 &= 12.8 \text{ dB} \\
 &= \min\{15 \text{ or } 12.8\} \\
 &= 12.8 \text{ dB}
 \end{aligned}$$

$$\begin{aligned}
 IL_{barrier} &= \max\{0 \text{ or } (A_{barrier} - 10(G_{NoBarrier} - G_{Barrier}) \log(\frac{D}{50}))\} \\
 &= 12.8 - 10(0.63 - 0.37) \log(\frac{170}{50}) \\
 &= 11.4 \text{ dB}
 \end{aligned}$$

Trees

Determine the attenuation due to trees using Table 4-30.

$$\begin{aligned}
 A_{trees} &= \min\{10 \text{ or } \frac{W}{20}\} \\
 &= 5 \text{ dB}
 \end{aligned}$$

Total Shielding

The total shielding is the maximum of the barrier and tree zone shielding, 11.4 dB.

$$\begin{aligned}
 A_{shielding} &= \max\{IL_{barrier} \text{ or } A_{buildings} \text{ or } A_{trees}\} \\
 &= \max\{11.4 \text{ or } 0 \text{ or } 5\} \\
 &= 11.4 \text{ dB}
 \end{aligned}$$

Note: Computation results should always be rounded to the nearest decibel at the end of the computation. In all examples of this section, however, the first decimal place is retained for readers to precisely match their own computations against the example computations.

3c. Combine the two propagation characteristics.

Combine the results from Steps 3a and 3b to determine the noise at the receiver considering the propagation characteristics of distance and shielding by applying the distance correction and attenuation due to shielding to the project noise exposure level at 50 ft.

The equations in Table 4-31 combine the equations in Steps 3a and 3b.

Table 4-31 Calculate L_{dn} or $L_{eq}(1hr)$

Source	Equation*
Stationary Sources	$L_{DistShield} = L - 20 \log\left(\frac{D}{50}\right) - 10G \log\left(\frac{D}{50}\right) - A_{shielding}$ Eq. 4-53
Fixed-guideway rail car passbys	$L_{DistShield} = L - 10 \log\left(\frac{D}{50}\right) - 10G \log\left(\frac{D}{42}\right) - A_{shielding}$ Eq. 4-54
Fixed-guideway locomotive and rubber-tired vehicle passbys, highway vehicle passbys and horns	$L_{DistShield} = L - 10 \log\left(\frac{D}{50}\right) - 10G \log\left(\frac{D}{29}\right) - A_{shielding}$ Eq. 4-55
$L = L_{dn} \text{ or } L_{eq}$ $D = \text{distance, ft}$ $G = \text{ground factor, see Section 4.5, Step 3a}$ $A_{shielding} = \text{attenuation due to shielding, see Section 4.5, Step 3b.}$	

*These equations assume the distance between the source and receiver is approximately 300 ft or less. At longer distances, ground effects have an upper limit and atmospheric conditions may affect propagation characteristics. Therefore, more detailed calculation methods may be required to account for those effects.^(28, 29)

Step 4: Combine Noise Exposure from All Sources

Combine all sources to predict the total project noise at the receivers using the equations in Table 4-32 after propagation adjustments have been made for the noise exposure from each source separately.

Table 4-32 Computing Total Noise Exposure

Total $L_{eq}(1hr)$ from all sources for the hour of interest:	$L_{eq.total(1hr)} = 10 \log(\sum_{all\ sources} 10^{L_{Aeq(1hr)}/10})$ Eq. 4-56
Total L_{dn} from all sources	$L_{dn.total} = 10 \log(\sum_{all\ sources} 10^{L_{dn}/10})$ Eq. 4-57

Example 4-10 Detailed Noise Analysis – Combine Sources**Computation of Total Exposure from Combined Sources**

Combine the noise exposure from the commuter train and light rail system to estimate the total noise exposure at the receiver.

Assumptions

A commuter train operation produces the following levels at a receiver of interest:

$$L_{eq.Commuter} = 72 \text{ dBA}$$

$$L_{dn.Commuter} = 68 \text{ dBA}$$

A light rail system produces the following levels at the same receiver:

$$L_{eq.LightRail} = 69 \text{ dBA}$$

$$L_{dn,LightRail} = 70 \text{ dBA}$$

No other project sources affect this receiver.

Calculate the total noise exposure at the receiver using the equations in Table 4-32.

$$\begin{aligned} L_{eq,total} &= 10\log(10^{(72/10)} + 10^{(69/10)}) \\ &= 73.8 \text{ dBA} \end{aligned}$$

$$\begin{aligned} L_{dn,total} &= 10\log(10^{(68/10)} + 10^{(70/10)}) \\ &= 72.1 \text{ dBA} \end{aligned}$$

Note: Computation results should always be rounded to the nearest decibel at the end of the computation. In all examples of this section, however, the first decimal place is retained for readers to precisely match their own computations against the example computations.

Step 5: Determine Existing Noise Exposure

Choose the appropriate method for characterizing noise and then determine the existing noise at each identified noise-sensitive receiver. The existing noise is needed to determine the noise impact according to the criteria described in Section 4.1, Step 2. Recall that impact is assessed based on a comparison of the existing ambient noise exposure and the additional noise exposure that will be caused by the project. The existing noise exposure must be estimated for all receivers of interest identified in Section 4.5, Step 1.

For a Detailed Noise Analysis, it is recommended to measure existing noise at each receiver of interest identified in Section 4.5, Step 1, for the most precise assessment of existing noise and conclusions concerning noise impact. However, measurements are expensive, often thwarted by weather, and take considerable time in the field. If taking measurements at each identified receiver is not possible, other less precise methods are available. Different methods may be used at different receivers along the project. However, it is important to recognize the correlation between the precision of measurements and the confidence in the impact assessment. Especially in a Detailed Noise Analysis, avoid using less precise methods of measuring existing noise just for the sake of convenience or expediency. The use of less precise methods must be clearly justified.

Option A. Noise Exposure Measurements – Full one-hour measurements are the most appropriate way to determine ambient noise exposure for non-residential receivers with the level of precision expected in a Detailed Noise Analysis. For residential receivers, full 24-hour measurements are more appropriate. These full-duration measurements are preferred over other methods of characterizing existing noise where time and study funds allow.

Follow the procedures below for these full-duration ambient noise exposure measurements:

Ai. Non-residential land uses – Measure a full hour $L_{eq(1hr)}$ at the receiver of interest on at least two non-successive weekdays (generally between noon on Monday and noon on Friday). Select the hour of the day when the maximum project activity is expected to occur.

A.ii. Residential land uses – Measure a full 24-hour L_{dn} at the receiver of interest for a single weekday (generally between noon on Monday and noon on Friday).

A.iii. Microphone position – The location of the microphone at the receiver depends upon the proposed location of the transit noise source, so use good technical judgment in positioning the measurement microphone. If, for example, a new rail line will be in front of the house, do not locate the microphone in the backyard behind the house where the line of sight between the noise source and receiver is obstructed. Figure 4-19 illustrates recommended measurement positions for various locations of the project, with respect to the house and the existing source of ambient noise.

A.iv. Measurement guidelines – Undertake all measurements in accordance with good engineering practice following guidelines given in ASTM and ANSI standards.⁽³⁰⁾⁽³¹⁾

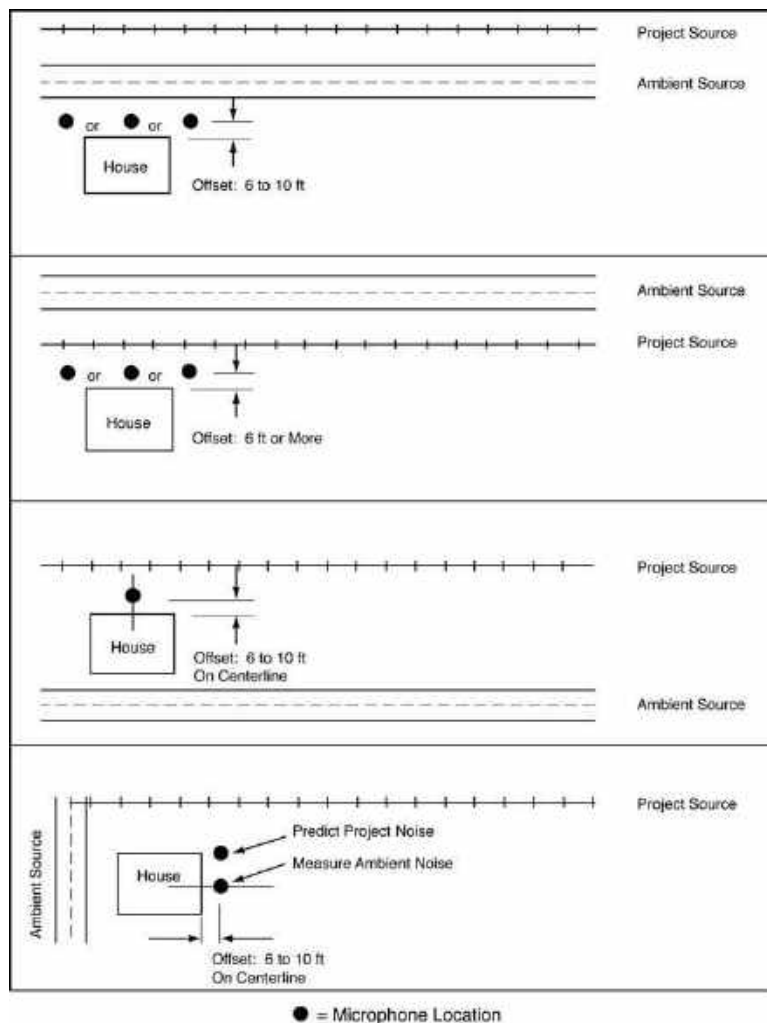


Figure 4-19 Recommended Microphone Locations for Existing Noise Measurements

Option B. Noise Exposure Computations from Partial Measurements

– Often, measurements can be made at some of the receivers of interest and used to estimate noise exposure at nearby receivers. In other situations, several $L_{eq(1hr)}$ measurements can be taken at a receiver and then the L_{dn} computed from these. Both options require experience and knowledge of acoustics to select representative measurement sites. If using this method to compute an L_{dn} , a minimum time period of one hour should be used for each measurement period. It is unacceptable to extrapolate a one hour measurement from a shorter measurement period.

Measurements at one receiver can be used to represent the noise environment at other sites, but only when proximity to major noise sources is similar among the sites. Residential neighborhoods with otherwise similar homes may have greatly varying noise environments. For example, one area of the neighborhood may be located where the ambient noise is clearly due to highway traffic. A second area toward the interior of the neighborhood may have highway noise as a factor, but also include other noise sources from the community. A third area located deep into the residential area could have local street traffic and other community activities dominate the ambient noise. In this example, three or more measurement sites would be required to represent the varying ambient noise conditions in a single neighborhood.

Typical situations where representative measurement sites can be used to estimate noise levels at other sites occur when both share the following characteristics:

- Proximity to the same major transportation noise sources, such as highways, rail lines and aircraft flight patterns
- Proximity to the same major stationary noise sources, such as power plants, industrial facilities, rail yards and airports
- Similar type and density of housing, such as single-family homes on quarter-acre lots and multi-family housing in apartment complexes

Acoustical professionals are often adept at such computations from partial data and are encouraged to use their experience and judgment in fully utilizing the measurements in their computations. This does necessitate a conservative estimate (underestimate) of existing noise to account for reduced precision from partial data as compared to full noise measurements.

Those without a background in acoustics are encouraged to use the procedures in Appendix E to compute existing noise from partial measurements. These methods include a factor to conservatively estimate (underestimate) existing noise to account for reduced precision from partial data as compared to full noise measurements.

Option C. Estimating Existing Noise Exposure – The least precise way to determine noise exposure is to estimate it from a table. This method is often used for the General Noise Assessment, but it is not recommended for a Detailed Noise Analysis. It can be used, however, in the absence of better data for locations where roadways or railroads are the predominant ambient noise source. Table 4-17 presents these existing levels. The levels in Table 4-17 are

conservative and underestimate existing noise to account for reduced precision compared to full noise measurements. If a simplified procedure to estimate existing noise exposure is chosen it must be clearly justified and receive approval by the FTA Regional office.

While measurements are considered the most precise method, there is one situation where it may be more accurate to estimate rather than measure the existing noise exposure, which is in areas near major airports where aircraft noise is dominant. Because airport noise is highly variable based on weather conditions and corresponding runway usage, it is preferable in such cases to base the existing noise exposure on published aircraft noise contours in terms of Annual Average L_{dn} .

Step 6: Assess Noise Impact

Assess noise impact at each receiver of interest identified in Section 4.5, Step 1 using the noise impact criteria in Section 4.1 and the procedures in this step. Choose the appropriate noise impact assessment procedure for a transit project or multimodal project.

Option A. Transit Projects – For transit projects, noise impact is assessed at each receiver of interest using the criteria for transit projects described in Section 4.1. The noise impact assessment procedure is as follows:

A.i. Tabulate existing ambient noise exposure (rounded to the nearest whole decibel) at all receivers identified Section 4.5, Step 1. In cases where large residential buildings are exposed to noise on one side only, the receivers on that side are included in the analysis.

A.ii. Tabulate project noise exposure at these receivers from Section 4.5, Step 4.

A.iii. Determine the level of noise impact (no impact, moderate impact, or severe impact) according to Section 4.1.

A.iv. Document the results in noise-assessment inventory tables. Include the following information:

- Receiver identification and location
- Land use description
- Number of noise-sensitive sites represented (number of dwelling units in residences or acres of outdoor noise-sensitive land)
- Closest distance to the project
- Existing noise exposure
- Project noise exposure
- Level of noise impact (no impact, moderate impact, or severe impact)
- A sum of the total number of receivers and numbers of dwelling units predicted to experience moderate impact or severe impact

A.v. Illustrate the areas of moderate impact and severe impact. Two methods of displaying impact are labeling and contouring.

- In a Detailed Noise Analysis, the most accurate indication of impact is to label each impacted building or cluster identified in the inventory table.
- A less precise illustration of impacted areas is a plot of project noise contours on the maps or aerial photographs, along with shaded impact areas. Use the procedures in Section 4.4, Step 6 and the levels from Section 4.5, Step 2 to develop these contours.

Note that it is difficult to position noise contours in urban areas due to shielding, terrain features, and other propagation anomalies. If noise contours are used, they should be considered illustrative rather than definitive. If desired to conform to the practices of another agency, the contouring may perhaps include several contour lines of constant project noise, such as L_{dn} 65, L_{dn} 70, and L_{dn} 75 dBA.

A.vi. Including information on the magnitude of the impacts is an essential part of the assessment. The magnitude of noise impact is defined by the two threshold curves delineating onset of moderate impact and severe impact.

Option B. Multimodal Projects – For multimodal projects, project noise comprised of both highway and transit noise sources that are assessed according to the FTA noise impact criteria (see Table 4-2), use the procedure in Option A above. For multimodal projects that require FHWA's noise assessment methods to inform FTA's evaluation (see Section 4.1, Step 1 - Option B), follow the FHWA guidance.⁽³²⁾ In general, the appropriate calculation method is to use the current version of FHWA's Traffic Noise Model (TNM).⁽²²⁾ TNM is a state-of-the-art computer program used for predicting noise impacts near highways.

TNM allows for a detailed assessment at each receiver of interest by separately calculating the noise contribution of each roadway segment. For each roadway segment, the noise from each vehicle type is computed from reference noise levels, adjusted for:

- Vehicle volume
- Vehicle speed
- Grade
- Roadway segment length
- Source-to-receiver distance

Further adjustments needed to accurately model the sound propagation from source to receiver include:

- Shielding provided by rows of buildings,
- Effects of different ground types,
- Source and receiver elevations, and
- Effect of any intervening noise barriers.

TNM sums the noise contributions of each vehicle type for a given roadway segment at the receiver. TNM then repeats this process for all roadway segments, summing their contributions to generate the predicted noise level at each receiver.

Step 7: Determine Noise Mitigation Measures

Evaluate alternative mitigation measures where the Detailed Noise Analysis shows either severe or moderate impact, and it is not feasible to change the alignment or location of the project to avoid impact. Project noise that is found to cause no impact does not generally require any mitigation.

Mitigation of noise impact from transit projects may involve treatments at the three fundamental components of the noise problem: at the noise source, along the source-to-receiver propagation path, or at the receiver. Generally, the transit property has authority to treat the source and some elements of the propagation path, but may have little or no authority to modify anything at the receiver. After mitigation options have been determined, repeat the project noise computations including the adopted mitigation and reassess the remaining noise impact.

Approximate costs for noise control measures are documented in a report from the Transit Cooperative Research Program (TCRP)⁽³³⁾ and are also presented in this section. These costs reflect the noise mitigation costs available in 1997 (unless otherwise noted), which are the most recent data available as of this publication, and should only be used as representative estimates when considering noise mitigation options. Current noise mitigation costs should be researched before decisions on noise mitigation options are finalized, and then they should be documented according to Section 8.

7a. Evaluate Source Treatments – The most effective noise mitigation treatments are applied at the noise source. This is the preferred approach to mitigation when possible. Common source treatments and their estimated acoustical effectiveness are included in Table 4-33 and described below. It is important to note that the values below are estimates and should be applied with good engineering judgement. It also important to note that these mitigation measures should not be applied as a reduction in the reference SEL values for a vehicle that already incorporates that measure as a feature, such as vehicle skirts. Measurements to determine the reference SEL source level are required in those instances.

Table 4-33 Transit Noise Mitigation Measures – Source Treatments

Mitigation Measure		Effectiveness
Stringent Vehicle & Equipment Noise Specifications		Varied
Operational Restrictions†		Varied
Resilient or Damped Wheels*	For rolling noise on tangent track:	2 dB
	For wheel squeal on curved track:	10-20 dB
Vehicle Skirts*		6-10 dB
Undercar Absorption*		5 dB
Quiet Fan Design and Fan Placement*		Varied
Preventative Maintenance on Rail Systems*		Varied
Resurfacing Roads**		10 dB
Guideway Support for Buses**		10 dB
Turn Radii Greater than 1000 ft*		Avoids Squeal
Rail Lubrication on Sharp Curves*		Reduces Squeal
Movable-Point Frogs (reduce rail gaps at crossovers)*		Reduces Impact Noise
Engine Compartment Treatments		6-10 dB
Quiet Zones*		Reduces occurrence of horn noise

†FTA does not normally accept operational restrictions as a noise mitigation measure – see below.

* Applies to rail projects only.

** Applies to bus projects only.

- **Stringent Vehicle and Equipment Noise Specifications**

- **Vehicles** – Among the most effective noise mitigation treatments is noise control during the specification and design of the transit vehicle. Such source treatments apply to all transit modes. By developing and enforcing stringent but achievable noise specifications, the transit property takes a major step in controlling noise everywhere on the system. It is important to ensure that the noise levels quoted in the specifications are achievable with the application of best available technology during the development of the vehicle and reasonable considering the noise reduction benefits and costs.

Effective enforcement includes penalties for non-compliance with the specifications. The noise mitigation achieved by source treatment is dependent on the quality of installation and maintenance. Vehicles failing to meet the noise specification could result in complaints from the public and require additional noise mitigation measures applied along the path or at receivers.

- **Stationary sources** – Stringent but achievable noise specifications for stationary sources are also an effective approach for mitigating noise impacts. Typical equipment includes fixed plant equipment such as transformers and mechanical equipment, as well as grade-crossing signals. For example, it may be possible to reduce noise impact from grade-crossing signals in some areas by specifying equipment that sets the level of the warning signal lower in locations where ambient noise is lower to minimize the signal noise in the direction of noise-sensitive receivers.

- **Operational Restrictions** – Changes in operations that can mitigate noise include the lowering of speed, the reduction of nighttime (10 p.m. to 7 a.m.) operations, and reduction of warning horns and signals.

- **Speed reduction** – Because noise from most transit vehicles is dependent on speed, a reduction of speed results in lower noise levels. The effect can be considerable. For example, the speed dependency of steel-wheel/steel-rail systems for $L_{eq(1hr)}$ and L_{dn} (Table 4-21) results in a 6-dB reduction when reducing the speed to half of the original speed.

Although there are tangible benefits from speed reductions during the most noise-sensitive time periods, FTA does not ordinarily accept speed reduction as a noise mitigation measure for two important reasons: speed reduction is unenforceable and negated if vehicle operators do not adhere to established policies, and it is contrary to the purpose of the transit investment by FTA, which is to move as many people as possible as efficiently and safely as possible.

- **Reduction of nighttime operations** – Complete elimination of nighttime operations has a strong effect on reducing the L_{dn} , because nighttime noise is increased by 10 dB when calculating L_{dn} . But restrictions on operations are usually not feasible because of service demands. FTA generally does not pursue restrictions on operations as a

noise reduction measure. However, if early morning idling can be curtailed to the minimum necessary, however, this can have a measurable effect on L_{dn} .

While there are tangible benefits from limits on operations during the most noise-sensitive time periods, FTA does not recommend limits on operations as a way to reduce noise impacts because it is contrary to the purpose of the transit investment by FTA which is to move as many people as possible as efficiently and safely as possible.

- **Reduction of warning horns and signals** – Minimizing or eliminating horns and other warning signals at gate crossings can reduce noise impact for light rail and commuter rail systems. Although these mitigation options are limited by safety considerations, they can be effective in the right circumstances. For examples, see quiet zones below and wayside horns in Step 7b.
- **Wheel Treatments (Rail)** – A major source of noise from steel-wheel and steel-rail systems is the wheel/rail interaction that can produce three distinctive sounds: roar, impact, and squeal (as discussed in Section 3.2). Roar is the rolling noise caused by small-scale roughness on the wheel tread and rail running surface. Impacts are caused by discontinuities in the running surface of the rail or by a flat spot on the wheels. Squeal occurs when a steel-wheel tread or its flange rubs across the rail, resulting in resonant vibrations in the wheel that creates a screeching sound. Various wheel designs and other mitigation measures exist to reduce the noise from each of these three mechanisms.
 - **Resilient wheels** – Resilient wheels are effective in eliminating wheel squeal on tight turns with reductions of 10 to 20 dB in the high-frequency range where squeal noise occurs. Rolling noise is also slightly reduced with resilient wheels and typically achieves a 2-dB reduction on tangent track. The costs for resilient wheels are approximately \$2000 to \$3000 per wheel, as compared to about \$400 to \$700 for standard steel wheels.^(vi)
 - **Damped wheels** – Damped wheels, like resilient wheels, are effective in eliminating wheel squeal on tight turns with reductions of 5 to 15 dB in the high-frequency range where squeal occurs. Rolling noise is also slightly reduced by approximately 2 dB on tangent track. This treatment involves attaching vibration absorbers to standard steel wheels. The costs for damped wheels add approximately \$500 to \$1000 to the normal \$700 for each steel wheel.

^{vi} Assumes 8 wheels per vehicle.

- **Vehicle Treatments** – Vehicle noise mitigation measures are applied to the various mechanical systems associated with propulsion, ventilation, and passenger comfort. Propulsion systems of transit vehicles include diesel engines, electric motors, and diesel-electric combinations. Noise from the propulsion system depends on the type of unit and how much noise mitigation is built into the design. Mufflers on diesel engines are generally required to meet noise specifications; however, mufflers are generally practical only on buses, not on locomotives. Control of noise from engine casings may require shielding the engine by body panels without louvers, dictating other means of cooling, and ventilation.

Ventilation requirements for vehicle systems are related to the noise generated by a vehicle. Fan noise often remains a major noise source after other mitigation measures have been instituted because of the need to have direct access to cooling air. This applies to heat exchangers for electric traction motors, diesel engines, and air-conditioning systems. The mitigation options for these systems include:

- **Quiet fan design and placement** – Fan noise can be reduced by installation of quiet, efficient fans. Forced-air cooling on electric traction motors can be quieter than self-cooled motors at operating speeds. Placement of fans on the vehicle can make a considerable difference in the noise radiated to the wayside or to patrons on the station platforms.
 - **Vehicle skirts and undercar absorption** – The vehicle body design can provide shielding and absorption of the noise generated by the vehicle components. Acoustical absorption under the car has been demonstrated to provide up to 5 dB of mitigation for wheel/rail noise and propulsion-system noise on rapid transit trains. Similarly, vehicle skirts over the wheels can provide more than 5 dB of mitigation. By carrying their own noise barriers, vehicles with these features can provide cost-effective noise reduction. The cost for vehicle skirts will add approximately \$5000 to \$10000 per vehicle. Undercar absorption will add approximately \$3500 per vehicle, assuming that 50% of the underside of the floor is treated.
- **Preventative Maintenance (Rail)** – Preventative maintenance is the best strategy to minimize rail and wheel deterioration. While these are not mitigation measures in the traditional sense and should not be included as mitigation in an environmental document, they can help to keep both noise and vibration levels at a “like-new” level or reduce both noise and vibration in systems with deferred maintenance. This can be accompanied by considerable life cost benefits for the transit system.
 - **Spin-slide control systems** – Similar to anti-locking brake systems (ABS) on automobiles, spin-slide control systems reduce the incidence of wheel flats, a major contributor of impact noise. Trains with smooth wheel treads can be up to 20 dB quieter than those with wheel flats. To be effective, the anti-locking feature should be in operation during all braking phases, including emergency braking. Wheel flats are more likely

to occur during emergency braking than during dynamic braking. The cost of slip-slide control may be incorporated in the new vehicle costs, but may be between \$5,000 and \$10,000 per vehicle with a maintenance cost of \$200 per year.

- **Wheel truing** – Maintenance of wheels by truing eliminates wheel flats from the treads and restores the wheel profile. As discussed above, wheel flats are a major source of impact noise. As a guideline, it is recommended that wheel sets match within approximately ± 0.01 inch and all wheels on the same truck should match within ± 0.02 inches to minimize damage and wear to wheels and rails.⁽³⁴⁾ A wheel truing machine costs approximately \$1 million, including associated maintenance materials and labor costs. The TCRP report estimates a system with 700 vehicles would incur a yearly cost of \$300,000 to \$400,000 for a wheel truing program.

It is recommended to install wheel-flat detector systems to identify vehicles that are most in need of wheel truing. These systems are becoming more common on railroads and intercity passenger systems, but are relatively rare on transit systems.

- **Rail grinding** – The smoothness of the running surface is critical in the mitigation of noise from a moving vehicle. Mill scale grinding before commencement of pre-revenue service train operations is critical. Experience shows that grinding new rails after approximately 3 months of train operations and scheduling routine grinding at approximate intervals of 2 years in the problem areas would minimize noise problems related to corrugation in most cases. Grinding with small machines when the corrugation depth is still small is a reasonable approach. As a guideline, it is recommended to spot-grind at locations where corrugation occurs before corrugation grows to 0.02 inches (32).

Periodic rail grinding can result in a net savings per year on wheel and rail wear. Most transit systems contract out rail grinding, although some of the larger systems make the investment of approximately \$1 million for the equipment and do their own grinding. Contractors typically charge a fixed amount per day for the equipment on site, plus an amount per pass-mile (one pass of the grinding machine for one mile). Typical rail grinding cost would be approximately \$7,000 to \$10,000 per pass-mile.

- **Wheel and rail profile matching** – It is important to consider the wheel and rail profile compatibility when truing wheels and grinding rails. If the profiles do not match, the benefits of this kind of preventative maintenance will not be achieved.

It is equally important to consider initial wheel and rail profile compatibility. Work with track designers and vehicle suppliers early in the design process to ensure wheel and rail profile compatibility. Profiles should be defined during the design phase and should be in

place when system opens.⁽³²⁾ The cost of wheel and rail profile matching may be incorporated in the new vehicle and new rail costs.

Profile grinding of the rail head in combination with a wheel truing program may be the most practical approach to controlling and reducing noise and vibration where such practices are not normally conducted.

- **Maintenance program** – Clearly defined maintenance specifications should be developed during design phase of the project. The specifications should define rail and wheel profiles, include detailed guidance for pre-revenue mill scale grinding, address issues related to healthy rail-wheel interface, and include a mechanism for periodic monitoring of wheel and rail condition and verification for compliance.⁽³²⁾ A diligent maintenance program can often resolve or reduce rail noise issues before they occur. Vehicle reconditioning programs should also be developed particularly for components such as suspension system, brakes, wheels, and slip-slide detectors.
- **Guideway Support (Bus)** – The smoothness of the running surface is critical in the mitigation of noise from a moving vehicle.
 - **Resurfacing roads** – Roughness on the guideway can be eliminated by resurfacing roads, thereby reducing noise levels by up to 10 dB.
 - **Bridge expansion joint angles and design** – Bridge expansion joints are also a source of noise for rubber-tire vehicles. This source of noise can be reduced by placing expansion joints on an angle or by specifying the serrated type rather than joints with right-angle edges.
- **Turn Radii and Rail Lubrication** – For steel-wheel/steel-rail systems with non-steerable trucks and sharp turns, squeal can typically be eliminated by designing all turn radii to be greater than 1000 ft, or 100 times the truck wheelbase, whichever is less. If this is not possible, squeal can be mitigated by installation of lubricators (though the potential environmental impacts of lubricant application should be factored into this decision). Rail lubricators cost approximately \$10,000 - \$40,000 per curve.
- **Movable-point and Spring-rail Frogs** – Frogs with spring-loaded mechanisms and frogs with movable points can reduce impact noise near crossovers. According to the TCRP report, a spring frog costs approximately \$12,000, twice the cost of a standard frog. A movable point frog involves elaborate signal and control circuitry resulting in higher costs of approximately \$200,000.
- **Use of Locomotive Horns at-grade Crossings and Quiet Zones** – In cases where commuter rail operations share tracks or ROW with freight or intercity passenger trains that are part of the general railroad system, the safety rules of the FRA, including the Train Horn Rule, apply.⁽³⁵⁾ The Train Horn Rule requires that locomotive horns be sounded at public highway grade crossings, although some exceptions are allowed in carefully defined circumstances. Locomotive horns are often a major contributor in

projections of adverse noise impact, in the community from proposed commuter rail projects. Since noise barriers are not feasible at highway-rail grade crossings, the establishment of quiet zones could be considered.

Quiet zones can be established in which supplemental safety measures (SSMs) are used in place of the locomotive horn to provide an equivalent level of safety at-grade crossings.^(vii) By adopting an approved SSM at each public grade crossing, a quiet zone of at least a half-mile long can be established. These measures are in addition to the standard safety devices required at most public grade crossings (e.g., stop signs, reflectorized crossbucks, flashing lights with gates that do not completely block travel over the tracks). Below are four SSMs that have been predetermined by the FRA to fully compensate for the lack of a locomotive horn:

- **Temporary closure of a public highway-rail grade crossing** – This measure requires closure of the grade crossing for one period each 24 hours, and the closure must occur at the same time each day.
- **Four-quadrant gate system** – This measure involves the installation of at least one gate for each direction of traffic to fully block vehicles from entering the crossing.
- **Gates with medians or channelization devices** – This measure keeps traffic in the proper travel lanes as it approaches the crossing. This denies the driver the option of circumventing the gates by traveling in the opposing lane.
- **One-way street with gates** – This measure consists of one-way streets with gates installed, so that all approaching travel lanes are completely blocked.

In addition to the pre-approved SSMs, the FRA rule also identifies a range of other measures that may be used in establishing a quiet zone. These could include modified SSMs or non-engineering types of measures, such as increased monitoring by law enforcement for grade crossing violations or instituting public education and awareness programs that emphasize the risks associated with grade crossings and applicable requirements. These alternative safety measures (ASMs) require approval by FRA based on a demonstration that public safety would not be compromised by eliminating horn usage.

The lead agency for designating a quiet zone is the local public authority responsible for traffic control and law enforcement on the roads crossing the tracks. To satisfy the FRA regulatory requirements, the public transit agency must work closely with this agency while also coordinating with any freight or passenger railroad operator sharing the ROW. The final environmental document should discuss the main considerations in adopting the quiet zone including: the engineering feasibility, receptiveness of the local public authority, consultation with the railroad, preliminary cost estimates, and evidence of the planning and interagency coordination that has occurred to date. If a quiet zone will be relied on as a mitigation measure, the final environmental document should provide reasonable

^{vii} For more information on quiet zones, visit: <https://www.fra.dot.gov/Page/P0889>.

assurance that any remaining issues can and will be resolved. For more information on documentation requirements see Section 8.

The cost of establishing a quiet zone varies considerably, depending on the number of intersections that must be treated and the specific SSMs, ASMs, or combination of measures that are used. The FRA gives a cost estimate of \$15,000 per crossing for installing two 100-foot-long, non-traversable medians that prevent motorists from driving around closed gates. A typical installation of a four-quadrant gate system is in the range of \$175,000–\$300,000 per crossing.⁽³⁶⁾ Who pays for the installation of modifications can become a major consideration in a decision to pursue a quiet zone designation, especially in cases where noise from preexisting railroad operations is controversial in the community. In many cases where a quiet zone would mitigate a severe impact caused by the proposed transit project, the costs are covered by the project sponsor and FTA in the same proportion as the overall cost-sharing for the project.

7b. Evaluate Path Treatments – When noise mitigation treatments cannot be applied at the noise source or additional mitigation is required after treating the source, the next preferred placement of noise mitigation is along the noise propagation path between the source and receiver. Common path treatments and their estimated acoustical effectiveness are included in Table 4-34 and described below.

Table 4-34 Transit Noise Mitigation Measures – Path Treatments

Mitigation Measure	Effectiveness
Noise barriers close to vehicles	6-15 dB
Noise barriers at row line	3-15 dB ⁽³⁷⁾
Alteration of horizontal & vertical alignments	Varied
Wayside horns	Varied
Acquisition of buffer zones	Varied
Ballast on at-grade guideway*	3 dB
Ballast on aerial guideway*	5 dB
Resilient track support on aerial guideway	Varied
Vegetation and trees	Varied, see Table 4-30

* Applies to rail projects only.

- **Noise Barriers** – Noise barriers are effective in mitigating noise when they break the line-of-sight between source and receiver. The mechanism of sound shielding is described in Section 3.3. The necessary height of a barrier depends on the source height and the distance from the source to the barrier, see Table 4-28 and Figure 4-18.
 - **Noise barriers close to vehicles** – Barriers located very close to a rapid transit train, for example, may only need to be approximately 3 to 4 ft above the top of rail to be effective. Standard barriers close to vehicles can provide noise reductions of 6 to 10 dB.
 - **Noise barriers at ROW line** – Barriers on the ROW line or for trains on the far track, the height must be increased to provide equivalent effectiveness to barriers located close to the vehicles. Otherwise, the effectiveness can drop to 3 dB or less, even if the barrier breaks the line-of-sight.

All barrier effectiveness can be increased by as much as 5 dB by applying sound-absorbing material to the inner surface of the barrier. The length of the barrier wall is also important to its effectiveness. The barrier must be long enough to block noise from a moving train along most of its visible path. This is necessary so that train noise from beyond the ends of the barrier will not severely compromise noise-barrier performance at noise-sensitive locations. The barrier length can be refined in the engineering phase, closely examining the predicted sound level exceedances at specific receivers, site geometries, and the contribution of barrier flanking noise, then adjusting the length as appropriate.

Noise barriers can be made of any outdoor weather-resistant solid material that meets the minimum sound transmission loss required by the project. Materials that are commonly used for noise barriers include 16-gauge steel, 1-inch thick plywood, and any reasonable thickness of concrete. Typically, a surface density of 4 pounds per square foot is required. Areas with strong winds may require more stringent structural requirements. It is critical to seal any gaps between barrier panels and between the barrier and the ground or elevated guideway deck for maximum performance.

Costs for noise barriers (based on highway installations) range from \$20 to \$25 per square foot of installed noise barrier at-grade with additional cost for design and inspection.⁽³⁸⁾ Installation on aerial structures could be twice the amount of installation at-grade, especially if the structure has to be strengthened to accommodate the added weight and wind load.

As described in Section 3.3, noise barriers, if not designed and sited carefully, can reduce visibility of trains for pedestrians and motorists, which causes safety concerns. It is important to consult with safety experts in choosing and siting a noise barrier.

- **Alteration of Horizontal and Vertical Alignments** – Transit alignment in a cut as part of grade separation can accomplish the same result as installation of a noise barrier at-grade or on aerial structure. The walls of the cut serve the same function as barrier walls in breaking the line-of-sight between source and receiver.
- **Wayside Horns** – The sounding of a locomotive horn as the train approaches an at-grade intersection produces a very wide noise footprint in the community. Using wayside horns at these intersections instead of the locomotive horn can substantially reduce the noise footprint without compromising safety at the grade crossing.

A wayside horn does not need to be as loud as a locomotive horn, and the warning sound is focused only on the area where it is needed. These are pole-mounted horns used in conjunction with flashing lights and gates at the intersection, with a separate horn oriented toward each direction of oncoming vehicle traffic. Noise levels in nearby residential and business areas can be reduced substantially with wayside horns, depending on the location with respect to the grade crossing.

A plan to use wayside horns in place of the locomotive horn at public grade crossings must be coordinated with several public and private entities, notably the local agency having responsibility for traffic control and law enforcement on the road crossings, the state agency responsible for railroad safety, any railroads that share the ROW, and FRA. Public notification must also be given. Preliminary cost information from testing programs indicates a wayside horn system at a railroad/highway grade crossing costs approximately \$50,000.

- **Buffer Zones** – Because noise levels attenuate with distance, one noise mitigation option is to increase the distance between noise sources and the closest noise-sensitive receivers. This can be accomplished by locating alignments away from noise-sensitive sites. Acquisition of land or purchasing easements for noise buffer zones is an option that may be considered if appropriate for the project.
- **Ground Absorption – Ballast on Guideways** – Propagation of noise over ground is affected by whether the ground surface is absorptive or reflective. Noise from vehicles on the surface is strongly affected by the character of the ground in the immediate vicinity of the vehicle. Roads and streets for buses are hard and reflective, but the ground at the side of a road has a substantial effect on the propagation of noise to greater distance. Guideways for rail systems can be either reflective or absorptive, depending on whether they are concrete or ballast. Ballast on a guideway can reduce train noise 3 dB at-grade and up to 5 dB on an aerial structure.
- **Vegetation and Trees** – In almost all cases, vegetation and trees are ineffective at providing noise mitigation. Vegetation and Trees can provide some mitigation if at least 100 ft of trees intervene between the source and receiver, if no clear line-of-sight exists between the source and receiver, and if the trees extend 15 ft or more above the line-of-sight as described in Section 4.5, Step 3b. This is generally not a recommended form of mitigation to pursue.

7c. Evaluate Receiver Treatments – Consider treatments to the receivers when noise mitigation treatments cannot be applied at the source or along the propagation path, or if combinations of treatments are required. Common receiver treatments and their estimated acoustical effectiveness are included in Table 4-35 and are described in this section.

Table 4-35 Transit Noise Mitigation Measures – Receiver Treatments

Mitigation Measure	Effectiveness
Acquisition of Property Rights for Construction of Noise Barriers	5-10 dB
Building Noise Insulation	5-20 dB

- **Noise Barriers** – In certain cases, it may be possible to acquire limited property rights for the construction of noise barriers at the receiver. As discussed above, barriers need to break the line-of-sight between the noise source and the receiver to be effective and are most effective when they are

closest to either the source or the receiver. See Section 3.3 for more information on noise barriers.

- **Building Insulation** – In cases where noise barriers are not feasible—such as multi-story buildings, buildings very close to the ROW, or grade crossings—the only practical noise mitigation measure may be to provide sound insulation for the buildings. In these cases, the need for mitigation at locations where impact has been identified will depend on the use (outdoor vs. indoor), any existing outdoor to indoor reduction in noise levels, and the feasibility of constructing effective noise barriers for second stories and above.

Depending on the quality of the original building façade, especially windows and doors, sound insulation treatments can improve the noise reductions from transit noise by 5 to 20 dB. To be considered cost-effective, a treatment should provide a minimum reduction of 5 dB in the interior of the building and meet the L_{dn} 45 dBA interior criterion. For more information, see Section 4.1.

In many cases, especially in locations with high ambient noise levels, the existing sound insulation of a building may already meet the 45 dBA L_{dn} interior noise criterion. It is recommended that sound insulation testing be conducted to determine if the existing sound insulation is sufficient or what additional measures would be required to meet the interior criterion.

Effective treatments include:

- Caulking and sealing gaps in the building façade; and
- Installation of new doors and windows that are specially designed to meet acoustical transmission-loss requirements:
 - Exterior doors facing the noise source should be replaced with well-gasketed, solid-core wood doors and well-gasketed storm doors.
 - Acoustical windows are typically made of multiple layers of glass with air spaces between to provide noise reduction. Acoustical performance ratings are published in terms of Sound Transmission Class (STC) for these windows. It is recommended to use a minimum STC rating of 39 on any window exposed to the noise source.

These treatments are beneficial for heat insulation as well as for sound insulation, but acoustical windows are typically non-operable and central ventilation or air conditioning is needed. Residents' preferences should be considered.

If needed, additional building sound insulation can be provided by sealing vents and ventilation openings and relocating them to a side of the building away from the noise source. In cases where the noise sources is low-frequency noise from diesel locomotives, it may be necessary to increase the mass of the building façade for wood-frame houses by adding a layer of sheathing to the exterior walls.

Examples of residential sound insulation for rail or highway projects are limited. However, much practical experience with sound insulation of buildings has been gained through grants for noise mitigation to local airport authorities by FAA.

SECTION

5

Transit Vibration

This section presents the basic concepts of transit ground-borne vibration, also referred throughout this manual as simple “vibration,” and low-frequency groundborne-noise that sometimes results from vibration. The steps for the screening and assessing of potential vibration impacts of transit projects for FTA NEPA approval are described in the following sections.

The Source-Path-Receiver framework for ground-borne vibration for a rail system illustrated in Figure 5-1 is central to all environmental vibration studies. The train wheels rolling on the rails create vibration energy that is transmitted through the track support system into the transit structure. The vibration of the transit structure excites the adjacent ground, creating vibration waves that propagate through the ground and into nearby buildings creating ground-borne vibration effects that potentially interfere with activities. The vibrating building components may radiate sound, which this manual refers to as ground-borne noise. Airborne noise from transit sources is covered in Sections 2.3–4.5 of this manual. Ground-borne noise refers to the noise generated by ground-borne vibration.

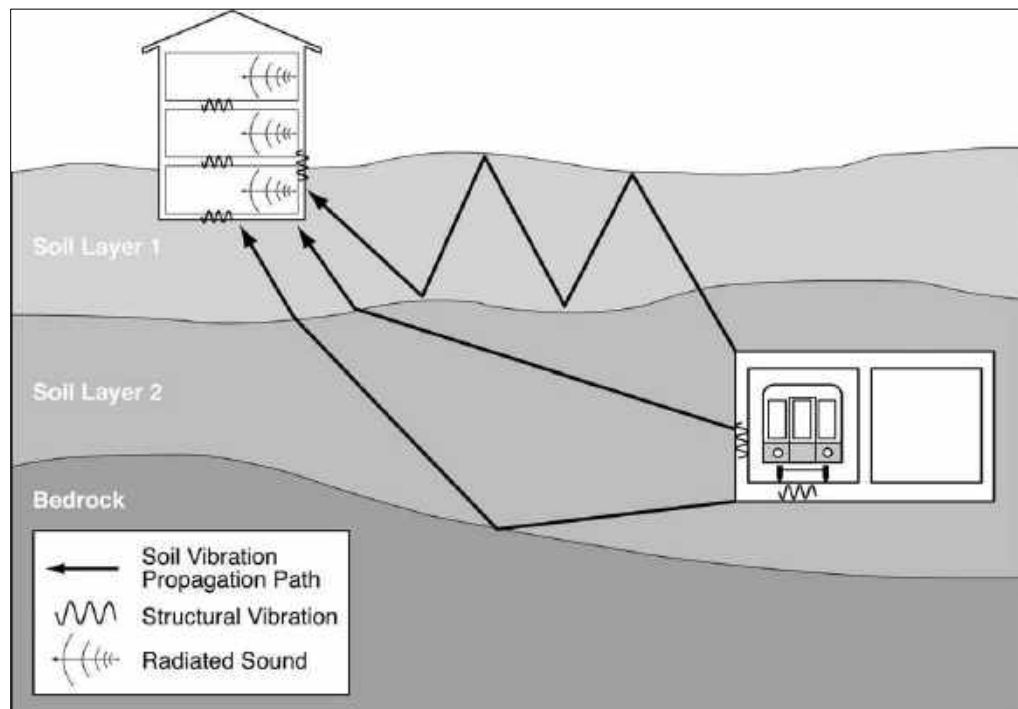


Figure 5-1 Propagation of Ground-Borne Vibration into Buildings

This section contains the following:

- Section 5.1 The ground-borne vibration and noise metrics used in this manual
- Section 5.2 An overview of transit vibration sources

- Section 5.3 An overview of transit vibration paths
- Section 5.4 An overview of receiver factors of transit vibration and a discussion of the technical background for ground-borne noise criteria

5.1 Ground-Borne Vibration and Noise Metrics

Vibration is an oscillatory motion that can be described in terms of the displacement, velocity, or acceleration. Because the motion is oscillatory, there is no net movement of the vibration element and the average of any of the motion metrics is zero. Displacement is the most intuitive metric. For a vibrating floor, the displacement is simply the distance that a point on the floor moves away from its static position. The velocity represents the instantaneous speed of the floor movement and acceleration is the rate of change of the speed.

Although displacement is easier to understand than velocity or acceleration, it is rarely used for describing ground-borne vibration. Most transducers used for measuring ground-borne vibration use either velocity or acceleration. Furthermore, the response of humans, buildings, and equipment to vibration is more accurately described using velocity or acceleration.

This manual uses the metrics outlined in Table 5-1 for transit ground-borne vibration and noise measurements, computations, and assessment. These metrics are consistent with common usage in the United States.

Table 5-1 Ground-borne Vibration and Noise Metrics

Metric	Abbreviation	Definition
Vibration Decibels	VdB	The vibration velocity level in decibel scale.
Peak Particle Velocity	PPV	The peak signal value of an oscillating vibration velocity waveform. Usually expressed in inches/second in the United States.
Root Mean Square	rms	The square root of the arithmetic average of the squared amplitude of the signal.
A-weighted Sound Level	dBA	A-weighted sound levels represent the overall noise at a receiver that is adjusted in frequency to approximate typical human hearing sensitivity. This unit is used to characterize ground-borne noise.

The metrics in the table above are illustrated in Figure 5-2. The components in the figure include:

- **Raw signal** – This curve shows the instantaneous vibration velocity, which fluctuates positively and negatively about the zero point.
- **Peak particle velocity (PPV)** – PPV is the maximum instantaneous positive or negative peak of the vibration signal. PPV is often used in monitoring of construction vibration (such as blasting) since it is related to the stresses that are experienced by buildings and is not used to evaluate human response.
- **Root mean square (rms) velocity** – Because the net average of a vibration signal is zero, the rms amplitude is used to describe smoothed vibration amplitude. The rms of a signal is the square root of the

average of the squared amplitude of the signal. The average is typically calculated over a one-second period. The rms amplitude is always less than the PPV^(viii) and is always positive. The rms amplitude is used to convey the magnitude of the vibration signal felt by the human body, in inches/second.

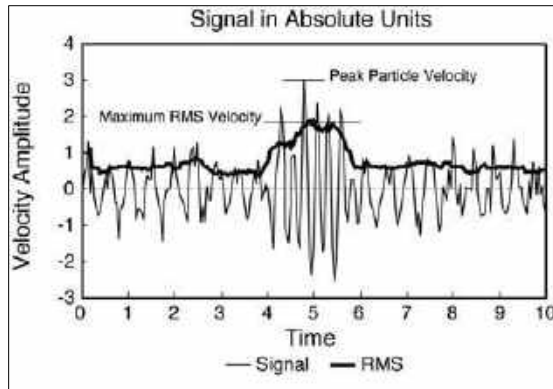


Figure 5-2 Vibration Signal in Absolute Units

The PPV and rms velocity are described in inches per second in the United States and meters per second internationally (with several different reference values). Although it is not universally accepted, vibration is commonly expressed in decibel notation. The decibel scale compresses the range of numbers required to describe vibration.

The graph in Figure 5-3 shows the rms curve from Figure 5-2 expressed in decibels.

Vibration velocity level in decibels is defined as:

$$L_v = 20 \log \left(\frac{v}{v_{ref}} \right) \quad \text{Eq. 5-1}$$

where:

- L_v = velocity level, VdB
- v = rms velocity amplitude
- v_{ref} = 1×10^{-6} in/sec in the USA
- v_{ref} = 1×10^{-8} m/sec internationally*

*Because of the variations in the reference quantities, it is important to be clear about what reference quantity is being used when specifying velocity levels. All vibration levels in this manual are referenced to 1×10^{-6} inches/second.

^{viii} The ratio of PPV to maximum rms amplitude is defined as the crest factor for the signal. The crest factor is typically greater than 1.41, although a crest factor of 8 or more is not unusual for impulsive signals. For ground-borne vibration from trains, the crest factor is usually 4 to 5.

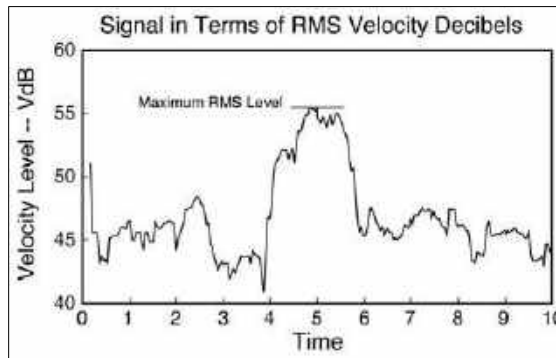


Figure 5-3 Vibration Signal in RMS Velocity Decibels

Ground-borne noise occurs when vibration radiates through a building interior and creates a low-frequency sound, often described as a rumble, as a train passes by. The annoyance potential of ground-borne noise is typically characterized with the A-weighted sound level. Although the A-weighted sound level is typically used to characterize community noise, characterizing low-frequency noise using A-weighting can be challenging because the non-linearity of human hearing causes sounds dominated by low-frequency components to seem louder than broadband sounds (sounds consisting of many frequency components, with no dominant frequencies) that have the same A-weighted level. The result is that ground-borne noise with a level of 40 dBA sounds louder than 40 dBA broadband noise. Because ground-borne noise sounds louder than broadband noise at the same noise level, the limits for ground-borne noise are lower (i.e., stricter) than would be the case for broadband noise.

5.2 Sources of Transit Ground-borne Vibration and Noise

Ground-borne vibration can be a concern for nearby neighbors of a transit system route or maintenance facility. However, in contrast to airborne noise, ground-borne vibration is not a common environmental problem. It is unusual for vibration from sources such as buses and trucks to be perceptible, even in locations close to major roads. This section discusses common sources of ground-borne vibration and noise.

Most perceptible indoor vibration is caused by sources within buildings such as operation of mechanical equipment, movement of people, or slamming of doors. Typical outdoor sources of vibration waves that propagate through the ground and create perceptible ground-borne vibration in nearby buildings include construction equipment, steel-wheeled trains, and traffic on rough roads. If the roadway is fairly smooth, the vibration from rubber-tired traffic is rarely perceptible. Building damage due to vibration is also rare for typical transportation projects; but in extreme cases, such as during blasting or pile-driving during construction, vibration could cause damage to buildings.

Figure 5-4 illustrates common vibration sources and the human and structural response to ground-borne vibration ranging from approximately 50 VdB (below

perceptibility) to 100 VdB (the threshold of potential damage). The background vibration velocity level in residential areas is usually 50 VdB or lower,^(ix) and the threshold of perception for humans is approximately 65 VdB. A vibration level of 85 VdB in a residence can result in strong annoyance.

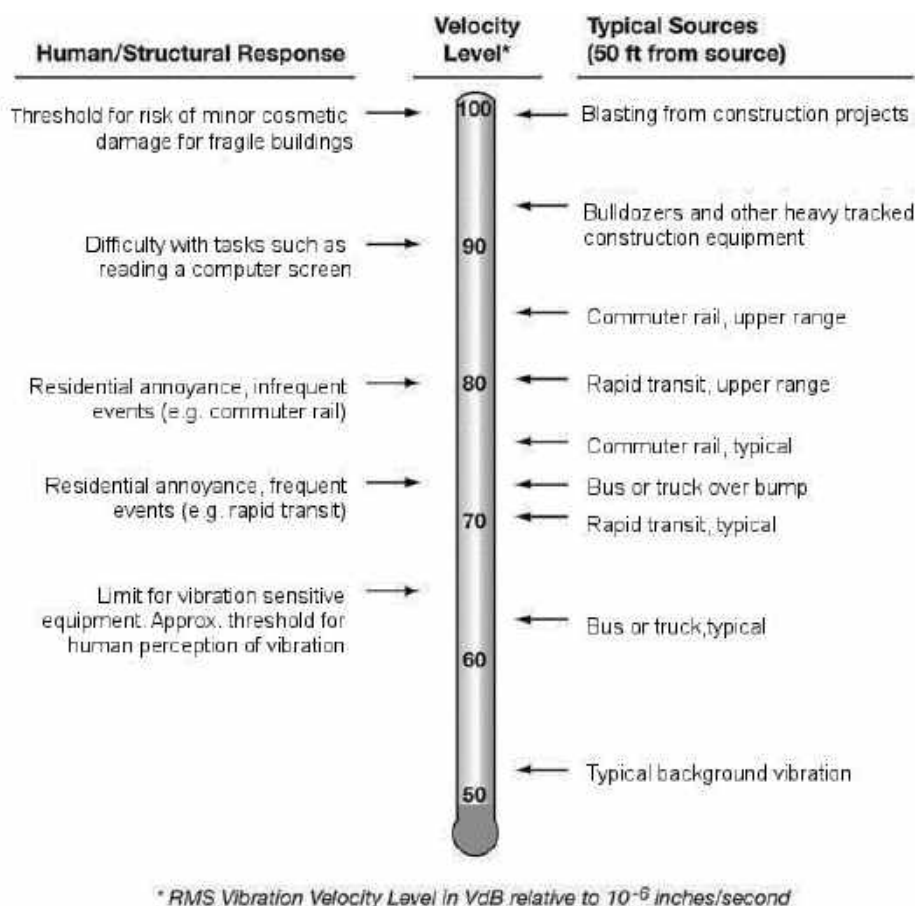


Figure 5-4 Typical Levels of Ground-Borne Vibration

Rapid transit or light rail systems typically generate vibration levels of 70 VdB or more near their tracks, while buses and trucks rarely create vibration that exceeds 70 VdB unless there are bumps due to frequent potholes in the road. Heavy locomotives on diesel commuter rail systems create vibration levels approximately 5 to 10 dB higher than rail transit vehicles.

Vibration from trains is strongly dependent on factors such as how smooth the wheels and rails are, as well as the resonance frequencies of the vehicle suspension system and the track support system. These systems, like all mechanical systems, have resonances that result in increased vibration response at certain frequencies, called natural frequencies. Unusually rough road or track, steel-wheel flats, geologic conditions that promote efficient propagation of vibration, or vehicles with very stiff suspension systems could increase typical

^{ix} Background vibration is typically well below the threshold of human perception and is of concern only when the vibration affects very sensitive manufacturing or research equipment. Electron microscopes and high-resolution lithography equipment are examples of equipment that is highly sensitive to vibration.

vibration levels by approximately 10 VdB. Common factors that contribute to ground-borne vibration and noise at the source are presented in Table 5-2. These factors are discussed in more detail throughout this Section.

Table 5-2 Factors that Influence Levels of Ground-Borne Vibration and Noise at the Source

Category	Factors	Influence
Operations and Vehicles	Speed	Higher speeds result in higher vibration levels. Doubling speed results in a vibration level increase of approximately 4 to 6 dB.
	Vehicle Suspension	Stiff suspension in the vertical direction can increase the effective vibration forces. On transit cars, the primary suspension has the largest effect on vibration levels.
	Wheel Condition and Type	Wheel flats and general wheel roughness are major sources of vibration from steel wheel/steel rail systems. Resilient wheels on rail transit systems can provide some vibration reduction over solid steel wheels, but are usually too stiff to provide substantial reduction. For more information, see Section 6.4, Step 2.
Guideway	Track/Roadway Surface	Rough track or rough roads are often sources of excessive vibration. Maintaining a smooth surface will reduce vibration levels.
	Track Support System	On rail systems, the track support system is one of the major components in determining the levels of vibration. The highest vibration levels are created by track that is rigidly attached to a concrete trackbed (e.g., track on wood half-ties embedded in the concrete). The vibration levels are much lower when special vibration control track systems such as resilient fasteners, ballast mats, and floating slabs are used.
	Transit Structure	Heavier transit structures typically result in the lower vibration levels. The vibration levels from a lightweight bored tunnel will usually be higher than from a poured concrete box subway.
	Transit System Elevation	<p>A rail system guideway will be either underground (subway), at-grade, or elevated, with substantial differences in the vibration characteristics at each elevation.</p> <ul style="list-style-type: none"> Underground: vibration is typically the most important environmental factor of interest. At-grade: airborne noise is typically the dominant factor, although vibration and noise can be a problem, particularly at interior locations well isolated from exterior noise. Elevated: it is rare for vibration to be an issue with elevated railways except when guideway supports are located within 50 ft of buildings.

Brief discussions of ground-borne vibration and noise sources for different modes of transit are provided below.

At-Grade Heavy Rail and Light Rail

Ground-borne vibration and noise from urban heavy rail and LRT is common when there is less than 50 ft between the track and building foundations. Local geology and structural details of the building determine if the source of complaints is due to perceptible vibration or audible ground-borne noise. Complaints about ground-borne vibration from surface track are more common than ground-borne noise complaints. A substantial percentage of complaints about both ground-borne vibration and noise correlate with proximity of special track work, rough or corrugated track, or wheel flats. Light rail systems tend to generate fewer complaints than heavy rail due to lower operating speeds.

Commuter and Intercity Passenger Trains

There is the potential for vibration-related issues when new commuter or intercity rail passenger service (including electric multiple units (EMUs) and diesel multiple units (DMUs)) powered by either diesel or electric locomotives is introduced in an urban or suburban area. Commuter and intercity passenger trains have similar characteristics, but commuter trains typically operate on a more frequent schedule. These passenger trains often share track with freight trains, which have different vibration characteristics as discussed below.

Freight Trains

Local and long-distance freight trains are similar in that they both are diesel-powered and have the same types of cars. They differ in their overall length, number and size of locomotives, and number of heavily loaded cars. However, because locomotive suspensions are similar, the maximum vibration levels of local and long-distance freights are similar. Locomotives and rail cars with wheel flats are the sources of the highest vibration levels.

If the transit project does not in any way change the freight service, tracks, etc., then vibration from the freight line would be part of the existing conditions and need to be considered in terms of cumulative impacts (see Section 6.2, Step 3 on how to consider cumulative impacts). If the project results in changes to the freight path, operations, frequency, etc. (e.g., relocating freight tracks within the ROW to make room for the transit tracks) then those potential impacts and mitigation should be evaluated as part of the proposed project. However, note that vibration mitigation is very difficult to implement on tracks where freight trains with heavy axle loads operate.

High-Speed Passenger Trains

Passenger trains travelling at high speeds, 90 to 250 miles per hour, have the potential for creating high levels of ground-borne vibration. Ground-borne vibration should be anticipated as one of the major environmental impacts of any trains travelling at high speeds located in an urban or suburban area.^(x) For projects that are specifically high-speed transportation refer to the FRA “High-Speed Ground Transportation Noise and Vibration Impact Assessment” guidance manual.⁽³⁹⁾

AGT Systems

AGT systems include a wide range of transportation vehicles that provide local circulation in downtown areas, airports, and theme parks. Because AGT systems normally operate at low speeds, have lightweight vehicles, run on elevated structures, and rarely operate in vibration-sensitive areas, ground-borne vibration problems are very rare.

Subway and At-grade Track

While ground-borne vibration produced from trains operating subway and at-grade track have very different characteristics, they have comparable overall vibration velocity levels. Complaints about ground-borne vibration are often more common near subways than near at-grade track. This is not because

^x Amtrak trains (branded Acela at the time of publication) on the Northeast Corridor between Boston and Washington, DC, which attain moderate to high speeds in some sections with improved track, fit into this category.

subways create higher vibration levels than at-grade systems, rather because subways are usually located in more densely developed areas in closer proximity to building foundations, and the airborne noise is usually a more serious problem for at-grade systems than the ground-borne vibration. Another difference between subway and at-grade track is that the ground-borne vibration from subways tends to be higher frequency than the vibration from at-grade track, which makes the ground-borne noise more noticeable.

Streetcars

Complaints about ground-borne vibration from street cars are uncommon given that streetcars typically operate at very low speeds (less than 25 mph).

Buses

Because the rubber tires and suspension systems of buses provide vibration isolation, it is unusual for buses to cause ground-borne vibration or noise problems. For most issues with bus-related vibration, such as rattling of windows, the cause is almost always airborne noise and directly related to running surface conditions such as potholes, bumps, expansion joints, or other discontinuities in the road surface (usually resolved by smoothing the discontinuities).

Buses operating inside buildings will likely cause vibration concerns for other building inhabitants. An example of this situation is a bus transfer station in the same building as commercial office space. Sudden loading of a building slab by a heavy moving vehicle or by vehicles running over lane divider bumps can cause intrusive building vibration.

5.3 Paths of Transit Ground-Borne Vibration and Noise

Vibration travels from the source through the transit structure and excites the adjacent ground, creating vibration waves that propagate through soil layers and rock strata to the foundations of nearby buildings. The vibration then propagates from the foundation throughout the remainder of the building structure. The vibration of the building structure and room surfaces can radiate a low-frequency rumble called ground-borne noise (Figure 5-1).

Soil and subsurface conditions are known to have a strong influence on the levels of ground-borne vibration. Among the most important factors are the stiffness and internal damping of the soil and the depth to bedrock. Vibration propagation is more efficient in stiff clay soils. Shallow rock may concentrate the vibration energy close to the surface, resulting in ground-borne vibration problems at large distances from the track. Factors such as soil layers and depth to water table can have substantial effects on the propagation of ground-borne vibration. These factors are summarized in Table 5-3.

Table 5-3 Factors that Influence Levels of Ground-borne Vibration and Noise along Path

Geology Factors	Influence
Soil type	Vibration levels are generally higher in stiff clay-type soil than in loose sandy soil.
Rock layers	Vibration levels are usually high near at-grade track when the depth to bedrock is 30 ft or less. Subways founded in rock will result in lower vibration amplitudes close to the subway. Vibration levels do not attenuate as rapidly in rock as in soil.
Soil layering	Soil layering can have a substantial effect on the vibration levels since each stratum can have considerably different dynamic characteristics.
Depth to water table	The presence of the water table may have a substantial effect on vibration, but a definite relationship has not been established.

5.4 Receiver Factors that Influence Ground-Borne Vibration and Noise

Ground-borne vibration is a concern almost exclusively inside buildings. Train vibration may be perceptible to people who are outdoors, but it is very rare for outdoor vibration to cause complaints.

The vibration levels inside a building are dependent on the vibration energy that reaches the building foundation, coupling of the building foundation to the soil, and propagation of the vibration through the building. In general, the heavier a building is, the lower the response will be to the incident vibration energy. Common factors that contribute to ground-borne vibration and noise at the receiver are presented in Table 5-4.

Table 5-4 Factors that Influence Levels of Ground-Borne Vibration and Noise at the Receiver

Receiver Building Factors	Influence
Foundation type	The heavier the building foundation, the greater the coupling loss as the vibration propagates from the ground into the building.
Building construction	Each building has different characteristics relative to structure-borne vibration, but, in general, the heavier the building, the lower the levels of vibration. The maximum vibration amplitudes of the floors and walls of a building will often occur at the resonance frequencies of the components of the building.
Acoustical absorption	The more acoustically absorptive materials in the receiver room, the lower the ground-borne noise level. Note that because ground-borne noise usually is a low-frequency phenomenon, it is affected by low-frequency absorption (e.g., below 250 Hz).

5.5 Human Response to Transit Ground-borne Vibration and Noise

This section contains an overview of human receiver response to ground-borne vibration and noise. It serves as background information for the vibration impact criteria in Section 6.2.

The effects of ground-borne vibration can include perceptible movement of floors in buildings, rattling of windows, shaking of items on shelves or hanging on walls, and low-frequency noise (ground-borne noise). Building damage is not a

factor for typical transportation projects, but in extreme cases, such as during blasting or pile-driving during construction, vibration could cause damage to buildings. Although the perceptibility threshold is approximately 65 VdB, human response to vibration is not usually substantial unless the vibration exceeds 70 VdB (Figure 5-4). A vibration level that causes annoyance is well below the damage risk threshold for typical buildings (100 VdB).

Ground-borne vibration is almost never a problem outdoors. Although the motion of the ground may be perceived, without the effects associated with the shaking of a building, the motion does not provoke the same adverse human reaction. Ground-borne noise that accompanies the building vibration is usually perceptible only inside buildings and typically is only an issue at locations with subway or tunnel operations where there is no airborne noise path or for buildings with substantial sound insulation such as a recording studio.

One of the challenges in developing suitable criteria for ground-borne vibration is that there has been relatively little research into human response to vibration and, specifically, human annoyance with building vibration. The American National Standards Institute (ANSI) developed criteria for evaluation of human exposure to vibration in buildings in 1983,⁽⁴⁰⁾ and the International Organization for Standardization (ISO) adopted similar criteria in 1989⁽⁴¹⁾ and revised them in 2003.⁽⁴²⁾ The 2003 version of ISO 2631-2 acknowledges that “human response to vibration in buildings is very complex.” It further indicates that the degree of annoyance cannot always be explained by the magnitude of the vibration alone. In some cases, complaints are associated with measured vibration that is lower than the perception threshold. Other phenomena such as ground-borne noise, rattling, visual effects such as movement of hanging objects, and time of day (e.g., late at night) all play some role in the response of individuals. To understand and evaluate human response, which is often measured by complaints, all of these related effects need to be considered.

Figure 5-5 illustrates the relationship between the vibration velocity level measured in 22 homes and the general response of the occupants to the vibration from measurements performed for several transit systems along with subjective ratings by researchers and residents. These data are published in the “State-of-the-Art Review of Ground-borne Noise and Vibration.”⁽⁴³⁾ The figure also includes a curve representing the percent of people annoyed by vibration from high-speed trains from a Japanese study for comparison.⁽⁴⁴⁾

Both the occupants and the people who performed the measurements agreed that floor vibration in the Distinctly Perceptible range is unacceptable for a residence. The data indicates that residential vibration exceeding 75 VdB is unacceptable for a repetitive vibration source such as rapid transit trains that pass every 5 to 15 minutes. The results from the Japanese study confirm the conclusion that at a vibration velocity level of 75 to 80 VdB, many people will find the vibration annoying. A Transportation Research Board (TRB) study of human response to vibration from 2009 also supports this finding and indicates that incidence of complaints fall rapidly with a level decreasing below 72 VdB.⁽⁴²⁾⁽⁴⁵⁾

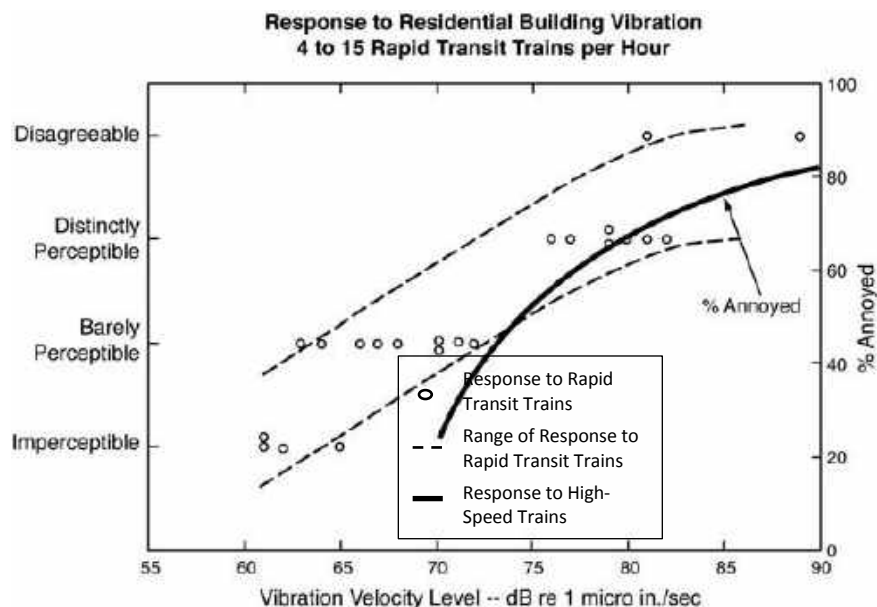


Figure 5-5 Response to Transit-Induced Residential Vibration

Table 5-5 presents the human response to different levels of ground-borne vibration and noise on which the criteria presented in Section 6.2 are based. The vibration level (VdB) is presented with the corresponding frequency assuming that the vibration spectrum peaks at 30 Hz or 60 Hz.^(xi) The ground-borne noise levels (dBA) are estimated for the specified vibration velocity with a peak vibration spectrum of 30 Hz (Low Freq) and 60 Hz (Mid Freq). Note that the human response differs for vibration velocity level based on frequency. For example, the noise caused by vibrating structural components may cause annoyance even though the vibration cannot be felt. Alternatively, a low-frequency vibration can cause annoyance while the ground-borne noise level it generates does not.

^{xi} The A-weighted level of ground-borne noise can be estimated by applying A-weighting to the vibration velocity spectrum and by subtracting an additional 5 dB for a room with average acoustical absorption. Since the A-weighting at 31.5 Hz is -39.4 dB, if the vibration spectrum peaks at 30 Hz, the A-weighted sound level will be approximately 40 dB lower than the velocity level. If the vibration spectrum peaks at 60 Hz, the A-weighted sound level will be approximately 25 dB lower than the velocity level.

Table 5-5 Human Response to Different Levels of Ground-Borne Vibration and Noise

Vibration Velocity Level	Noise Level		Human Response
	Low Freq*	Mid Freq**	
65 VdB	25 dBA	40 dBA	Approximate threshold of perception for many humans. Low-frequency sound: usually inaudible. Mid-frequency sound: excessive for quiet sleeping areas.
75 VdB	35 dBA	50 dBA	Approximate dividing line between barely perceptible and distinctly perceptible. Many people find transit vibration at this level annoying. Low-frequency noise: tolerable for sleeping areas. Mid-frequency noise: excessive in most quiet occupied areas.
85 VdB	45 dBA	60 dBA	Vibration tolerable only if there are an infrequent number of events per day. Low-frequency noise: excessive for sleeping areas. Mid-frequency noise: excessive even for infrequent events for some activities.

*Approximate noise level when vibration spectrum peak is near 30 Hz.

**Approximate noise level when vibration spectrum peak is near 60 Hz.

SECTION

6

Vibration Impact Analysis

The FTA vibration impact analysis process is a multi-step process used to evaluate a project for potential vibration impacts. If impact is determined, measures necessary to mitigate adverse impacts are to be considered for incorporation into the project.⁽³⁾

The FTA vibration impact analysis steps are summarized as follows and are described in the following sections:

6.1 Determine vibration analysis level.

6.2 Determine vibration impact criteria.

Option A: General Vibration Assessment Criteria

Option B: Vibration Impact Criteria for a Detailed Vibration Analysis

6.3 Evaluate Impact: Vibration Screening Procedure

Step 1: Classify project vehicles.

Step 2: Determine project type.

Step 3: Determine screening distance.

Step 4: Identify vibration-sensitive land uses.

6.4 Evaluate Impact: General Vibration Assessment.

Step 1: Select base curve for ground surface vibration level.

Step 2: Apply adjustments.

Step 3: Inventory vibration impact.

6.5 Evaluate Impact: Detailed Vibration Analysis

Step 1: Characterize Existing Vibration

Step 2: Estimate Vibration Impact

Step 3: Assess Vibration Impacts

Step 4: Determine Vibration Mitigation Measures

A similar process for the noise impact analysis is presented in Section 4. After the noise and vibration analyses have been completed, assess construction noise and vibration according to Section 7 and document findings according to Section 8.

6.1 Determine Vibration Analysis Level

There are three levels of analysis to assess the potential ground-borne vibration and noise impacts resulting from a public transportation project. The appropriate level of analysis varies by project based on the type and scale of the project, the stage of project development, and its environmental setting. These three levels are: the Vibration Screening Procedure, the General Vibration Assessment, and the Detailed Vibration Analysis. These levels of vibration analysis mirror the levels of noise analysis discussed in Section 4.2.

The Vibration Screening Procedure, performed first, defines the study area of any subsequent vibration impact assessment. Where there is potential for

impact, the General Vibration Assessment and Detailed Vibration Analysis procedures are used to determine the extent and severity of impact. In some cases, a General Vibration Assessment may be all that is needed. However, if the proposed project is near noise-sensitive land uses and it appears at the outset that the impact would be substantial, it is prudent to conduct a Detailed Vibration Analysis.

The methods for analyzing transit vibration are consistent with those described in recognized handbooks and international standards.⁽⁴⁶⁾⁽⁴⁷⁾

Conduct the vibration screening procedure and then determine the appropriate vibration analysis option:

Vibration Screening Procedure – The Vibration Screening Procedure is a simplified method of identifying the potential for vibration impact from transit projects. The Vibration Screening Procedure is applicable to all types of transit projects and does not require any specific knowledge about the vibration characteristics of the system or the geology of the area. This procedure uses simplified assumptions and considers the type of project and the presence or absence of vibration-sensitive land uses within a screening distance that has been developed to identify most potential vibration impacts. If no vibration-sensitive land uses are present within the defined screening distance, then no further vibration assessment is necessary.

The Vibration Screening Procedure steps are provided in Section 6.3, Step 1.

General Vibration Assessment – The General Vibration Assessment is used to examine potential impacts to vibration-sensitive land use areas identified in the screening step more closely. It uses generalized information likely to be available at an early stage in the project development process and during the development of most environmental documents.

Vibration levels at receivers are determined by estimating the overall vibration velocity level and A-weighted ground-borne noise levels as a function of distance from the track and applying adjustments to account for factors such as track support systems, vehicle speed, type of building, and track and wheel conditions.

A General Vibration Assessment is sufficient for the environmental review of many projects, including projects that compare transit modal alternatives or relocate a crossover or turnout. The General Vibration Assessment may also be sufficient if it results in a commitment to mitigation that eliminates the vibration impacts, such as a change in transit mode or alignment. However, if impact is identified through the General Vibration Assessment procedures and not mitigated, a Detailed Vibration Analysis of the selected alternative must be completed. Most vibration mitigation measures can only be specified after a Detailed Vibration Analysis has been done.

The General Vibration Assessment procedure is provided in Section 6.3, Step 2.

Detailed Vibration Analysis – The Detailed Vibration Analysis procedure is a comprehensive assessment method that produces the most accurate estimates

of vibration impact for a proposed project and is often accomplished during the engineering phase of a project when there are sufficient data identifying potential adverse vibration impacts from the project. However, a Detailed Vibration Analysis may be warranted earlier in the environmental review process if there are potentially severe impacts due to the proximity of vibration-sensitive land uses. This type of assessment requires professionals with experience in performing and interpreting vibration propagation tests.

A Detailed Vibration Analysis may not be necessary for all segments of a project. Generalized prediction curves from the General Vibration Assessment procedures may be sufficient for most of the alignment, and the Detailed Vibration Analysis procedure may only need to be applied to particularly sensitive receivers (Section 6.3). Note that a Detailed Vibration Analysis is typically required when designing special track-support systems such as floating slabs or ballast mats. These and other costly vibration mitigation measures can only be specified after a Detailed Vibration Analysis has been done in the engineering phase of the project.

The Detailed Vibration Analysis procedure is presented in Section 6.3, Step 3.

6.2 Determine Vibration Impact Criteria

Use the FTA criteria presented in this section when conducting a General Vibration Assessment or a Detailed Vibration Assessment. Like noise, the sensitivity to vibration varies by land use type, and the criteria represent these sensitivities. These criteria are based on national and international standards,⁽³⁸⁾⁽³⁹⁾⁽⁴⁸⁾ as well as experience on human response to building vibration. See Section 5.5 for additional background information on the development of FTA vibration criteria. The criteria for environmental impact from ground-borne vibration and noise are based on the maximum root-mean-square (rms) vibration velocity levels for repeated events of the same source.

Determine the appropriate criteria based on the level of analysis (Section 6.1). The impact criteria for the General Vibration Assessment are presented in Option A, and the impact criteria for the Detailed Vibration Analysis are presented in Option B.

Option A: General Vibration Assessment Criteria

Determine the land use according to Step 1 and the frequency of events according to Step 2. The impact criteria for the General Vibration Analysis are presented in Step 3.

Step 1: Land Use Categories

Determine the appropriate land use category for the receiver of vibration impacts of the project or project segment. Sensitive land use categories for vibration assessment are presented in Table 6-1 in order of sensitivity. Consider indoor use of the buildings when determining land use categories for ground-borne vibration and noise, since impact is experienced indoors.

Table 6-1 Land Use Categories for General Vibration Assessment Impact Criteria

Land Use Category	Land Use Type	Description of Land Use Category
-	Special Buildings	This category includes special-use facilities that are very sensitive to vibration and noise that are not included in the categories below and require special consideration. However, if the building will rarely be occupied when the source of the vibration (e.g., the train) is operating, there is no need to evaluate for impact. Examples of these facilities include concert halls, TV and recording studios, and theaters.
1	High Sensitivity	This category includes buildings where vibration levels, including those below the threshold of human annoyance, would interfere with operations within the building. Examples include buildings where vibration-sensitive research and manufacturing* is conducted, hospitals with vibration-sensitive equipment, and universities conducting physical research operations. The building's degree of sensitivity to vibration is dependent on the specific equipment that will be affected by the vibration. Equipment moderately sensitive to vibration, such as high resolution lithographic equipment, optical microscopes, and electron microscopes with vibration isolation systems are included in this category.** For equipment that is more sensitive, a Detailed Vibration Analysis must be conducted.
2	Residential	This category includes all residential land use and buildings where people normally sleep, such as hotels and hospitals. Transit-generated ground-borne vibration and noise from subways or surface running trains are considered to have a similar effect on receivers.***
3	Institutional	This category includes institutions and offices that have vibration-sensitive equipment and have the potential for activity interference such as schools, churches, doctors' offices. Commercial or industrial locations including office buildings are not included in this category unless there is vibration-sensitive activity or equipment within the building. As with noise, the use of the building determines the vibration sensitivity.

* Manufacturing of computer chips is an example of a vibration-sensitive process.

** Standard optical microscopes can be impacted at vibration levels below the threshold of human annoyance.

*** Even in noisy urban areas, the bedrooms will often be in quiet buildings with effective noise insulation. However, ground-borne vibration and noise are experienced indoors, and building occupants have practically no means to reduce their exposure. Therefore, occupants in noisy urban areas are just as likely to be exposed to ground-borne vibration and noise as those in quiet suburban areas.

- **Ground-borne Vibration** – Locations with equipment that is highly-sensitive to vibration should be included in category 1 or assessed using the Detailed Vibration Analysis procedures (Section 6.3, Step 3) and criteria (Section 6.2, Option B) or specific criteria of the equipment manufacturer.

Most computer installations or telephone switching equipment is not considered sensitive to vibration. Although the owners of this type of equipment often are concerned with the potential for ground-borne vibration interrupting smooth operation of their equipment, it is rare for computer or other electronic equipment to be particularly sensitive to vibration. This type of equipment is typically designed to operate in common building environments where the equipment may experience occasional disturbances and continuous background vibration caused by other equipment.

- **Ground-borne Noise** – Ground-borne noise is typically only assessed at locations with subway or tunnel operations where there is no airborne noise path, or for buildings with substantial sound insulation such as a recording studio. For typical buildings with at-grade or elevated transit operations, the interior airborne noise levels are often higher than the

ground-borne noise levels. For interior rooms or other special cases, ground-borne noise may need to be assessed.

Step 2: Identify Event Frequency

Determine the appropriate frequency of events for the project or project segment.

Community response to vibration correlates with the frequency of events and, intuitively, more frequent events of low vibration levels may evoke the same response as fewer high vibration level events. This effect is accounted for in the ground-borne vibration and noise impact criteria by characterizing projects by frequency of events. Event frequency definitions are presented in Table 6-2.

Table 6-2 Event Frequency Definitions

Category	Definition	Typical Project Types
Frequent Events	More than 70 events per day	Most rapid transit
Occasional Events	30–70 events per day	Most commuter trunk lines
Infrequent Events	Fewer than 30 events per day	Most commuter rail branch lines

Step 3: Apply Impact Criteria by Land Use and Event Frequency

Select the appropriate impact criteria for ground-borne vibration and noise based on the previously identified land use categories and frequency of events. It is also important to consider the time of vibration sensitivity. If the building is not typically occupied when the vibration source (e.g., train) is operating, it is not necessary to consider impact.

The criteria in this section are appropriate for assessing human annoyance or interference with vibration-sensitive equipment for common projects. While not typical, existing conditions, freight train operations, and building damage may require consideration.

- **Existing Conditions** – The criteria in this section do not consider existing conditions. In most cases, the existing environment does not include a substantial number of perceptible ground-borne vibration or noise events. However, existing conditions must be evaluated in some cases, such as for projects located in an existing rail corridor. For criteria considering existing conditions, see Step 3b.
- **Freight Train Operations** – The criteria are primarily based on experience with passenger train operations. Passenger train operations (rapid transit, commuter rail, and intercity passenger railroad) create vibration events that last approximately 10 seconds or less while a typical line-haul freight train event lasts approximately two minutes. This manual is oriented to transit projects. However, situations will occur when freight train operations must be evaluated, such as when freight train tracks are relocated for a transit project within a railroad ROW. Guidelines on applying these criteria to freight train operations are presented in Step 3c.

- **Building Damage** – It is extremely rare for vibration from train operations to cause substantial or even minor cosmetic building damage. However, damage to fragile historic buildings located near the ROW may be of concern. Even in these cases, damage is unlikely except when the track is located very close to the structure. Damage thresholds that apply to these structures are discussed in Section 7.2, Step 4 on Construction Vibration Impacts.

3a. Choose the impact criteria by land use category and event frequency. The criteria for ground-borne vibration and noise land use categories 1-3 are presented in Table 6-3. The criteria are presented in terms of acceptable indoor ground-borne vibration and noise levels. Impact will occur if these levels are exceeded. Criteria for ground-borne vibration are expressed in terms of rms velocity levels in VdB, and criteria for ground-borne noise are expressed in terms of A-weighted sound pressure levels in dBA.

**Table 6-3 Indoor Ground-Borne Vibration (GBV) and Ground-Borne Noise (GBN)
Impact Criteria for General Vibration Assessment**

Land Use Category	GBV Impact Levels (VdB re 1 micro-inch /sec)			GBN Impact Levels (dBA re 20 micro Pascals)		
	Frequent Events	Occasional Events	Infrequent Events	Frequent Events	Occasional Events	Infrequent Events
Category 1: Buildings where vibration would interfere with interior operations.	65 VdB*	65 VdB*	65 VdB*	N/A**	N/A**	N/A**
Category 2: Residences and buildings where people normally sleep.	72 VdB	75 VdB	80 VdB	35 dBA	38 dBA	43 dBA
Category 3: Institutional land uses with primarily daytime use.	75 VdB	78 VdB	83 VdB	40 dBA	43 dBA	48 dBA

* This criterion limit is based on levels that are acceptable for most moderately sensitive equipment such as optical microscopes. For equipment that is more sensitive, a Detailed Vibration Analysis must be performed.

** Vibration-sensitive equipment is generally not sensitive to ground-borne noise; however, the manufacturer's specifications should be reviewed for acoustic and vibration sensitivity.

The criteria for ground-borne vibration and noise for special land uses are presented in Table 6-4. The criteria are presented in terms of acceptable indoor ground-borne vibration and noise levels. Impact will occur if these levels are exceeded. As for the other land uses, the criteria for ground-borne vibration are expressed in terms of rms velocity levels in VdB, and criteria for ground-borne noise are expressed in terms of sound pressure levels in dBA.

Table 6-4 Indoor Ground-Borne Vibration and Noise Impact Criteria for Special Buildings

Type of Building or Room	Ground-Borne Vibration Impact Levels (VdB re 1 micro-inch/sec)		Ground-Borne Noise Impact Levels (dBA re 20 micro-Pascals)	
	Frequent Events	Occasional or Infrequent Events	Frequent Events	Occasional or Infrequent Events
Concert halls	65 VdB	65 VdB	25 dBA	25 dBA
TV studios	65 VdB	65 VdB	25 dBA	25 dBA
Recording studios	65 VdB	65 VdB	25 dBA	25 dBA
Auditoriums	72 VdB	80 VdB	30 dBA	38 dBA
Theaters	72 VdB	80 VdB	35 dBA	43 dBA

3b. Consider the presence of existing vibration conditions.

When the project will cause vibration more than 5 dB above the existing vibration, the existing source can be ignored, and the standard vibration criteria in Step 3a are appropriate. When the project will cause vibration less than 5 dB above the existing vibration level, use the instructions presented in this section to determine the appropriate impact criteria for the project. For information on characterizing existing vibration conditions, see Section 6.2, Step 3.

Use Table 6-5 and Figure 6-1 to determine the appropriate impact criteria. Sources of existing vibration are typically longer in duration than the events introduced into the environment due to the project. The frequency of use in the rail corridor is also a factor in characterizing the existing conditions. Both factors are considered in the process of determining appropriate impact criteria in Table 6-5 and Figure 6-1.

Examples of projects considering the existing vibration conditions in Table 6-5 and Figure 6-1 include:

- An automated people mover system planned for a corridor with an existing rapid transit service with 220 trains per day that did not have a significant increase in events from the existing 220 trains per day and that is not 3 dB above the existing vibration level would cause no additional impact.
- Where a new commuter rail line shares a heavily-used corridor with a rapid transit system, the project vibration exceeds the existing vibration level, there is not a significant increase in the number of events, and the project vibration exceeds the existing vibration level by 3 dB or more, the projected vibration levels must be evaluated using the standard impact criteria to determine impact.
- If a new transit project will use an existing railroad ROW and the location of existing railroad tracks are shifted, existing vibration can be substantial. The track relocation and reconstruction can result in lower vibration levels that would benefit the receivers and not introduce any adverse impact. However, if the track relocation causes higher vibration levels at vibration-sensitive receivers, then the projected vibration levels must be evaluated using the standard impact criteria to determine impact.

Table 6-5 Impact Criteria Considering Existing Conditions

Category	Number of Operations (At present – without project)	Criteria
Heavily Used	More than 12 trains per day	<p>Use the standard vibration criteria in Section 6.2, Step 3a for the following scenarios:</p> <ul style="list-style-type: none"> ▪ The existing vibration does not exceed the standard vibration criteria. ▪ The existing vibration exceeds the standard vibration criteria and there is a significant increase in events.* ▪ The existing vibration exceeds the standard vibration criteria, and the project vibration is 3 dB or more above the existing vibration. <p>The project has no impact if the existing vibration exceeds the standard vibration criteria, the number of events does not increase significantly, and the project vibration does not exceed the existing vibration by 3 dB or more.</p>
Moderately Used	5 – 12 trains per day	<p>Use the standard vibration criteria in Section 6.2 Step 3a for the following scenarios:</p> <ul style="list-style-type: none"> ▪ The existing vibration does not exceed the standard vibration criteria. ▪ The existing vibration exceeds the standard vibration criteria, and the project vibration is not 5 dB or more below the existing vibration. <p>The project has no impact if the existing vibration exceeds the standard vibration criteria and the project vibration is at least 5 dB below the existing vibration.</p>
Infrequently Used	Fewer than 5 trains per day	The standard vibration criteria in Section 6.2, Step 3a apply.

* Approximately doubling the number of events is required for a significant increase.

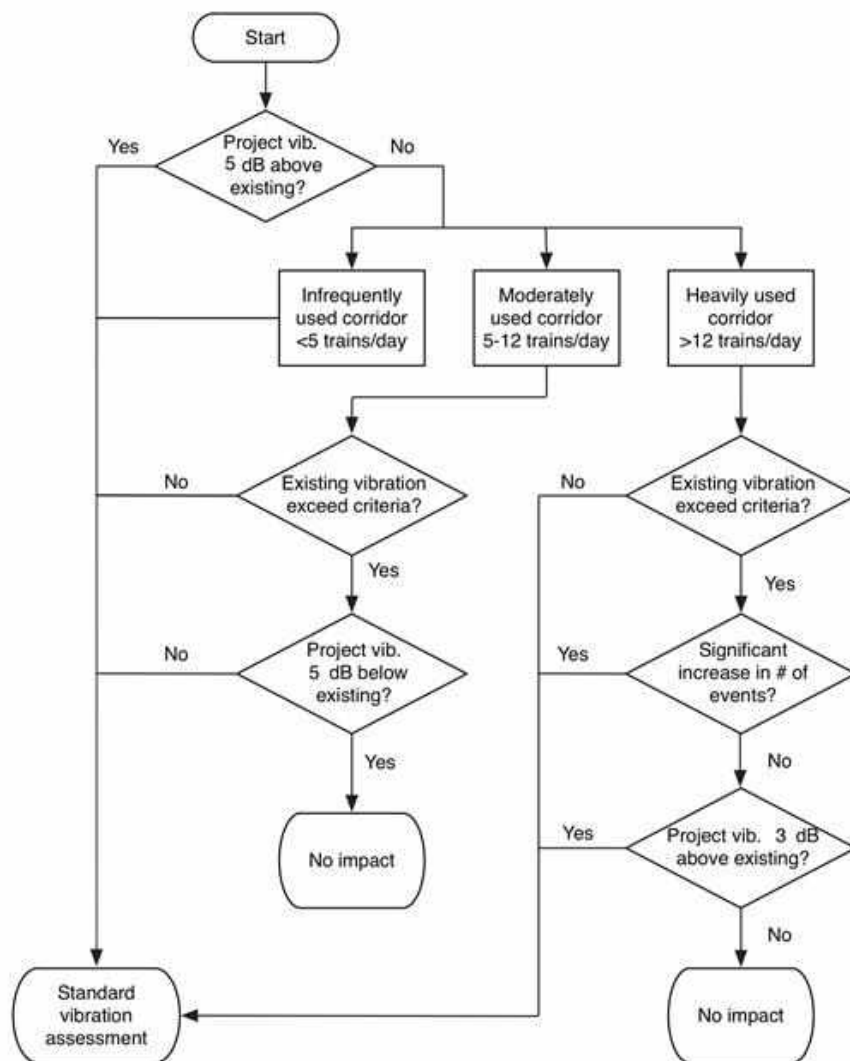


Figure 6-1 Existing Vibration^{xii} Criteria Flow Chart

3c. Apply criteria to freight trains if part of the project.

Use the criteria presented in Step 3a to assess the vibration from freight trains in shared ROW scenarios because no specific impact criteria exist for freight railroads. It is important to consider that freight operations occur over substantially greater distances than passenger train operations and have different weight and axle loads.

When assessing vibration from freight train operations, consider the locomotive and rail car vibration separately. Since locomotive vibration lasts for a very short time, it can be characterized by the infrequent events category in Table 6-2. Rail car vibration from a typical line-haul freight train usually lasts for several minutes and can be characterized by the frequent events category in Table 6-2. Note

^{xii} Vibration is abbreviated as “vib.” in this flowchart.

that locomotives often create vibration levels that are 3 to 8 dB higher than those created by rail cars.

Use good engineering judgment to confirm the approach is reasonable for each project. For example, some spur rail lines carry very little rail traffic (sometimes only one train per week) or have short trains, in which case it may not be necessary to evaluate for impact. If there is uncertainty in how to determine the appropriate criteria, contact the FTA Regional office.

Decisions to relocate freight tracks closer to vibration-sensitive sites should be made with the understanding that increased vibration due to freight rail may not be possible to mitigate. Freight rail vibration may not always be successfully mitigated by the same methods as rail transit systems.

Option B: Vibration Impact Criteria for a Detailed Vibration Analysis

Determine the appropriate impact criteria for ground-borne vibration and ground-borne noise for a Detailed Vibration Analysis.

Step 1: Ground-Borne Vibration

Choose the appropriate criteria based on Figure 6-2 and Table 6-6.

Ground-borne vibration criteria presented in this section are more detailed than in the General Vibration Assessment. The criteria are based on international standards for the effects of vibration on people related to annoyance and interference with activities in buildings⁽³⁹⁾ as well as industry standards for vibration-sensitive equipment.⁽⁴⁶⁾ The criteria in this section are used to assess the potential for interference or annoyance from building response and to determine performance of vibration reduction methods. Note that for highly-sensitive equipment, specific vibration criteria provided by the manufacturer supersede the criteria in this section.

The criteria are presented by category in Figure 6-2 and are defined by international and industry standards.⁽³⁹⁾⁽⁴⁶⁾ These criteria define limits for acceptable maximum rms vibration velocity level with a one-second averaging time at the floor of the receiving building in terms of a one-third octave band frequency spectrum. Band levels that exceed a particular criterion curve indicate impact; and therefore, mitigation options should be evaluated considering the specific frequency range in which the treatment is most effective. Interpretations of the criteria are presented in Table 6-6.

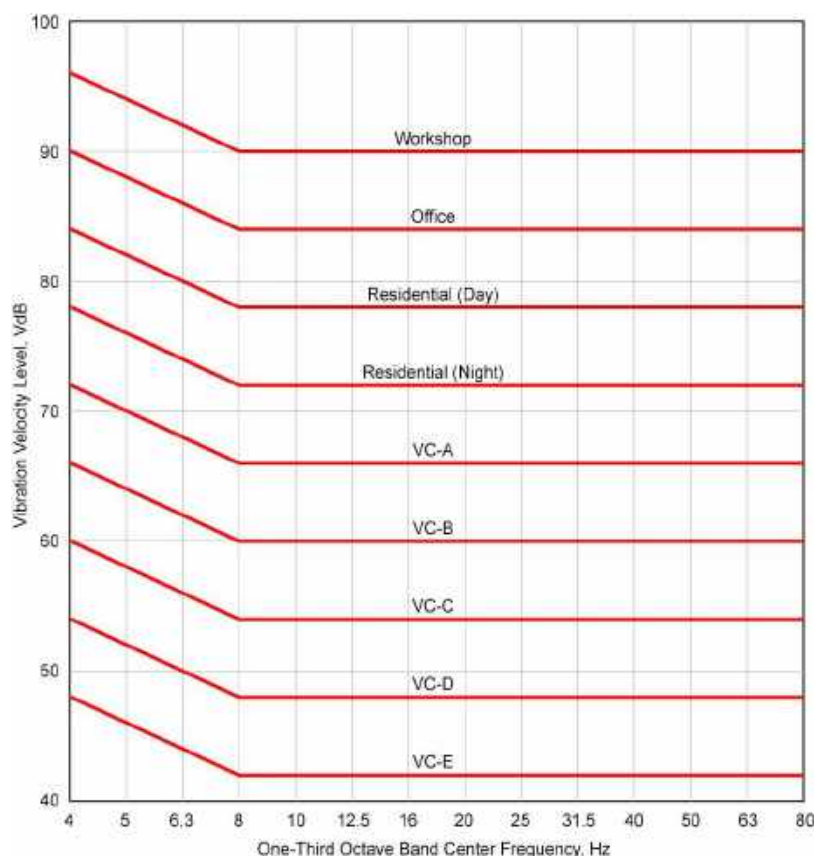


Figure 6-2 Criteria for Detailed Vibration Analysis

Table 6-6 Interpretation of Vibration Criteria for Detailed Vibration Analysis

Criterion Curve	Max Lv,* VdB	Description of Use
Workshop (ISO)	90	Vibration that is distinctly felt. Appropriate for workshops and similar areas not as sensitive to vibration.
Office (ISO)	84	Vibration that can be felt. Appropriate for offices and similar areas not as sensitive to vibration.
Residential Day (ISO)	78	Vibration that is barely felt. Adequate for computer equipment and low-power optical microscopes (up to 20X).
Residential Night, Operating Rooms (ISO)	72	Vibration is not felt, but ground-borne noise may be audible inside quiet rooms. Suitable for medium-power optical microscopes (100X) and other equipment of low sensitivity.
VC-A	66	Adequate for medium- to high-power optical microscopes (400X), microbalances, optical balances, and similar specialized equipment.
VC-B	60	Adequate for high-power optical microscopes (1000X) and inspection and lithography equipment to 3-micron line widths.
VC-C	54	Appropriate for most lithography and inspection equipment to 1-micron detail size.
VC-D	48	Suitable in most instances for the most demanding equipment, including electron microscopes operating to the limits of their capabilities.
VC-E	42	The most demanding criterion for extremely vibration-sensitive equipment.

* As measured in 1/3-octave bands of frequency over the frequency range 8 to 80 Hz.

In addition to the uses described in Table 6-6, the detailed vibration criteria can be applied to the three land use categories presented in Table 6-3.

- For residential land uses (category 2), use the residential night criterion curve in Table 6-6.
- For institutional uses (category 3), use the residential day criterion curve in Table 6-6.
- For category 1, the specific use of the building should be matched to the appropriate criterion curve in Table 6-6.
- For special buildings, such as those found in Table 6-4, either the criteria in Table 6-4 or specific criteria presented by the building operator should be used.

These criteria use a frequency spectrum because vibration-related problems generally occur due to resonances of the structural components of a building or vibration-sensitive equipment. Resonant response is frequency-dependent. A Detailed Vibration Analysis can provide an assessment that identifies potential problems resulting from resonances.

The detailed vibration criteria are based on generic cases when people are standing or equipment is mounted on the floor in a conventional manner. Consequently, the criteria are less stringent at very low frequencies below 8 Hz. Where special vibration isolation has been provided in the form of pneumatic isolators, the resonant frequency of the isolation system is very low. Consequently, in this special case, the curves may be extended flat at lower frequencies.

Step 2: Ground-borne Noise

Ground-borne noise impacts are assessed based on criteria for human annoyance and activity interference. The Detailed Vibration Analysis procedure provides vibration spectra inside a building. To evaluate ground-borne noise, convert these vibration spectra to sound pressure level spectra in the occupied spaces using the method described in Section 6.5 and compare to the criteria as follows:

- For residential buildings, use the criteria presented in Table 6-3.
- For special buildings listed in Table 6-4, A-weighted noise may not be sufficient to assess activity interference for a Detailed Vibration Analysis. Each special building may have a unique specification for acceptable noise levels and criteria must be determined on a case-by-case basis. For example, a recording studio may have stringent requirements for allowable noise in each frequency band.

6.3 Evaluate Impact: Vibration Screening Procedure

Determine the potential for impact using the Vibration Screening Procedure by identifying any vibration-sensitive land uses (Table 6-1) within the appropriate screening distance.

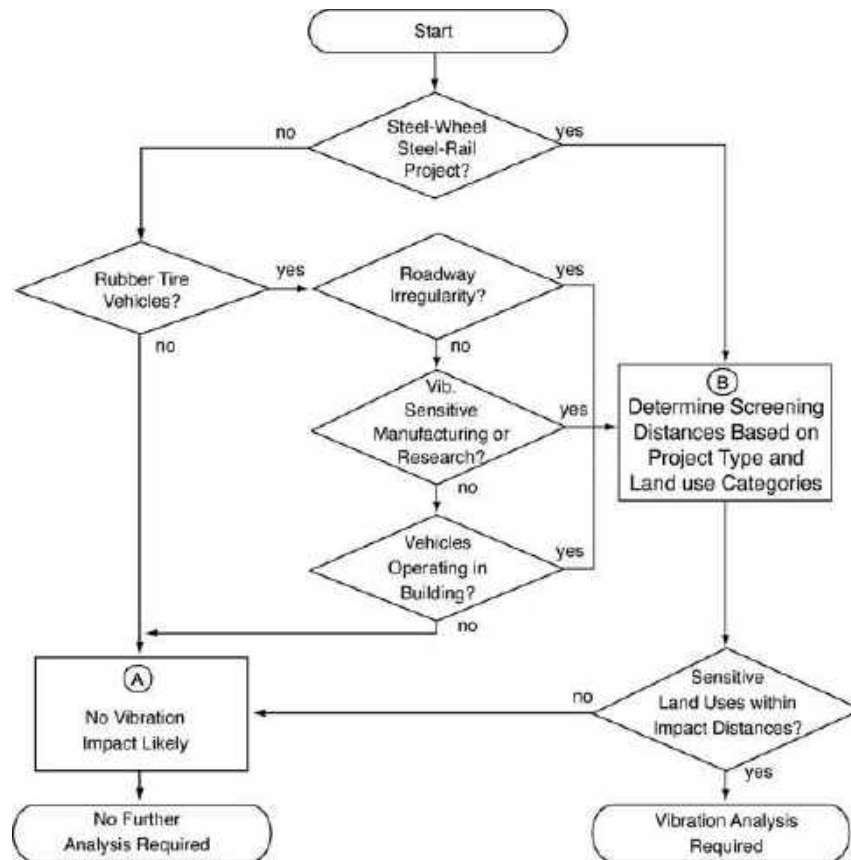


Figure 6-3 Flow Chart of Vibration Screening Process

Step 1: Classify Project Vehicles

Determine the project type and the next step based on the guidelines below.

Option A: No Vehicles – Transit projects that do not involve vehicles do not have potential for vibration impact and do not require further analysis (Box A in Figure 6-3).

Many smaller FTA-funded projects, such as bus terminals, park-and-ride lots, and station rehabilitation are in this category, and do not require further analysis of ground-borne vibration impact. However, if track systems are modified (e.g., tracks moved or switches modified), *proceed to Step 2*.

Option B: Steel-wheeled/Steel-rail Vehicles – Transit projects with steel-wheeled/steel-rail vehicles have potential for vibration impact (Box B in Figure 6-3); *proceed to Step 2*. These rail systems include urban rapid transit, LRT, commuter rail, and steel-wheel intermediate capacity transit (ICT) systems.

Option C: Rubber-tire Vehicles – For projects that involve rubber-tire vehicles and do not meet the following conditions, vibration impact is unlikely, and no further analysis is needed. *Proceed to Step 2* for projects that involve rubber-tire vehicles and meet the following conditions (Box A in Figure 6.3):

- **Roadway irregularity** – Expansion joints, speed bumps, or other design features that result in unevenness in the road surface can result in perceptible ground-borne vibration at distances up to 75 ft away.
- **Operation close to vibration-sensitive buildings** – Buses, trucks, or other heavy vehicles operating close to a vibration-sensitive building (within approximately 100 ft from the property line) may impact vibration-sensitive activities, such as research that uses electron microscopes or manufacturing of computer chips.
- **Vehicles operating within buildings** – Special considerations are often required for shared use facilities where vehicles operate inside or directly underneath buildings such as bus stations located inside an office building complex.

Step 2: Determine Project Type

Determine the project type according to Table 6-7.

Table 6-7 Project Types for Vibration Screening Procedure

Project Type Number	Project Type	Description
1	Conventional Commuter Railroad	Both locomotives and passenger vehicles create vibration. For commuter trains, the highest vibration levels are typically created by the locomotives. Electric commuter rail vehicles create levels of ground-borne vibration that are comparable to electric rapid transit vehicles.
2	RRT	Ground-borne vibration impact from rapid transit trains is one of the major environmental issues for new systems. Ground-borne vibration is usually a major concern for subway operations. It is less common for at-grade and elevated rapid transit lines to create intrusive ground-borne vibration and noise since air-borne noise typically dominates.
3	LRT and Streetcars	The ground-borne vibration characteristics of light rail systems are very similar to those of rapid transit systems. Because the speeds of light rail systems are usually lower, typical vibration levels are usually lower. Steel-wheel/steel-rail AGT is included in either this category or the ICT category depending on the level of service and train speeds.
4	Intermediate Capacity Transit	Because of the low operating speeds of most ICT systems, vibration problems are not common. However, steel-wheel ICT systems that operate close to* vibration-sensitive buildings have the potential of causing intrusive vibration. With a stiff suspension system, an ICT system could create intrusive vibration.
5	Bus and Rubber-Tire Transit Projects	This category encompasses most projects that do not include steel-wheel trains of some type. Examples include diesel buses, electric trolley buses, and rubber-tired people movers. Most projects that do not include steel-wheel trains do not cause vibration impacts.**

*See the screening distances for category 1 land uses in Table 6-8.

** Most complaints about vibration caused by buses and trucks are related to rattling of windows or items hung on the walls. These vibrations are usually the result of airborne noise and not ground-borne vibration. In the case where ground-borne vibration is the source of the complaint, the vibration can usually be attributed to irregularities in the road.

Step 3: Determine Screening Distance

Determine the appropriate screening distances based on land use and project type according to Table 6-8.

The distances are based on the criteria presented in Section 6.3, the procedures in Section 6.4 assuming normal vibration propagation, and include a 5-dB factor of safety. Even so, areas with very efficient vibration propagation can have substantially higher vibration levels.

Because of the 5-decibel safety factor, the screening distances will identify most of the potentially impacted areas, even for areas with efficient propagation. However, when there is evidence of efficient propagation, such as previous complaints about existing transit facilities or a history of problems with construction vibration, increase the distances in Table 6-8 by a factor of 1.5.

Table 6-8 Screening Distances for Vibration Assessments

Type of Project	Critical Distance for Land Use Categories*		
	Distance from ROW or Property Line, ft		
	Land Use Cat. 1	Land Use Cat. 2	Land Use Cat. 3
Conventional Commuter Railroad	600	200	120
RRT	600	200	120
LRT and Streetcars	450	150	100
ICT	200	100	50
Bus Projects (if not previously screened out)	100	50	--

*For the Vibration Screening Procedure, evaluate special buildings as follows: Category 1 - concert halls and TV studios, Category 2 - theaters and auditoriums

Step 4: Identify Vibration-Sensitive Land Uses

Identify all vibration-sensitive land uses (Table 6-1) within the chosen screening distance. If no vibration-sensitive land uses are identified, no further vibration analysis is needed. If one or more of the vibration-sensitive land uses are in the screening distance, complete a General Vibration Assessment (Section 6.4) or a Detailed Vibration Analysis (Section 6.5).

6.4 Evaluate Impact: General Vibration Assessment

Evaluate for impact using the General Vibration Assessment procedure if the Vibration Screening Procedure (Section 6.3) identified vibration-sensitive receivers within the screening distance of the transit vibration source.

For guidelines on when the General Vibration Assessment is appropriate, review Section 6.1.

The basic approach for the General Vibration Assessment is to define a curve or set of curves that predicts the overall ground-borne vibration as a function of distance from the source, then apply adjustments to these curves to account for factors such as vehicle speed, geologic conditions, building type, and receiver location within the building. When the vehicle type is not covered by the curves included in this section, it will be necessary to define an appropriate curve either by extrapolating from existing information or performing measurements at an existing facility.

Step 1: Select Base Curve for Ground Surface Vibration Level

Select a standard vibration curve to represent general vibration characteristics for the source.

The curves presented in Figure 6-4 are based on measurements of ground-borne vibration at representative North American transit systems and can be used to represent vibration characteristics for standard transportation systems in the General Vibration Assessment.

These curves assume typical ground-borne vibration levels, equipment in good condition, and speeds of 50 mph for the rail systems and 30 mph for buses. Adjustments to account for differences in speed and geologic conditions are included in Step 2.

Select a base curve from Figure 6-4 according to the guidelines in Table 6-9. Equations for the curves in Figure 6-4 are included in Table 6-10. Additional considerations for selecting a base curve for systems not included in Table 6-9 are presented below by transit mode.

Table 6-9 Ground Surface Vibration Level Base Curve Descriptions

Curve	Description
Locomotive-Powered Passenger or Freight Curve	Appropriate for vehicles powered by diesel or electric locomotives including intercity passenger trains and commuter rail trains.
Rapid Transit or Light Rail Vehicles Curve	Appropriate for both heavy and light-rail vehicles on at-grade and subway track.
Rubber-Tired Vehicles Curve	Appropriate for rubber-tire vehicles. These types of vehicles rarely create ground-borne vibration problems unless there is a discontinuity or bump in the road that causes the vibration. This curve represents the vibration level for a typical bus operating on smooth roadway.

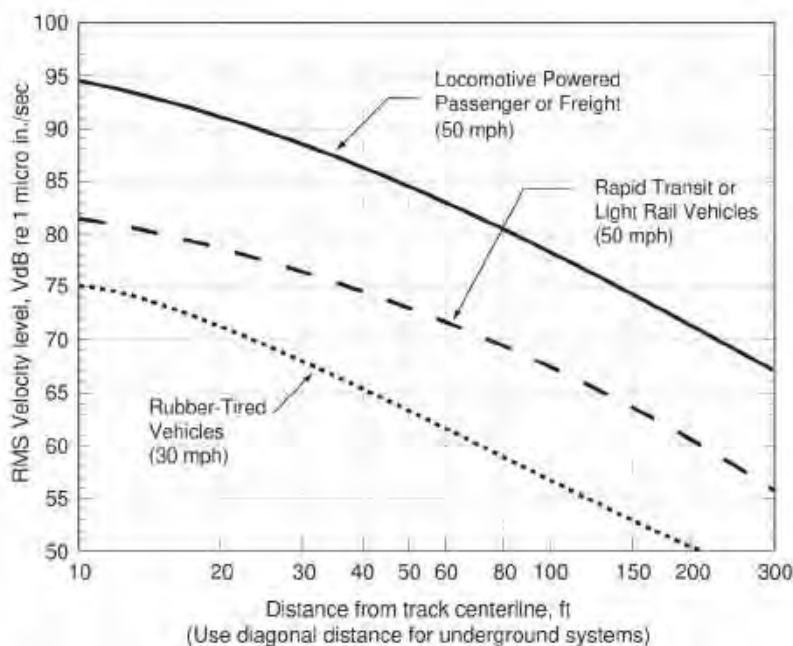


Figure 6-4 Generalized Ground Surface Vibration Curves

Table 6-10 Generalized Ground Surface Vibration Equations

Curve	Equation	
Locomotive Powered Passenger or Freight Curve	$L_v = 92.28 + 14.81 \log(D) - 14.17 \log(D)^2 + 1.65 \log(D)^3$	Eq. 6-1
Rapid Transit or Light Rail Vehicles Curve	$L_v = 85.88 - 1.06 \log(D) - 2.32 \log(D)^2 - 0.87 \log(D)^3$	Eq. 6-2
Rubber-Tired Vehicles Curve	$L_v = 66.08 + 34.28 \log(D) - 30.25 \log(D)^2 + 5.40 \log(D)^3$	Eq. 6-3
L_v = velocity level, VdB D = distance, ft		

Considerations for selecting a base curve for different transit modes include:

- **Intercity passenger trains** – Although intercity passenger trains can be an important source of environmental vibration, it is rare that they are considered for FTA-funded projects unless a new transit mode uses an existing rail alignment. When a new transit line uses an existing rail alignment, changes in the intercity passenger traffic can result in either positive or negative impacts. Use the locomotive-powered passenger or freight curve for intercity passenger trains unless there are specific data available on the ground-borne vibration created by the new train operations.
- **Locomotive-powered commuter rail** – Use the locomotive-powered passenger or freight curve for all commuter rail system powered by either diesel or electric locomotives.
- **Electric multiple unit (EMU)** – Use the rapid transit or light rail vehicles curve for self-powered electric commuter rail trains.
- **Diesel multiple unit (DMU)** – Self-powered DMUs create vibration levels somewhere between rapid transit vehicles and locomotive-powered passenger trains. A vibration curve for DMUs can be estimated by lowering the locomotive-powered passenger or freight curve by 5 dB.
- **Subway heavy rail or light rail** – Use the rapid transit or light rail vehicles curve for subway heavy rail and subway light rail. Although vibrations from subway and at-grade tracks have very different characteristics, the overall vibration velocity levels are comparable. When applied to subways, the rapid transit or light rail vehicles curve assumes a relatively lightweight bored concrete tunnel in soil. The vibration levels will be lower for heavier subway structures such as cut-and-cover box structures and stations.
- **At-grade heavy rail or light rail** – Use the rapid transit or light rail vehicles curve for at-grade heavy rail or light rail. Heavy rail and LRT vehicles have similar suspension systems and axle loads and create similar levels of ground-borne vibration.

- **Elevated guideways or aerial structures** – Vibration from operations on an elevated structure is typically not an issue unless the guideway is supported by a building or located very close to buildings. Apply the appropriate adjustment for the aerial structures (Section 6.4, Step 2).
- **Streetcars** – Use the rapid transit or light rail vehicles curve for street cars.
- **ICT** – Use the rapid transit or light rail vehicles curve for ICT systems with steel wheels and the rubber-tired vehicles curve for ICT systems with rubber tires.
- **Other vehicle types** – For less common modes such as magnetically-levitated vehicles (maglev), monorail, or AGT, use good engineering judgment to choose a standard curve to best fit the mode or if a new curve needs to be developed, as a function of distance from the track. Examples include:
 - Vibration from a rubber-tire monorail operating on aerial guideway can be approximated using the rubber-tired vehicles curve with the appropriate adjustment for the aerial structure (Section 6.4, Step 2).
 - Most of the data available on the noise and vibration characteristics of maglev vehicles comes from high-speed systems intended for inter-city service. Even though there is no direct contact between the vehicle and the guideway, the dynamic loads on the guideway can generate ground-borne vibration. Measurements on a German high-speed maglev resulted in ground-borne vibrations at 75 mph which is comparable to the base curve for rubber-tired vehicles at 30 mph.⁽⁴⁹⁾

Step 2: Apply Adjustments

Apply project-specific adjustments to the standard vibration curve.

Once the base curve has been selected, use the adjustments in the following instructions to develop project-specific vibration projections at each receiver. All adjustments are given as single numbers to add to, or subtract from, the base level.

Adjustments are separated by source, path, and receiver and include speed, wheel and rail type and condition, type of track support system, type of building foundation, and number of floors above the basement level. Calculate the appropriate adjustments to the base level. An example of the General Vibration Assessment is provided at the end of this Section.

It should be recognized that many of these adjustments are strongly dependent on the frequency spectrum of the vibration source and the frequency dependence of the vibration propagation. The adjustments in this section are suitable for generalized evaluation of the vibration impact and vibration

mitigation measures because they are based on typical vibration spectra. However, these adjustments are not adequate for detailed evaluations of impact of vibration-sensitive buildings or for detailed specification of mitigation measures.

2a. Apply source adjustments to the base curve using Table 6-11 and the descriptions below to account for the project-specific source characteristics.

Table 6-11 Source Adjustment Factors for Generalized Predictions of GB Vibration and Noise

Source Factor	Adjustment to Propagation Curve			Comment
Speed		Reference Speed		Vibration level is approximately proportional to $20\log(\text{speed}/\text{speed}_{\text{ref}})$, see Eq. 6-4.
	<u>Vehicle Speed</u>	<u>50 mph</u>	<u>30 mph</u>	
	60 mph	+1.6 dB	+6.0 dB	
	50 mph	0.0 dB	+4.4 dB	
	40 mph	-1.9 dB	+2.5 dB	
	30 mph	-4.4 dB	0.0 dB	
	20 mph	-8.0 dB	-3.5 dB	
Vehicle Parameters (not additive, apply greatest value only)				
Vehicle with stiff primary suspension	+8 dB			Transit vehicles with stiff primary suspensions have been shown to create high vibration levels. Include this adjustment when the primary suspension has a vertical resonance frequency greater than 15 Hz.
Resilient Wheels	0 dB			Resilient wheels do not generally affect ground-borne vibration except at frequencies greater than about 80 Hz.
Worn Wheels or Wheels with Flats	+10 dB			Wheel flats or wheels that are unevenly worn can cause high vibration levels.
Track Conditions (not additive, apply greatest value only)				
Worn or Corrugated Track	+10 dB			Corrugated track is a common problem. Mill scale* on new rail can cause higher vibration levels until the rail has been in use for some time. If there are adjustments for vehicle parameters and the track is worn or corrugated, only include one adjustment.
Special Trackwork within 200 ft	+10 dB (within 100 ft) +5 dB (between 100 and 200 ft)			Wheel impacts at special trackwork will greatly increase vibration levels. The increase will be less at greater distances from the track. Do not include an adjustment for special trackwork more than 200 ft away.
Jointed Track	+5 dB			Jointed track can cause higher vibration levels than welded track.
Uneven Road Surfaces	+5 dB			Rough roads or expansion joints are sources of increased vibration for rubber-tire transit.
Track Treatments (not additive, apply greatest value only)				
Floating Slab Trackbed	-15 dB			The reduction achieved with a floating slab trackbed is strongly dependent on the frequency characteristics of the vibration.
Ballast Mats	-10 dB			Actual reduction is strongly dependent on frequency of vibration.
High-Resilience Fasteners	-5 dB			Slab track with track fasteners that are very compliant in the vertical direction can reduce vibration at frequencies greater than 40 Hz.

*Mill scale on a new rail is a slightly corrugated condition caused by certain steel mill techniques.

In addition to the comments in Table 6-11, use the following guidelines to select the appropriate adjustment factors. Some adjustments in the same category are not cumulative (additive) and only the greatest applicable adjustment should be applied. The adjustments that are not additive are noted in Table 6-11 and in the descriptions below. Note that some adjustments are not additive across multiple categories and are noted in the comments of Table 6-11. For example, the adjustment for a vehicle with stiff primary suspension is 8 dB, and the adjustment for wheel flats is 10 dB. If the vehicle has a stiff primary suspension and has wheel flats, the projected vibration levels should be increased by 10 dB, not 18 dB.

In addition, some vibration control measures are targeted for specific frequency ranges. The shape of the actual vibration spectra should be considered so that an appropriate vibration control measure may be selected.

- **Speed** – The levels of ground-borne vibration and noise vary, approximately, as 20 times the logarithm of speed. This means that doubling train speed will increase the vibration levels approximately 6 dB, and halving train speed will reduce the levels by 6 dB. The adjustments in Table 6-11 have been tabulated for reference vehicle speeds of 30 mph for rubber-tired vehicles and 50 mph for steel-wheel vehicles. Use the following relationship to calculate the adjustments for other speeds.

$$Adj_{speed} (dB) = 20 \log \left(\frac{speed}{speed_{ref}} \right) \quad \text{Eq. 6-4}$$

Variation with speed has been observed to be as low as $15 \log \left(\frac{speed}{speed_{ref}} \right)$, but unless specific speed data for vibration for a vehicle has been obtained, use Eq. 6-4.

- **Vehicle Parameters** – The most important factors for the vehicles are the suspension system, wheel condition, and wheel type. Most new heavy rail and light rail vehicles have relatively soft primary suspensions. However, a stiff primary suspension (vertical resonance frequency greater than 15 Hz) can result in higher levels of ground-borne vibration than soft primary suspensions. Vehicles, for which the primary suspension consists of rubber or neoprene around the axle bearing, usually have a very stiff primary suspension with a vertical resonance frequency greater than 40 Hz or more.

Deteriorated wheel condition is another factor that increases vibration levels. It can be assumed that a new system has vehicles with wheels in good condition. When older vehicles are used on new track, it is important to consider the condition of the wheels, and it may be appropriate to include an adjustment for the wheel condition.

Resilient wheels will reduce vibration levels at frequencies greater than the effective resonance frequency of the wheel. When this resonance

frequency is relatively high, greater than 80 Hz, resilient wheels may only have a marginal effect on ground-borne vibration.

The adjustments in this category are not additive; apply the greatest applicable value only.

- **Track Conditions** – This category includes the type of rail (welded, jointed, or special trackwork), the track support system, and the condition of the rail. The base curves assume welded rail in good condition. Jointed rail causes higher vibration levels than welded rail and the increase depends on the condition of the joints.

Wheel impacts at special trackwork, such as frogs at crossovers, create much higher vibration forces than typical track conditions. Because of the higher vibration levels at special trackwork, crossovers are the principal areas of vibration impact on new systems. Methods of mitigating the vibration impact include modifying the track support system, installing low-impact frogs, or relocating the crossover. Special track support systems such as ballast mats, high-resilience track fasteners, resiliently supported ties, and floating slabs have all been shown to be effective in reducing vibration levels.

The condition of the running surface of the rails can strongly affect vibration levels. Factors such as corrugations, general wear, or mill scale on new track can cause vibration levels 5 to 15 dB higher than normal. Mill scale will typically wear away after some time in service, but the track must be ground to remove corrugations or to reduce the roughness from wear.

Roadway surfaces in the rubber-tired vehicle base curve are assumed to be smooth. Rough washboard surfaces, bumps, or uneven expansion joints are the types of running surface defects that cause increased vibration levels over the smooth road condition.

The adjustments in this category are not additive; apply the greatest applicable value only. If there are adjustments for vehicle parameters and the track is worn or corrugated, only include one adjustment.

2b. Apply path adjustments to the base curve using Table 6-12 and the descriptions below to account for the project-specific path characteristics.

Table 6-12 Path Adjustment Factors for Generalized Predictions of GB Vibration and Noise

Path Factor	Adjustment to Propagation Curve		Comment	
Resiliently Supported Ties (Low-Vibration Track, LVT)	-10 dB		Resiliently supported tie systems have been found to provide very effective control of low-frequency vibration.	
Track Structure (not additive, apply greatest value only)				
Type of Transit Structure	Relative to at-grade tie & ballast:		In general, the heavier the structure, the lower the vibration levels. Putting the track in cut may reduce the vibration levels slightly. Rock-based subways generate higher-frequency vibration.	
	Elevated structure			-10 dB
	Open cut			0 dB
	Relative to bored subway tunnel in soil:			
	Station			-5 dB
	Cut and cover		-3 dB	
	Rock-based		-15 dB	
Ground-borne Propagation Effects				
Geologic conditions that promote efficient vibration propagation	Efficient propagation in soil		+10 dB	Refer to the text for guidance on identifying areas where efficient propagation is possible.
	Propagation in rock layer	Dist.	Adjust.	The positive adjustment accounts for the lower attenuation of vibration in rock compared to soil. It is generally more difficult to excite vibrations in rock than in soil at the source.
		50 ft	+2 dB	
		100 ft	+4 dB	
		150 ft	+6 dB	
	200 ft	+9 dB		
Coupling to building foundation	Wood-Frame Houses	-5 dB	In general, the heavier the building construction, the greater the coupling loss.	
	1-2 Story Masonry	-7 dB		
	3-4 Story Masonry	-10 dB		
	Large Masonry on Piles	-10 dB		
	Large Masonry on Spread Footings	-13 dB		
	Foundation in Rock	0 dB		

In addition to the comments in Table 6-12, use the following guidelines to select the appropriate adjustment factors.

- **Track Structure** – The weight and size of a transit structure affects the vibration radiated by that structure. In general, vibration levels are lower for heavier transit structures. Therefore, the vibration levels from a cut-and-cover concrete double-box subway can be assumed to be lower than the vibration from a lightweight concrete-lined bored tunnel.

The vibration from elevated structures is lower than from at-grade track because of the mass and damping of the structure and the extra distance that the vibration must travel before it reaches the receiver. Elevated structures in AGT applications are sometimes designed to bear on building elements. This is a special case and may require detailed design considerations.

The adjustments in this category are not additive; apply the greatest applicable value only.

- **Ground-Borne Propagation Effects – Geologic Conditions –**

Although it is known that geologic conditions have a considerable effect on the vibration levels, it is rarely possible to develop more than a general understanding of the vibration propagation characteristics for a General Vibration Assessment. One of the challenges with identifying the cause of efficient propagation is the difficulty in determining whether higher than normal vibration levels are due to geologic conditions or due to special source conditions (e.g., rail corrugations or wheel flats).

Some geologic conditions are repeatedly associated with efficient propagation. Shallow bedrock, less than 30 ft below the surface, is likely to have efficient propagation. Soil type and stiffness are also important factors in determining propagation characteristics. In particular, stiff, clayey soils, consolidated sand, gravel, and glacial till can be associated with efficient vibration propagation. Investigation of soil boring records can be used to estimate depth to bedrock and the presence of problem soil conditions.

A conservative approach would be to use the 10-dB adjustment for efficient propagation for areas where efficient propagation is likely. However, this adjustment can greatly overstate the potential for vibration impact where efficient propagation is not present and should be applied using good judgment. Review available geological data and any complaint history from existing transit lines and major construction sites near the transit corridor to identify areas where efficient propagation is possible. If there is reason to suspect efficient propagation conditions, conduct a Detailed Vibration Analysis during the engineering phase and include vibration propagation tests at the areas with potential for efficient propagation.

- **Track Structure and Geologic Conditions – Examples**

- **Subway**

For a subway, determine if the subway will be founded in bedrock. Bedrock is considered to be hard rock. It is usually appropriate to consider soft siltstone and sandstone to be more like soil than hard rock. Whether a subway is founded in soil or rock can make a 15-dB difference in the vibration levels.

When a subway structure is founded in rock, include the following Track Structure and Ground-borne Propagation Effects adjustments from Table 6-12:

- Type of Transit Structure adjustment: Rock-based – 15 dB
- Geologic Conditions adjustment: Propagation in rock layer for the appropriate distance.

This adjustment increases with distance because vibration attenuates more slowly in rock than in the soil used as a basis for the reference curve.

- **At-grade** – When considering at-grade vibration sources, determine if the vibration propagation characteristics are typical or efficient. Efficient

vibration propagation results in vibration levels approximately 10 dB higher than typical levels. This more than doubles the potential impact zone for ground-borne vibration.

- **Ground-Borne Propagation Effects – Coupling to Building Foundation** – Since annoyance from ground-borne vibration and noise is an indoor phenomenon, the effects of the building structure on the vibration must be considered. Wood-frame buildings, such as typical residential structures, are more easily excited by ground vibration than heavier buildings. In contrast, large masonry buildings with spread footings have a low response to ground vibration.

When a building foundation is directly on the rock layer, there is no coupling loss due to the weight and stiffness of the building. Use the standard coupling factors based on building type if there is at least a 10-foot layer of soil between the building foundation and the rock layer.

2c. Apply receiver adjustments to the base curve using Table 6-13 and the descriptions below to account for the project-specific receiver characteristics. The data in Table 6-13 is applicable when the building structural features are known.

For more generic cases that do not have detailed information on individual buildings, use a conservative approach and apply the following adjustments to predict indoor vibration based on the outdoor vibration, instead of using the adjustments in Table 6-13:⁽⁴³⁾⁽⁵⁰⁾

- Light-weight, wood-frame construction 1st floor: +3 dB
- Light-weight, wood-frame construction 2nd and 3rd floors: +6 dB
- Large buildings: 0 dB
- Small masonry buildings: +3 dB

Table 6-13 Receiver Adjustment Factors for Generalized Predictions of GB Vibration and Noise

Receiver Factor	Adjustment to Propagation Curve		Comment
Floor-to-floor attenuation	1 to 5 floors above grade 5 to 10 floors above grade	-2 dB/floor -1 dB/floor	This factor accounts for dispersion and attenuation of the vibration energy as it propagates through a building starting with the first suspended floor.*
Amplification due to resonances of floors, walls, and ceilings	+6 dB		The actual amplification will vary greatly depending on the type of construction. The amplification is lower near the wall/floor and wall/ceiling intersections.

* Floor-to-floor attenuation adjustments for the first floor assume a basement.

In addition to the comments in Table 6-13, use the following guidelines to select the appropriate adjustment factors. Note that receiver adjustments are additive.

- Vibration generally reduces in level as it propagates through a building. As indicated in Table 6-13, a 1- to 2-decibel attenuation per floor is typically appropriate.
- Resonances of the building structure, particularly the floors, will cause some amplification of the vibration. Consequently, for a wood-frame structure, the building-related adjustments nearly cancel out. Example: All adjustments for the first floor assuming a basement are: -5 dB for the coupling loss; -2 dB for the propagation from the basement to the first floor; and +6 dB for the floor amplification. The total adjustment in this case is -1 dB.

2d. Apply adjustments to the final adjusted curve using Table 6-14 and the descriptions below to convert ground-borne vibration levels to ground-borne noise levels.

Table 6-14 Conversion to Ground-borne Noise

Conversion to Ground-borne Noise			
Noise Level in dBA	Peak frequency of ground vibration:		Use these adjustments to estimate the A-weighted sound level given the average vibration velocity level of the room surfaces. See text for guidelines for selecting low-, mid-, or high-frequency characteristics. Use the high-frequency adjustment for subway tunnels in rock or if the dominant frequencies of the vibration spectrum are known to be 60 Hz or greater.
	Low frequency (<30 Hz)	-50 dB	
	Mid Frequency (peak 30 to 60 Hz)	-35 dB	
	High frequency (>60 Hz)	-20 dB	

Estimate the levels of radiated noise using the average vibration amplitude of the room surfaces (floors, walls, and ceiling), and the total acoustical absorption in the room.

The un-weighted sound pressure level is approximately 5 dB⁽³⁷⁾⁽⁴³⁾ less than the vibration velocity level when the velocity level is referenced to 1×10^{-6} inches/sec; but for a better estimate, it is necessary to consider general frequency ranges. Since ground-borne noise is A-weighted, the adjustments vary by frequency range, as described below. See Appendix B.1.4.1 for more information on A-weighting.

To select the appropriate adjustment, classify the frequency characteristics according to the guidelines below.

- **Low Frequency (<30 Hz)** – Low-frequency vibration characteristics can be assumed for the following conditions:
 - Subways surrounded by cohesionless sandy soil
 - Vibration isolation track support systems
 - Most surface track
- **Mid Frequency (peak 30 to 60 Hz)** – The mid-frequency vibration characteristic can be assumed for the following conditions:
 - Subways, unless other information indicates that one of the other assumptions is appropriate,
 - Surface track when the soil is very stiff with high clay content
- **High Frequency (>60 Hz)** – High-frequency characteristics can be assumed for the following conditions:
 - Subways with the transit structure founded in rock
 - Subways, when there is very stiff, clayey soil

Step 3: Inventory of Vibration Impact

Take inventory of vibration-sensitive land uses with impact and determine if a Detailed Vibration Analysis is required.

Compare the projected vibration levels, including all appropriate adjustments in Section 6.4, Step 2, to the criteria to determine if impact from ground-borne vibration or noise is likely. Note that for any transit mode, variation in vibration levels under apparently similar conditions is not uncommon. In the General Vibration Assessment, it is preferable to make a conservative assessment of the impact and include buildings that may ultimately not be subject to impact.

The standard curves in Section 6.4, Step 1, represent the upper range of vibration levels from well-maintained systems. Although actual levels fluctuate widely, it is rare that ground-borne vibration will exceed these curves by more than 1 or 2 dB unless there are extenuating circumstances such as wheel- or running-surface defects. However, because actual levels of ground-borne vibration will sometimes differ substantially from the projections, use the following guidelines to interpret vibration impact:

- **Projected vibration is below the impact threshold** – Vibration impact is unlikely, and the environmental document should state this.
- **Projected ground-borne vibration is 0 to 5 dB greater than the impact threshold** – There is a strong chance that actual ground-borne vibration levels will be below the impact threshold. The environmental document should report impact at these locations as exceeding the applicable threshold, present possible mitigation measures and costs, and commit to conducting more detailed studies to refine the vibration impact analysis during the engineering phase. During the Detailed Vibration Analysis, determine appropriate mitigation, if necessary. A site-specific Detailed Vibration Analysis may show that vibration impacts will not occur and control measures are not needed.

- **Projected ground-borne vibration is 5 dB or greater than the impact threshold** – Vibration impact is probable and Detailed Vibration Analysis must be conducted during the engineering phase to determine appropriate vibration control measures. The environmental document should report impact at these locations as exceeding the applicable threshold, present possible mitigation measures and costs, and commit to conducting more detailed studies to refine the vibration impact analysis during the engineering phase. During the Detailed Vibration Analysis, determine appropriate mitigation, if necessary. A site-specific, Detailed Vibration Analysis may show that very costly vibration mitigation must be incorporated into the project to eliminate the impacts.

FTA recommends the reporting of a vibration level as a single value and not as a range, as ranges tend to confuse the interpretation of impact.

Express the results of the General Vibration Assessment in terms of an inventory with the following components:

- Include all vibration-sensitive land uses as identified in the Vibration Screening Procedure.
- Organize the inventory according to the categories described in Table 6-8.
- Include information on potentially feasible mitigation measures to reduce vibration to acceptable levels based on the generalized reduction estimates provided in this section. To be considered feasible, the measure or combination of measures must provide at least a 5-dB reduction of the vibration levels and be reasonable in terms of cost.

These potential mitigation measures are considered preliminary. Final vibration mitigation measures can only be specified after a Detailed Vibration Analysis has been done; see Section 6.5 for more information. Vibration control is frequency-dependent; therefore, specific recommendations of vibration control measures can only be made after evaluating the frequency characteristics of the vibration.

Example 6-1 General Vibration Assessment – LRT

General Vibration Assessment for an LRT project

The hypothetical project is a LRT system that operates at 40 mph on at-grade, ballast and tie track with welded rail. The first floor of houses is at 125 ft from the LRT tracks and there is efficient propagation through the soil. The houses are constructed with wood frames. The houses will be exposed to 260 train passbys per day. Calculate the ground-borne vibration and assess for impact.

Select Base Curve for Ground Surface Vibration

Determine the appropriate base curve and the RMS velocity level (L_v).

According to Table 6-9, the Rapid Transit or Light Rail Vehicles curve is appropriate.

$$L_v = 65 \text{ VdB at 125 ft for this curve at 50 mph}$$

Apply Adjustments

Apply the appropriate source adjustments using Table 6-11.

$$\text{Source Speed Adjustment} = 20 \log \left(\frac{40}{50} \right) = -1.9 \text{ dB}$$

$$L_v = 65 - 1.9 = 63.1 \text{ VdB}$$

Apply the appropriate path adjustments using Table 6-12.

$$\text{Efficient propagation} = +10 \text{ dB}$$

$$\text{Coupling to building foundation (wood frame)} = -5 \text{ dB}$$

$$L_v = 63.1 + 10 - 5 = 68.1 \text{ VdB}$$

Apply the appropriate receiver adjustments using Table 6-13.

$$\text{Amplification due to resonance of floor} = +6 \text{ dB}$$

$$\text{First floor attenuation} = -2 \text{ dB}$$

$$L_v = 68.1 + 6 - 2 = 72.1 \text{ VdB}$$

Assess for Impact

Because there are more than 70 events per day, this project is in the Frequent Events category (Table 6-2). For category 2 land uses (residences) with frequent events, the impact criteria is 72 VdB (Table 6-3). Therefore, according to the General Vibration Assessment, there is potential for impact and a Detailed Vibration Analysis should be completed.

6.5 Evaluate Impact: Detailed Vibration Analysis

Evaluate for impact using the Detailed Vibration Analysis procedure, if appropriate (Section 6.1).

The goal of the Detailed Vibration Analysis is to use all available tools to develop accurate projections of potential ground-borne vibration impact and when necessary, to design mitigation measures. A Detailed Vibration Analysis requires developing estimates of the frequency components of the vibration signal, usually in terms of 1/3-octave-band spectra. The analytical techniques for solving vibration problems are complex, and the technology continually advances. Therefore, the approach presented in this section focuses on the key steps for these analyses. The key elements of the Detailed Vibration Analysis procedure and recommended steps are described below.

The methods in this section generally assume a steel-wheel/rail system. The procedures could be adapted to bus systems. However, this is rarely necessary because vibration impact is very infrequent with rubber-tired transit.

In general, when situations arise that are not explicitly covered in the Detailed Vibration Analysis, professional judgment may be used to extend these methods to cover these unique cases, when appropriate. Appendix G provides information on developing and using non-standard modeling procedures.

Step 1: Characterize Existing Vibration Conditions

Conduct measurements to survey and document the existing vibration conditions.

In contrast to noise impact analysis, the existing ambient vibration is not required to assess vibration impact in most cases; but, it is important to

document general background vibration in the project corridor. Because the existing environmental vibration is usually below human perception, a limited vibration survey is sufficient even for a Detailed Vibration Analysis.

It is particularly valuable to survey vibration conditions at sensitive locations for the following reasons:

- To obtain valuable information on the true sensitivity of the activity to external vibration and obtain a reference condition under which vibration is not problematic.
- To document that existing vibration levels are above or below the normal threshold of human perception for the existing condition.
- To document levels of vibration created by existing rail lines. If vibration from an existing rail line is higher than the proposed train, there may not be impact even if the standard impact criteria are exceeded.
- To use existing vibration sources to characterize propagation. Existing vibration sources such as freight trains, industrial processes, quarrying operations, or normal traffic can be used to characterize vibration propagation. Carefully designed and performed measurements may eliminate the need for more complex propagation tests. See Appendix G for information on using non-standard modeling procedures.
- To identify the potential for efficient vibration propagation. If a measurement site has existing vibration approaching the range of human perception (e.g., the maximum vibration velocity levels are greater than about 65 VdB), then this site should be carefully evaluated for the possibility of efficient vibration propagation.

Conduct measurements to characterize existing vibration conditions. The goal of most ambient vibration measurements is to characterize the rms vertical vibration velocity level at the ground surface. In almost all cases, it is sufficient to measure only vertical vibration and ignore the transverse components of the vibration. Although transverse components⁽⁵¹⁾ can transmit vibration energy into a building, the vertical component typically dominates.

Ia. Choose Measurement Locations – Conduct outdoor and/or indoor measurements to characterize existing vibration conditions, as appropriate, for the project. Although ground-borne vibration is almost exclusively a problem inside buildings, it is generally recommended to perform measurements outdoors because equipment inside the building may cause more vibration than exterior sources. Additionally, the building structure and the resonances of the building can have strong effects on the vibration that are difficult to predict. It can also be important to measure and document those indoor sources of vibration. These indoor sources may cause vibration greater than that due to external sources like street traffic or aircraft overflights. When measuring (indoor) floor vibration, take measurements near the center of a floor span where the vibration amplitudes are the highest.

Ib. Measurement Considerations

- **Site selection** – Selecting sites for an ambient vibration survey requires good judgment. Sites selected to characterize a transit corridor should be distributed along the entire project where potential for impacts have been identified and should be representative of the types of vibration environments found in the corridor. This would commonly include:
 - Measurements in quiet, residential areas removed from major traffic arterials to characterize low-ambient vibration areas;
 - Measurements along major traffic arterials and highways or freeways to characterize high-ambient vibration areas;
 - Measurements in any area with vibration-sensitive activities; and
 - Measurements at any major existing source of vibration such as railroad lines.
- **Transducer placement** – Place the transducers near the building setback line. For ambient measurements along railroad lines, it is recommended to include:
 - Multiple sites at several distances from the rail line at each site, and
 - 4 to 10 train passbys for each test.

Because of the irregular schedule for freight trains and the low number of operations each day, it is often impractical to perform tests at more than two or three sites along the rail line or to measure more than two or three passbys at each site.

Rail type and condition strongly affect the vibration levels. Consequently, it is important to inspect the track to locate any switches, bad rail joints, corrugations, or other factors that could be responsible for higher than normal vibration levels. Locations with these kinds of irregularities should be represented in addition to locations with rail in better condition.

- **Transducer mounting methods** – The way a transducer is mounted can affect the measured levels of ground-borne vibration.
 - Straightforward methods of mounting transducers on the ground surface or on pavement are adequate for vertical vibration measurements for the frequencies of concern for ground-borne vibration (less than about 200 Hz).
 - Quick-drying epoxy, clay, or beeswax can be used to mount transducers to smooth paved surfaces or metal stakes driven into the ground.
 - Rough concrete or rock surfaces require special mountings. One approach is to use a liberal base of epoxy to attach small aluminum blocks to the surface, and then mount the transducers on the aluminum blocks.
 - When in doubt, review the specific transducer documentation and discuss additional mounting guidance with the transducer manufacturer.

Ic. Existing Vibration Characterization – The appropriate methods of characterizing ambient vibration are dependent on the type of information required for the analysis. Consider the following when characterizing the existing vibration:

- **Ambient vibration** – Ambient vibration is usually characterized with a continuous 10- to 30-minute measurement of vibration. The rms velocity level of the vibration velocity level over the measurement period provides an indication of the average vibration energy. The rms velocity level over the measurement period is typically equivalent to a long averaging time rms level.
- **Specific events** – Characterize specific events such as train passbys by the rms level over the time that the train passes by. If the locomotives produce vibration levels more than 5 dB higher than the passenger or freight cars, obtain a separate rms level for the locomotives. The locomotives can usually be characterized by the L_{max} during the train passby. The rms averaging time or time constant should be 1 second when determining L_{max} . In some cases, it may be adequate to characterize the train passby using L_{max} , which is simpler to obtain than the rms averaged over the entire train passby.
- **Spectral analysis** – Perform a spectral analysis of vibration propagation data. For example, if vibration transmission of the ground is suspected of having particular frequency characteristics, use 1/3-octave band charts to describe vibration behavior. Narrowband spectra also can be valuable, particularly for identifying discrete frequency components and designing specific mitigation measures.

Note that it is preferred to characterize existing vibration in terms of the rms velocity level instead of the peak PPV, which is commonly used to monitor construction vibration. As discussed in Section 5.1, rms velocity is considered more appropriate than PPV for describing human response to building vibration.

Step 2: Estimate Vibration Impact

Estimate ground-borne vibration and noise at sites where significant impact is probable and assess for impact.

Predicting ground-borne vibration associated with a transportation project continues to be a developing field. Because ground-borne vibration is a complex phenomenon that is difficult to model and predict accurately, most projection procedures that have been used for transit projects rely on empirical data.

The procedure described in this section is based on site-specific tests of vibration propagation. This procedure was developed under a FTA-funded research contract⁽⁵²⁾ and is recommended for detailed evaluations of ground-borne vibration. Other approaches to a prediction procedure, such as finite element methods, can be used. See Appendix G for information on using non-standard modeling procedures.

Overview of Prediction Procedure – This procedure was developed to allow the use of data collected in one location to accurately predict vibration levels in another site where the geologic conditions may be completely different. The procedure is based on transfer mobility. Transfer mobility is the complex velocity response produced by a point force as a function of frequency. It represents the relationship between a vibration source that excites the ground and the resulting vibration of the ground surface. It is a function of both frequency and distance from the source. The analyses in this manual focus on transfer mobility magnitude, which is the magnitude for the velocity relative to the force without reference to phase. The transfer mobility level is the level in decibels relative to $1\text{E-}6\text{ in/lb-s}$.

The transfer mobility measured at an existing transit system is used to normalize ground-borne vibration data and remove the effects of geology. The normalized vibration is referred to as the force density. Force density is the force per root distance along the track in $\text{lb/ft}^{1/2}$. The force density can be combined with transfer mobility measurements at vibration-sensitive sites along a new project to develop projections of future ground-borne vibration.

The transfer mobility between two points completely defines the composite vibration propagation characteristics between the two points. In most practical cases, receivers are close enough to the train tracks that the vibration cannot be considered as originating from a single point. Therefore, the vibration source must be modeled as a line-source. Consequently, the point transfer mobility must be modified to account for a line-source. The subsequent line-source transfer mobility is given in units of decibels relative to $1\text{e-}6\text{ in/s/lb/sqrt(ft)}$.

The prediction procedure considers ground-borne vibration to be divided into several basic components described below and shown in Figure 6-5.

- **Excitation Force (Force Density)** – The vibration energy is created by oscillatory and impulsive forces. Steel wheels rolling on smooth steel rails create random oscillatory forces. When a wheel encounters a discontinuity such as a rail joint, an impulsive force is created. The force excites the transit structure, such as the subway tunnel or the ballast for at-grade track.

In the prediction method, the combination of the actual force generated at the wheel/rail interface and the vibration of the transit structure are usually combined into an equivalent force density level. The force density level is the level in decibels of the force density relative to $1\text{ lb/ft}^{1/2}$ and describes the force that excites the soil/rock surrounding the transit structure.

- **Vibration Propagation (Transfer Mobility)** – The vibration of the transit structure causes vibration waves in the soil that propagate away from the transit structure. The vibration energy can propagate through the soil or rock in a variety of wave forms. All ground vibration includes shear and compression waves. Rayleigh waves ⁽⁴⁹⁾ are also created and propagate along the ground surface. These Rayleigh waves can be a

major carrier of vibration energy. The mathematical modeling of vibration is complicated when there are soil strata with different elastic properties, which is common. As indicated in Figure 6-5, the propagation through the soil/rock is modeled using the transfer mobility, which is usually determined experimentally.

The combination of the force density level and the transfer mobility is used to predict the ground- surface vibration. This is the major difference from the General Vibration Assessment, which generalizes estimates of the ground-borne vibration.

- **Building Vibration** – When the ground vibration excites a building foundation, it sets the building into vibratory motion and vibration waves propagate throughout the building structure. The interaction between the ground and the foundation causes some reduction in vibration levels. The amount of reduction is dependent on the mass and stiffness of the foundation. The more massive the foundation, the lower the response to ground vibration. As the vibration waves propagate through the building, they can create vibration that can be felt and cause windows and household items to rattle.
- **Audible Noise** – In addition to vibration that can be felt, the vibration of room surfaces radiates low-frequency sound that may be audible. The sound level is affected by the amount of acoustical absorption in the receiver room.

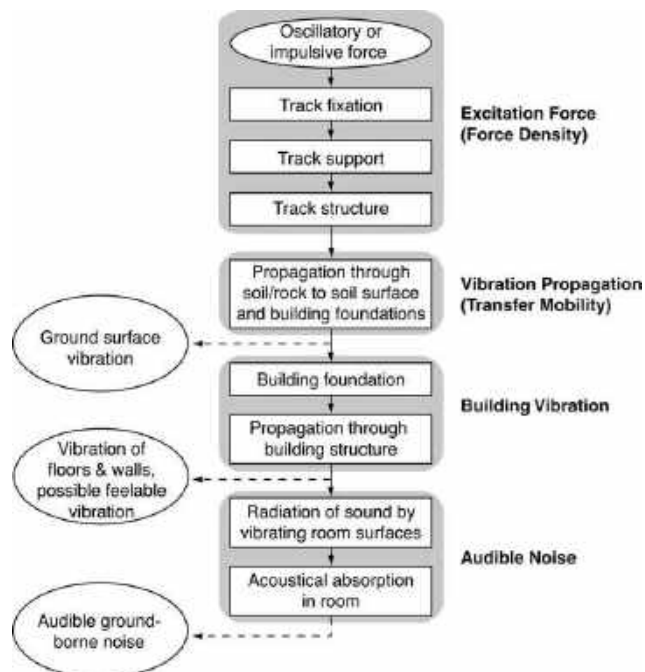


Figure 6-5 Ground-Borne Vibration and Noise Model

A fundamental assumption of the prediction approach outlined in this section is that the force density, transfer mobility, and the building coupling to the ground are all independent factors. The following equations are the basis for the

prediction procedure, where all of the quantities are one-third octave band spectral levels in decibels with consistent reference values:

$$L_v = FDL + LSTM + C_{build} \quad \text{Eq. 6-5}$$

$$L_A = L_v + K_{rad} + K_{A-wt} \quad \text{Eq. 6-6}$$

where:

- L_v = rms vibration velocity level in VdB
- FDL = force density level in dB for a line vibration source such as a train
- $LSTM$ = line-source transfer mobility level in dB from the tracks to the sensitive site
- C_{build} = adjustments to account for ground-building foundation interaction and attenuation of vibration amplitudes as vibration propagates through buildings
- L_A = A-weighted sound level
- K_{rad} = adjustment to account for conversion from vibration to sound pressure level including accounting for the amount of acoustical absorption inside the room. A value of -5 dB can be used for K_{rad} for typical residential rooms when the decibel reference value for L_v is 1 micro in/sec ⁽³⁷⁾⁽⁵⁰⁾
- K_{A-wt} = A-weighting adjustment at the 1/3-octave band center frequency

All of the quantities given above are functions of frequency, and the standard approach is to develop projections on a 1/3-octave band basis using the average values for each 1/3-octave band. The end results of the analysis are the 1/3-octave band spectra of the ground-borne vibration and the ground-borne noise.

The spectra are then compared to the vibration criteria for the Detailed Vibration Analysis. The A-weighted ground-borne noise level can be calculated from the vibration spectrum and compared to the criteria. This more detailed approach differs from the General Vibration Assessment, where the overall vibration velocity level and A-weighted sound level are predicted without any consideration of the particular frequency characteristics of the propagation path.

The key steps in obtaining quantities for Eq. 6-5 and Eq. 6-6 are presented in the following steps and include:

- Step 2a.** Estimate force density
- Step 2b.** Measure the point-source transfer mobility
- Step 2c.** Estimate line-source transfer mobility
- Step 2d.** Project ground-borne vibration and ground-borne noise

2a. Estimate Force Density – The estimate of force density can be based on previous measurements or a special test program can be designed to measure the force density at an existing facility.

If no suitable measurements are available, conduct testing at a transit facility with equipment similar to the planned vehicles. Adjustments for factors such as train speed, track support system, and vehicle suspension may be needed to match the force density to the conditions at a specific site. Review the report

"State-of-the-Art Review: Prediction and Control of Ground-Borne Noise and Vibration from Rail Transit Trains" ⁽⁴¹⁾ for examples of appropriate adjustments.

Force density is not a quantity that can be measured directly; it must be inferred from measurements of transfer mobility and train vibration at the same site. To derive force density, the best results are achieved by deriving line-source transfer mobility from a line of impacts. The standard approach is to average the force density from measurements at three or more positions at one site. If feasible, it is recommended to take measurements at more than one site and at multiple speeds.

If no suitable measurements are available, see Steps 2b and 2c for guidelines on obtaining line-source transfer mobility.

The force density for each 1/3-octave band is as follows:

$$FDL = L_v - LSTM \quad \text{Eq. 6-7}$$

where:

FDL	= force density level in dB
L_v	= measured train ground-borne vibration level in VdB
$LSTM$	= line-source transfer mobility level in dB

Figure 6-6 shows example trackbed force densities in decibels relative to $1 \text{ lb}/(\text{ft})^{1/2}$. These force densities were developed from measurements of vibration from heavy and LRT vehicles and represent an incoherent line of vibration force equal to the length of transit trains. This figure provides a comparison of the vibration forces from heavy commuter trains and LRT vehicles with different types of primary suspensions, illustrating the range of vibration forces commonly experienced in a transit system. A force density of a vehicle includes the characteristics of its track support system at the measurement site. Adjustments must be applied to the force density to account for differences between the facility where the force density was measured and the new system being analyzed.

Figure 6-7 shows typical force densities for rail transit vehicles at 40 mph on ballast and tie tracks, which are approximately within the tolerances shown in Figure 6-6. The force densities should be applied very carefully for other track types and speeds. The embedded tracks, although considerably stiffer than ballast and tie tracks, are expected to show similar force density levels.⁽⁵³⁾ The curves in Figure 6-7 should also be applied with caution for newer generations of light rail vehicles as well as vehicles that utilize direct fixation tracks. The preferred approach for vibration predictions would be to perform force density measurements at a system with vehicles and operations that are similar to those of the future project.

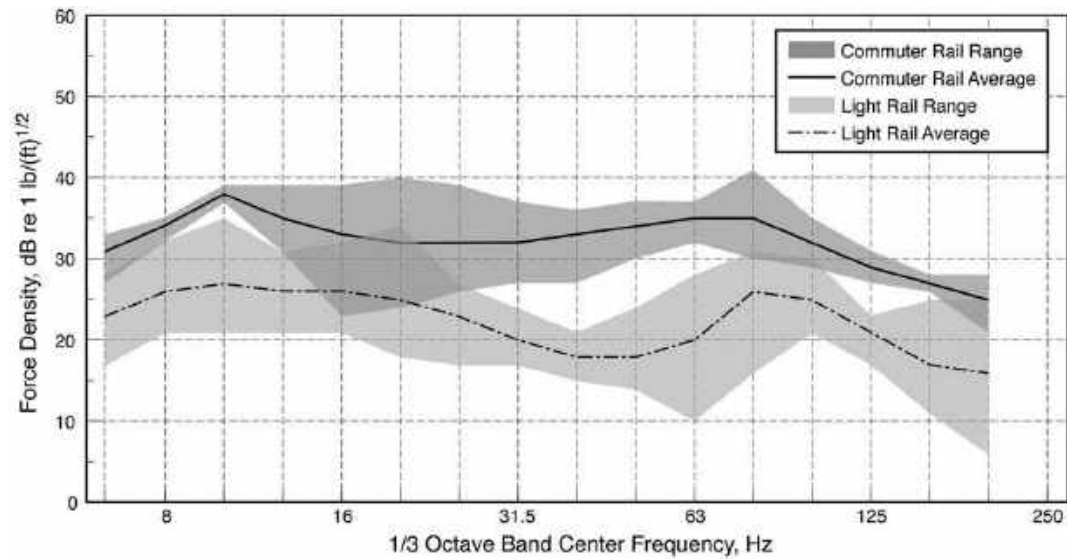


Figure 6-6 Typical Force Densities for Rail Transit Vehicles, 40 mph

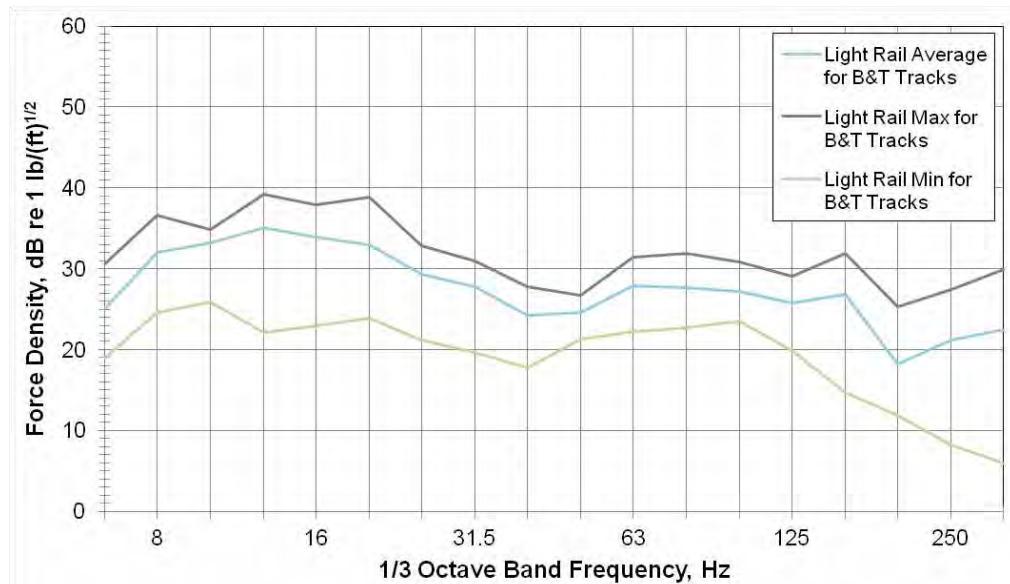


Figure 6-7 Typical Force Densities for LRT Vehicles, 40 mph

2b. Measure Point-Source Transfer Mobility – Using the appropriate instrumentation, measure point-source transfer mobility for sources with short lengths, such as buses or single car vehicles or columns supporting elevated structures. For longer vehicles, see Section 2c for a discussion of measuring line-source transfer mobilities.

The test procedure to measure point-source transfer mobility consists of impacting the ground by dropping a heavy weight and measuring the force into the ground and the response at several distances from the impact. Other excitation sources may include swept sine, sine-dwell, random vibration, and maximum length sequence. The goal of the test is to create vibration pulses that

travel from the source to the receiver using the same path that will be taken by the transit system vibration.

Figure 6-8 illustrates the field procedure for measuring both at-grade and subway testing of transfer mobility. A weight is dropped from a height of 3 to 4 ft onto a force transducer. The responses of the force and vibration transducers are recorded on a multichannel recorder for later analysis in the laboratory. An alternative approach is to set up the analysis equipment in the field and capture the signals directly. This complicates the field testing, but eliminates the laboratory analysis of recorded data.

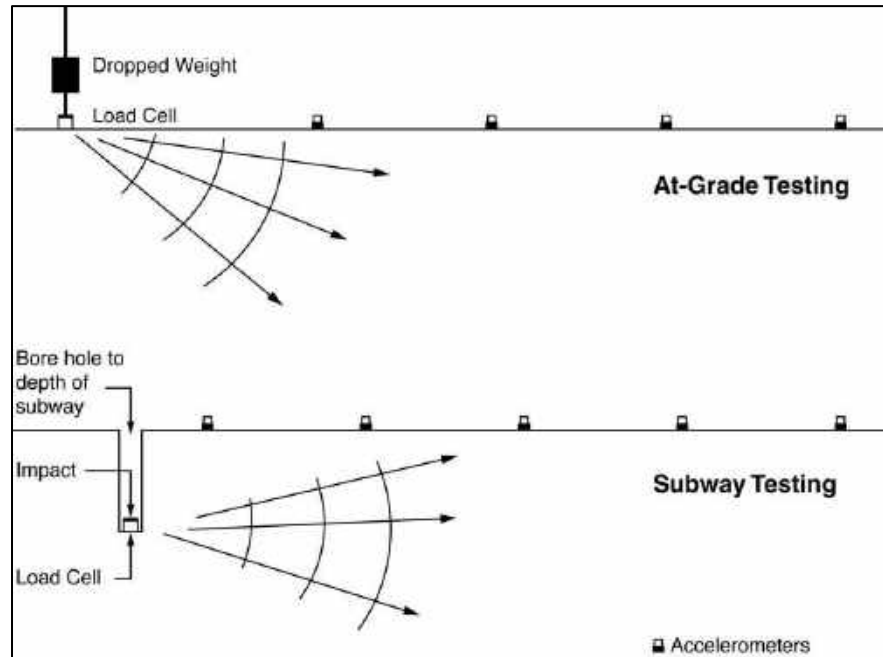


Figure 6-8 Test Configuration for Measuring Transfer Mobility

When the procedure is applied to subways, the force must be located at the approximate depth of the subway. This is done by drilling a bore hole and locating the force transducer at the bottom of the hole. The tests are usually performed while the bore holes are drilled to allow for the use of the soil-sampling equipment on the drill rig for the transfer mobility testing. The force transducer is attached to the bottom of the drill string and lowered to the bottom of the hole. A standard soil sampling hammer is used to excite the ground; typically, a 140-pound weight is dropped 18 inches onto a collar that is attached to the drill string. The force transducer must be capable of operating under water if the water table is near the surface or a slurry drilling process is used.

Standard signal-processing techniques are used to determine the transfer function (frequency response function) between the exciting force and the resultant ground-borne vibration. Numerical regression methods are used to combine a number of two-point transfer functions into a smooth point-source transfer mobility level that represents the average vibration propagation characteristics of a site as a function of both distance from the source and

frequency. The transfer mobility level is usually expressed in terms of a group of 1/3-octave band transfer mobility levels. Figure 6-9 is an example of point-source transfer mobility levels from a series of tests at the Transportation Technology Center in Pueblo, Colorado.⁽⁵⁰⁾⁽⁵⁴⁾⁽⁵⁵⁾⁽⁵⁶⁾⁽⁵⁷⁾

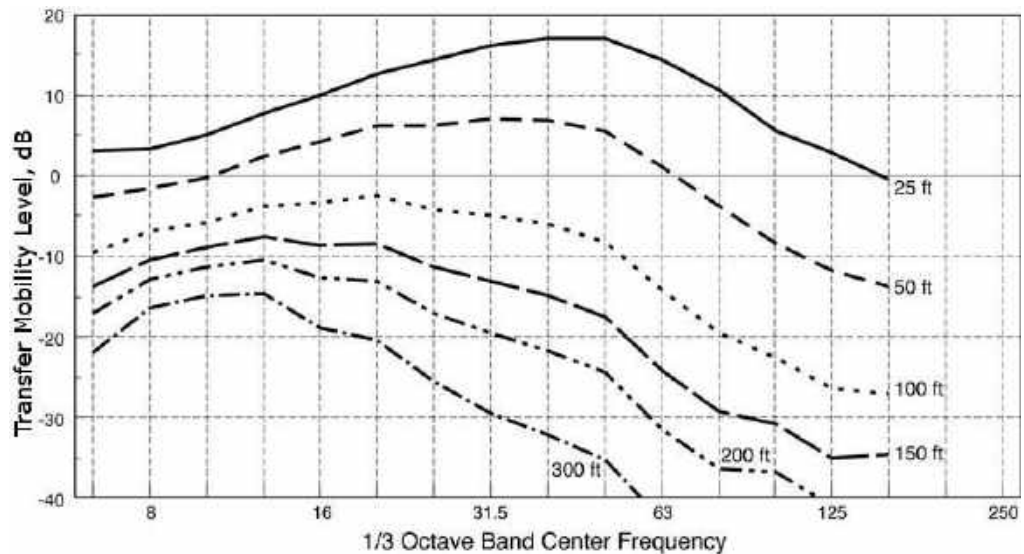


Figure 6-9 Example of Point-Source Transfer Mobility

Instrumentation

Performing a transfer mobility test requires specialized equipment, which is generally available from commercial sources. Typical instrumentation for field-testing and laboratory analysis of transfer mobility is shown in Figure 6-10.

A load cell can be used as the force transducer. The force transducer should be capable of impact loads of 5,000 to 50,000 pounds depending on the hammer used for the impact. For borehole testing, the load cell must be hermetically sealed and capable of being used at the bottom of a 30- to 100-foot-deep hole partially filled with water.

Either accelerometers or geophones can be used as the vibration transducers. Geophones should be carefully mounted so that they are vertical. The requirement is that the transducers with the associated amplifiers be capable of accurately measuring levels of 0.0001 in/sec at 40 Hz and have a flat frequency response from 6 Hz to 400 Hz. Data should be acquired with a digital acquisition system with a flat frequency response over the range of 6 to 400 Hz.

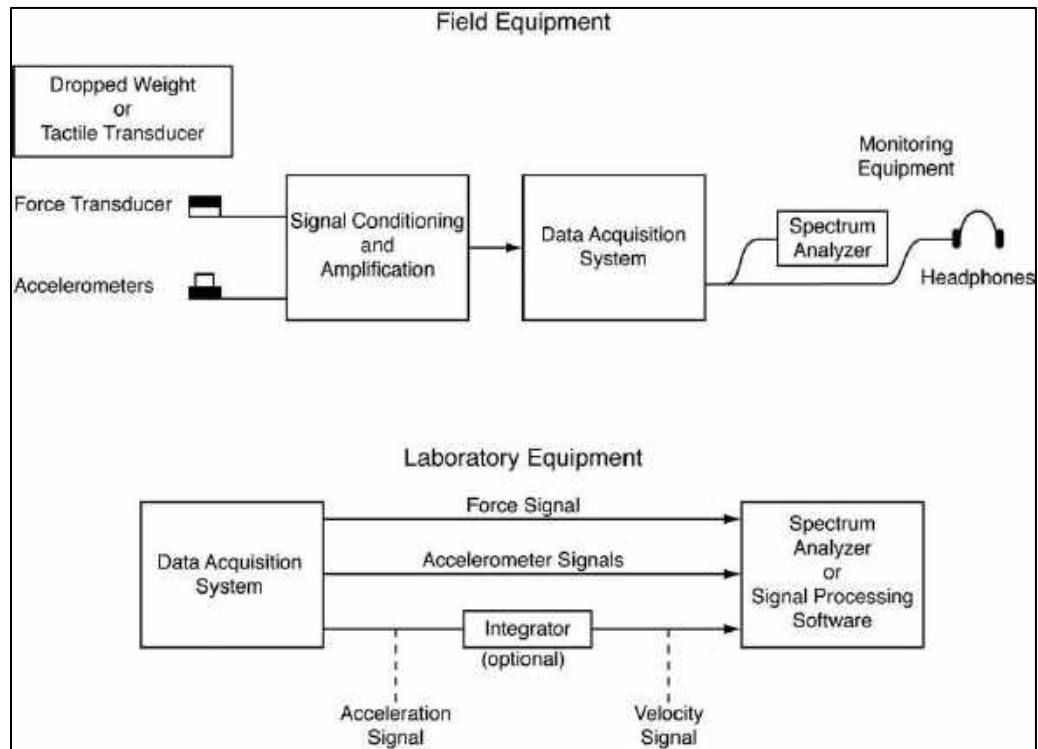


Figure 6-10 Equipment Required for Field Testing and Laboratory Analysis

A narrowband spectrum analyzer or signal-processing software can be used to calculate the transfer function and coherence between the force and vibration data. The analyzer must be capable of capturing impulses from at least two channels to calculate the frequency spectrum of the transfer function between the force and vibration channels. All transfer functions should include the average of at least 20 impulses. Time averaging of the impulses will provide substantial signal enhancement, which is usually required to accurately characterize the transfer function. Signal enhancement is particularly important when the vibration transducer is more than 100 ft from the impact.

Alternative methods of determining transfer mobility may be used, provided that these techniques have been demonstrated to provide the same results as the conventional weight-drop method over the frequency range of 6 Hz to 400 Hz. See Appendix G for information on developing and using non-standard procedures. These methods may include using other impulse-response measurement systems involving the use of shakers or electro-mechanical actuators, stimuli such as sweeps or maximum length sequences (MLS), and various signal processing techniques. A forthcoming ANSI Standard will describe in detail the procedures, methodologies, and reporting requirements for performing ground-borne vibration propagation measurements.

The transfer function can be calculated with either a spectrum analyzer or signal-processing software. Note that transfer functions should include the average of at least 20 impulses. Specialized multi-channel spectrum analyzers have built-in capabilities for computing transfer functions and are computationally efficient. However, signal-processing software can offer more

flexibility in analyzing data signals and allows the use of different digital signal processing methods. Typical measurement programs involve acquisition of data in the field and later processing of the information in a laboratory. However, recent advances in instrumentation and signal-processing software allow data to be collected and analyzed while in the field.

2c. Estimate Line-Source Transfer Mobility – Estimate line-source transfer mobility for long sources such as multi-car trains. Line-source transfer mobilities are used to normalize measured vibration velocity levels from train passbys and to obtain force density. Two different approaches can be used to develop estimates of line-source transfer mobility. The first consists of using lines of transducers and the second consists of a line of impact positions.

Option A: Lines of Transducers – Develop line-source transfer mobility curves from tests using one or more lines of transducers as shown in Figure 6-11 and described below.

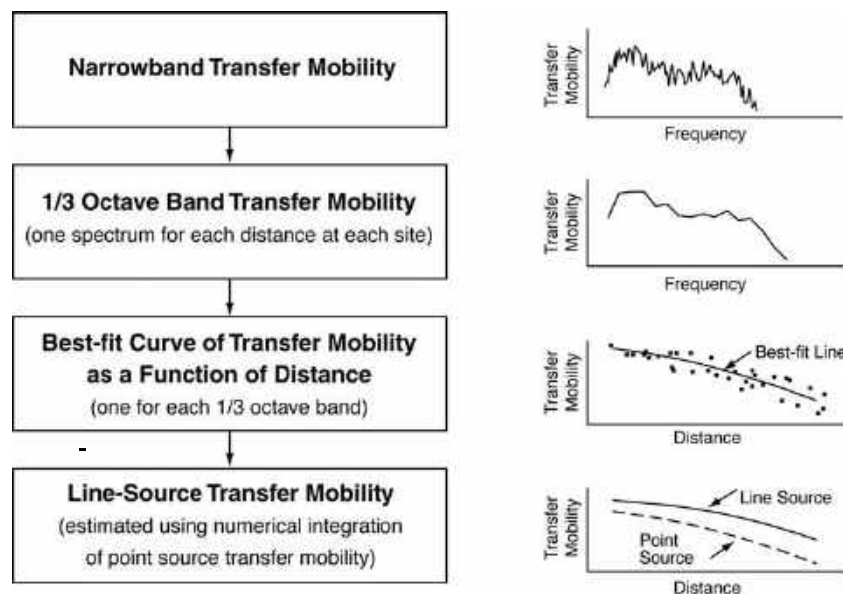


Figure 6-11 Analysis of Transfer Mobility

Ai. Obtain the narrowband transfer function between source and receiver at each measurement position. There should be a minimum of four distances in any test line. Because of the possibility of local variations in propagation characteristics, two or more lines should be used to characterize a site if possible. A total of 10 to 20 transducer positions are often used to characterize a site.

Aii. Calculate the equivalent 1/3-octave band transfer functions, generally between 6 and 400 Hz. This reduces each spectrum to 15 numbers. As shown in Figure 6-11, the 1/3-octave band spectrum is much smoother than the narrowband spectrum.

Aiii. Calculate a best-fit curve of transfer mobility as a function of distance for each 1/3-octave band. When analyzing a specific site, the best-fit curve will be

based on 10 to 20 points. Up to several hundred points could be used to determine average best-fit curves for a number of sites.

Aiv. Apply the best-fit curve to the vibration sources. The 1/3-octave band best-fit curves can be directly applied to point vibration sources. Buses can usually be considered point-sources, as can columns supporting elevated structures. However, for a line vibration source such as a train, numerical integration must be used to calculate the equivalent line-source transfer mobility. The numerical integration procedures are detailed in the TRB publication: “A Prediction Procedure for Rail Transportation Ground-Borne Noise and Vibration.”⁽⁵⁰⁾

Option B: Line of Impulses – This second procedure for estimating line-source transfer mobility is best for detailed assessment of specific vibration paths or specific buildings and is a more direct approach.

Bi. Measure multiple point-source transfer mobilities according to the procedures in Step 2b above. The vibration transducers are placed at specific points of interest and a line of impacts is used. For example, a 150-foot train might be represented by a line of 11 impact positions along the track centerline at 15-foot intervals (Figure 6-12).

Bii. Sum the point-source results using Simpson's rule^{xiii} for numerical integration to calculate the line-source transfer mobility.

Figure 6-13 shows an example of line-source transfer mobilities that were derived from the point-source transfer mobilities shown in Figure 6-9.

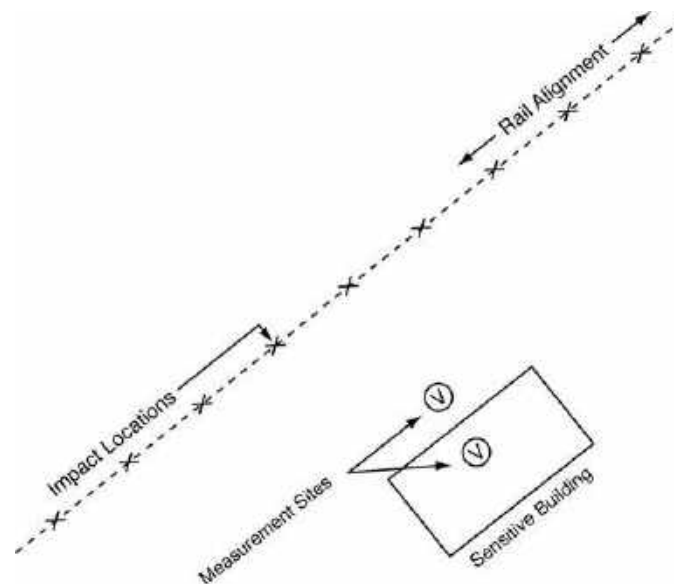


Figure 6-12 Schematic of Transfer Mobility Measurements Using a Line of Impacts

^{xiii} Simpson's rule is a method for approximating integrals.

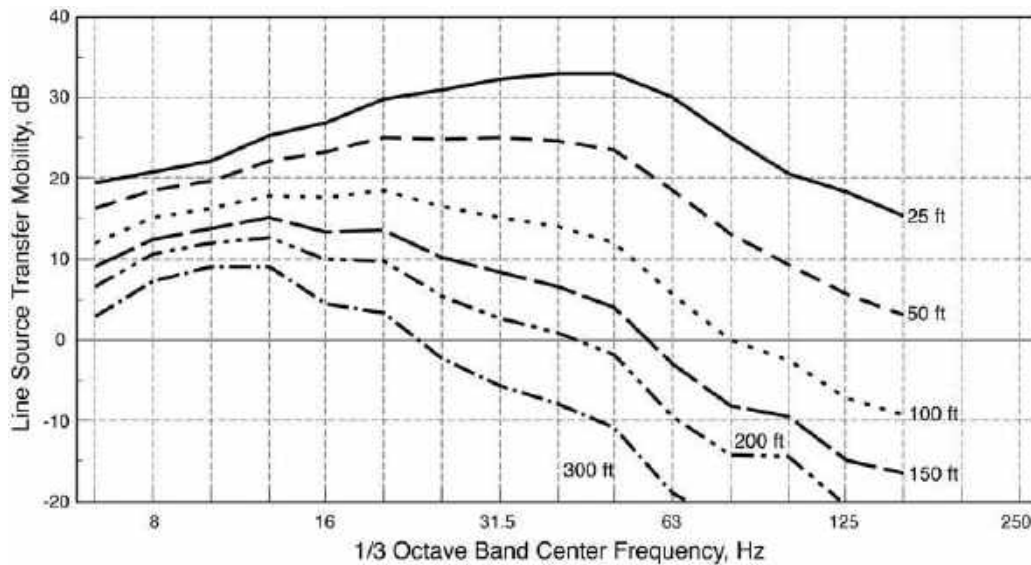


Figure 6-13 Example of Line-source Transfer Mobility

2d. Project Ground-Borne Vibration and Noise – Combine force density and line-source transfer mobility to project ground-borne vibration. Then, apply adjustment factors to estimate the building response to the ground-borne vibration and to estimate the A-weighted sound level inside buildings.

The propagation of vibration from the building foundation to the receiver room is very complex and dependent on the specific design of the building. Detailed evaluation of the vibration propagation would require extensive use of numerical procedures such as the finite element method. Such a detailed evaluation is generally not practical for individual buildings considered in this manual. If the detailed features of the individual buildings are available, the recommended procedure is to estimate the propagation of vibration through a building and the radiation of sound by vibrating building surfaces using simple empirical or theoretical models. The recommended procedures are outlined in the Handbook of Urban Rail Noise and Vibration Control.⁽⁴⁴⁾ The approach consists of adding the following adjustments to the 1/3-octave band spectrum of the projected ground-borne vibration:

- **Building response or coupling loss** – This adjustment represents the change in the incident ground-borne vibration due to the presence of the building foundation. The adjustments described in the handbook ⁽⁴⁴⁾ are shown in Figure 6-14. Note that the correction is zero when estimating basement floor vibration or vibration of at-grade slabs. Measured values may be used in place of these generic adjustments.
- **Transmission through the building** – The vibration amplitude typically decreases as the vibration energy propagates from the foundation through the remainder of the building. The general assumption is that vibration attenuates by 1 to 2 dB for each floor.
- **Floor resonances** – Vibration amplitudes will be amplified because of resonances of the floor/ceiling systems. For a typical wood-frame

residential structure, the fundamental resonance is usually in the 15 to 20 Hz range. Reinforced-concrete slab floors in modern buildings will have fundamental resonance frequencies in the 20 to 30 Hz range. An amplification resulting in a gain of approximately 6 dB should be used in the frequency range of the fundamental resonance.

- **Floor vibration and ground-borne noise** – The projected floor vibration is used to estimate the levels of ground-borne noise. The primary factors affecting noise level are the average vibration level of the room surfaces and the amount of acoustical absorption within the room. The radiation adjustment is -5 dB for typical rooms, ⁽³⁷⁾ ⁽⁵⁰⁾ which gives:

$$L_A \approx L_V + K_{A-wt} - 5$$

Eq. 6-8

where:

$$\begin{aligned} L_A &= \text{A-weighted sound level in a 1/3-octave band} \\ L_v &= \text{rms vibration velocity level in that band} \\ K_{A-wt} &= \text{A-weighting adjustment at the 1/3-octave band center frequency} \end{aligned}$$

The A-weighted levels in the 1/3-octave bands are combined to produce the overall A-weighted sound level.

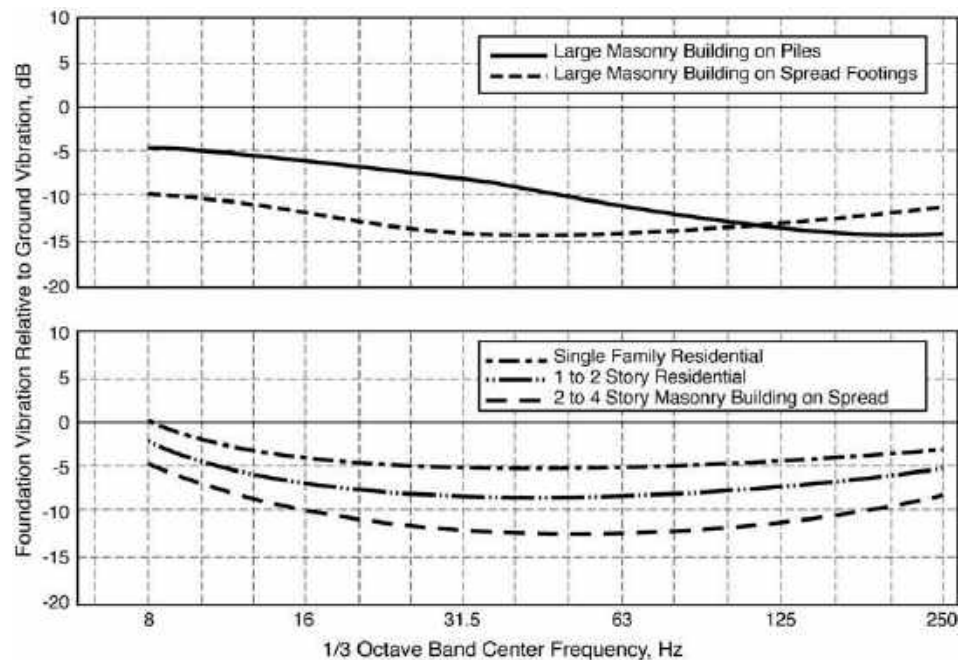


Figure 6-14 Foundation Response for Various Types of Buildings

Where detailed information on the structural features of individual buildings are unavailable and there are no site-specific data on outdoor to indoor propagation characteristics, the preferred approach is to apply a combined factor for the foundation response and the gain from floor resonances. Empirical data based on the TCRP D-12 Project from 34 measurement sites across 5 cities in North

America and other studies suggest that the average change in vibration from outdoor to indoor was 0 dB across all 1/3-octave bands with a standard deviation of approximately 5 to 6 dB in the 31.5 to 63 Hz frequency.⁽⁴³⁾⁽⁴⁸⁾ Therefore, the recommended approach for predicting indoor vibration based on outdoor data is to use an adjustment of +3 to +6 dB for light-weight, wood-frame construction and use an adjustment of 0 dB for heavier buildings.

However, for buildings with high-vibration sensitivity or where there is concern regarding interference with vibration-sensitive equipment, it is advisable to measure the outdoor-indoor response of the building, using the process described in Section 2b or 2c, to determine the actual response of the foundation and building to vibration.

Step 3: Assess Vibration Impact

Take inventory of vibration-sensitive land uses with impact.

Assess vibration impact at each receiver of interest using the impact criteria in Section 6.3. Note that ground-borne vibration and noise levels that exceeded criteria in the General Vibration Assessment may not cause impact according to the more detailed procedures of the Detailed Vibration Analysis; in which case, mitigation is not required. But if projected levels still exceed the criteria, evaluate vibration mitigation measures using the spectra provided by the Detailed Vibration Analysis.

Step 4: Determine Vibration Mitigation Measures

Select practical vibration control measures that will be effective at the dominant vibration frequencies and compatible with the given transit structure and track support system.

The purpose of vibration mitigation is to minimize the adverse effects that the project ground-borne vibration and ground-borne noise will have on sensitive land uses. Because ground-borne vibration is not as common a problem as environmental noise, the mitigation approaches have not been as well defined. In some cases it may be necessary to develop innovative approaches to control the impact. See Appendix G for information on using non-standard methods.

Standard vibration control measures for rail transit systems are discussed in this step. Note that vibration control measures for rail transit systems are not always effective for freight trains.^(xiv) Bus systems rarely cause vibration impact, but if impact occurs, roadway roughness or unevenness caused by bumps, pot holes, expansion joints, or driveway transitions are usually the causes. Smoothing the roadway surface is typically the recommended course of action.^(xv)

^{xiv} The heavy axle loads associated with freight rail are outside the range of applicable design parameters for vibration reduction on lighter rail transit systems. Plans to relocate existing railroad tracks closer to vibration-sensitive sites in order to accommodate a new rail transit line in the ROW must be carefully considered because it may not be possible to mitigate the increased vibration impact from freight trains.

^{xv} In cases where a rubber-tired system runs inside a building, such as an airport people mover, vibration control may involve additional measures. Loading and unloading of guideway support beams may generate dynamic forces that transmit into the building structure. Special guideway support systems may be required, similar to the discussion below regarding floating slabs.

Vibration reduction measures incur additional costs to a system. Some of the same treatments for noise mitigation can be considered for vibration mitigation. Costs for noise control measures are documented in a report from the Transit Cooperative Research Program (TCRP).⁽³¹⁾ Where applicable to vibration reduction, costs for noise abatement methods from that report are given in the following sections. These costs reflect the noise mitigation costs as of 1997 (unless otherwise noted), and should only be used as representative estimates when considering noise mitigation options. Current noise mitigation costs should be researched before decisions on noise mitigation options are finalized, and then they should be documented according to Section 8.

Mitigation of vibration impacts may involve treatments at the source, along the source-to-receiver propagation path, or at the receiver.

Ia. Evaluate Source Treatments – The most effective vibration mitigation treatments are applied at the vibration source. This is the preferred approach to mitigation when possible. Possible source treatments include:

- **Preventative Maintenance** – Effective maintenance programs are essential for controlling ground-borne vibration. Key vibration points are discussed below; see Section 4.5, Step 7 for more detailed information on the benefits of effective maintenance programs on controlling transit noise and vibration. While these are not mitigation measures in the traditional sense, and should not be included as mitigation in an environmental document, they can help to keep both noise and vibration levels at a “like-new” level or reduce both in systems with deferred maintenance.
 - **Rail grinding** is a particularly important practice for vibration mitigation for rail that develops corrugations. The TCRP report notes that periodic rail grinding results in a net savings per year on wheel and rail wear. Most transit systems contract out rail grinding, although some of the larger systems make the investment and do their own grinding. As mentioned in Section 4.5, Step 7, the typical rail grinding cost would be \$1000 to \$7000 per grinding pass mile, with an additional investment of approximately \$1 million for the equipment for a larger transit system to do its own grinding.
 - **Dramatic vibration reduction** results can be achieved by removing wheel flats through **wheel truing**. As mentioned in Section 4.5, Step 7, a wheel truing machine costs approximately \$1 million, including associated maintenance, materials, and labor costs. The TCRP report figures a system with 700 vehicles would incur a yearly cost of \$300,000 to \$400,000 for a wheel truing program.
 - **Profile grinding of the rail head** in combination with a wheel truing program may be the most practical approach to controlling and reducing vibration and noise where such practices are not normally conducted. Profiles should be defined during the design phase and should be in place when system opens.⁽³²⁾ The cost of

wheel and rail profile matching may be incorporated in the new vehicle and new rail costs.

Rough wheels or rails can increase vibration levels by as much as 20 dB in extreme cases, negating the effects of even the most effective vibration control measures. Yet, it is rare that vibration control measures (such as those discussed below) will provide more than 15 to 20 dB attenuation. When there are ground-borne vibration impacts with existing transit equipment, the best vibration control measure often is to implement new or improved maintenance procedures. Grinding rough or corrugated rail and wheel truing to eliminate wheel flats and restore the wheel contour may provide considerable vibration reduction. Regular maintenance may replace the need to modify the existing track system, such as through adding floating slabs.

- **Planning and Design of Special Trackwork** – A large percentage of the vibration impact from a new transit facility is often caused by wheel impacts at special trackwork for turnouts and crossovers. When feasible, the most effective vibration control measure is to relocate the special trackwork to a less vibration-sensitive area. This may require adjusting the location by several hundred feet provided it will not have an adverse impact on the operation plan for the system. Careful review of crossover and turnout locations during the project development phase is an important step to minimizing potential for vibration impact.

Another approach is to use special devices (frogs) at turnouts and crossovers that incorporate mechanisms to close the gaps between running rails. Frogs with spring-loaded mechanisms and frogs with movable points can substantially reduce vibration levels near crossovers. According to the TCRP report, a spring frog costs about \$12,000, twice the cost of a standard frog. A movable point frog involves elaborate signal and control circuitry resulting in higher costs at approximately \$200,000.

- **Vehicle Specifications** – The ideal rail vehicle with respect to minimizing ground-borne vibration should have the following characteristics:
 - Low, unsprung weight
 - Soft primary suspension
 - A minimum of metal-to-metal contact between moving parts of the truck
 - Smooth wheels that are perfectly round

A limit for the vertical resonance frequency of the primary suspension should be included in the specifications for any new vehicle. A vertical resonance frequency of 12 Hz or less is sufficient to control the levels of ground-borne vibration, although some have recommended the vertical resonance frequency be less than 8 Hz.

- **Special Track Support Systems** – When the vibration assessment indicates that vibration levels will be excessive, the track support system is typically modified to reduce the vibration levels.

Floating slabs, resiliently supported ties, high-resilience fasteners, and ballast mats can be used to reduce the levels of ground-borne vibration. To be effective, all of these measures must be optimized for the frequency spectrum of the vibration. Most of these relatively standard procedures have been successfully used on several subway projects.

Applications on at-grade and elevated track are less common. This is because vibration impact is less common for at-grade and elevated track. Note that the cost of these types of vibration control measures is a higher percentage of the overall construction costs for at-grade and elevated track, and exposure to the elements can require substantial design modifications.

Each major vibration control measure for track support is discussed below. Costs for these treatments are not covered by the TCRP report, but are given as estimates based on transit agency experience.

- **Resilient fasteners** – Resilient fasteners are used to fasten the rail to concrete track slabs. Standard resilient fasteners are very stiff in the vertical direction, usually in the range of 200,000 lb/in, and do provide some vibration reduction compared to the rigid fastening systems used on older systems (e.g., wood half-ties embedded in concrete).

Special fasteners with vertical stiffness in the range of 30,000 lb/in may reduce vibration by as much as 5 to 10 dB at frequencies above 30 to 40 Hz. These premium fasteners vary in cost and can be priced competitively when purchased in large quantities.

- **Ballast mats** – A ballast mat consists of a rubber or other type of elastomer pad that is placed under the ballast. In general, the mat must be placed on a concrete pad to be effective. They will not be as effective if placed directly on the soil or the sub-ballast. Consequently, most ballast mat applications are in subway or elevated structures.

Ballast mats can provide 8 to 12 dB attenuation at frequencies above 25 to 30 Hz.⁽⁵⁸⁾ Ballast mats are often a good retrofit measure for existing tie-and-ballast track where there is vibration impact. Installed ballast mats cost approximately \$180 per track-foot.

- **Undertie pads** – Undertie pads (resiliently supported concrete ties) consist of a rubber pad mounted on the bottom of a concrete tie directly on the ballast. The pads provide vibration isolation at frequencies above 25 Hz and are easy to

install or retrofit. Installed undertie pads cost approximately \$260 per track-foot.

- **Resiliently supported ties** – The resiliently supported tie system consists of concrete ties supported by rubber pads resting on top of a slab track or subway invert. The rails are fastened directly to the concrete ties using standard rail clips. Resiliently supported ties provide vibration reduction in between 15 to 40 Hz, which is particularly appropriate for transit systems with vibration impact in the 20 to 30 Hz range. A resiliently supported tie system costs approximately \$400 per track-foot.
- **Floating slabs** – Floating slabs can be very effective at controlling ground-borne vibration and noise and consist of a concrete slab supported on resilient elements such as rubber or a similar elastomer. Floating slabs are effective at frequencies greater than their single-degree-of-freedom vertical resonance frequency.

Floating slabs are among the most expensive vibration control treatments. A typical double-tie floating slab system costs approximately 4 times the cost of ballast and tie per track foot. Examples of floating slabs include:

- Floating slabs used in Washington, DC; Atlanta, GA; and Boston, MA, were all designed to have a vertical resonance in the 14 to 17 Hz range.
 - A special system referred to as the double-tie system was first used in Toronto. It consists of 5-foot-long slabs with four or more rubber pads under each slab. This system was designed with a resonance frequency in the 12 to 16 Hz range.
 - Another special floating slab was used in San Francisco's Bay Area Rapid Transit (BART) system. It uses a discontinuous precast concrete double-tie system with a resonance frequency in the 5 to 10 Hz frequency range.
- **Tire-derived aggregate (TDA)** – TDA (shredded tires) consists of a layer of tire shreds wrapped in geotech fabric placed underneath the ballast on hard packed ground. This is a new, low-cost option that can provide reduction in vibration levels at frequencies above 25 Hz. This mitigation measure has proven to be effective for the Denver Regional Transportation District (RTD) light rail system as well as the Santa Clara Valley Transportation Authority (VTA) light rail system,⁽⁵⁹⁾ but the effective life of TDA has not been determined. Installed TDA costs approximately \$260 per track-foot.
 - **Other treatments** – Changing any feature of the track support system can change the levels of ground-borne vibration. Approaches

such as using heavier rail, thicker ballast, or heavier ties can be expected to reduce the vibration levels. There also is some indication that vibration levels are lower with wood ties compared to concrete ties. But there is little confirmation that any of these approaches will make a substantial change in the vibration levels.

- **Operational Changes** – The most effective operational change is to reduce the vehicle speed. Reducing the train speed by a factor of two will reduce vibration levels approximately 6 dB. Other operational changes include:
 - Use of equipment that generates the lowest vibration levels during the nighttime hours when people are most sensitive to vibration and noise.
 - Adjusting nighttime schedules to minimize movements in the most sensitive hours.

While there are tangible mitigation benefits from speed reductions and limits on operations during the most sensitive time periods, FTA does not generally accept speed reduction as a vibration mitigation measure for two important reasons: (1) speed reduction is unenforceable and negated if vehicle operators do not adhere to established policies, and (2) it is contrary to the purpose of the transit investment by FTA, which is to move as many people as possible as efficiently and safely as possible. FTA does not recommend limits on operations as a way to reduce vibration impacts.

Ib. Evaluate Path Treatments – When vibration mitigation treatments cannot be applied at the vibration source or additional mitigation is required after treating the source, the next preferred placement of vibration mitigation is along the vibration propagation path between the source and receiver. Possible path treatments include:

- **Trenches** – Use of trenches to control ground-borne vibration is analogous to controlling airborne noise with noise barriers. This approach has not received much attention in the United States, but trenches could be a practical method for controlling transit vibration from at-grade track. A rule-of-thumb given by Richert and Hall⁽⁶⁰⁾ is that if the trench is located close to the source, the trench bottom must be at least 0.6 times the Rayleigh wavelength below the vibration source. For most soils, Rayleigh waves travel at around 600 ft/sec, which means that the wavelength at 30 Hz is 20 ft, requiring that a trench be approximately 15 ft deep to be effective at 30 Hz.

A trench can be effective as a vibration barrier if it is either open or solid. The Toronto Transit Commission tested a trench filled with Styrofoam to keep it open and reported successful performance over a period of at least one year. Solid barriers can be constructed with sheet piling or concrete poured into a trench.

- **Buffer Zones** – Expanding the rail ROW can be the most economical method of reducing the vibration impact by simply increasing the distance between the source and receiver. A similar approach is to

negotiate a vibration easement from the affected property owners (e.g., a row of single-family homes adjacent to a proposed commuter rail line). There may be legal limitations, however, on the ability of funding agencies to acquire land strictly for the purpose of mitigating vibration (or noise) impact.

Ic. Evaluate Receiver Treatments – When vibration mitigation treatments cannot be applied at the source or along the propagation path, or if combinations of treatments are required, treatments to the receivers can be considered as described below.

- **Building Modifications** – In some circumstances, it is practical to modify the affected building to reduce the vibration level. Vibration isolation of buildings consists of supporting the building foundation on elastomer pads, similar to bridge bearing pads. Vibration isolation of buildings is seldom an option for existing buildings and is typically only possible for new construction. Vibration impacts on sensitive laboratory instruments, such as electron microscopes, may be controlled with vibration isolation tables.

This approach is particularly important for shared-use facilities such as an office space above a transit station or terminal. When vibration-sensitive equipment such as electron microscopes will be affected by transit vibration, specific modifications to the building structure may be the most cost-effective method of controlling the impact aside from modification of equipment mounting systems. For example, the floor upon which the vibration-sensitive equipment is located could be stiffened and isolated from the remainder of the building to reduce the vibration. Alternatively, the equipment mounting systems could be modified or the equipment could be relocated to a different building at far less cost.

SECTION 7

Noise and Vibration during Construction

Construction noise and vibration often generates complaints from the community, even when construction is for a limited timeframe. Public concerns about construction noise and vibration increase considerably with lengthy periods of heavy construction on major projects as well as prevalence of nighttime construction (often scheduled to avoid disrupting workday road and rail traffic). Noise and vibration complaints typically arise from interference with people's activities, especially when the adjacent community has no clear understanding of the extent or duration of the construction. Misunderstandings can arise when the community thinks a contractor is being insensitive, and the contractor believes it is performing the work in compliance with local ordinances. This situation underscores the need for early identification and assessment of potential problem areas.

This section outlines the procedures for assessing noise and vibration impacts during construction. The type of assessment (qualitative or quantitative) and the level of analysis are determined based on the scale of the project and surrounding land uses. In cases where a full quantitative assessment is not warranted, a qualitative assessment of the construction noise and vibration environment can lead to greater understanding and tolerance in the community. For major projects with extended periods of construction at specific locations, a quantitative assessment can aid contractors in making bids by allowing changes in construction approach and including mitigation costs before the construction plans are finalized.

Generally, local noise ordinances are not very useful for evaluating construction noise impact. They usually relate to nuisance and hours of allowed activity, and sometimes specify limits in terms of maximum levels, but are generally not practical for assessing the impact of a construction project. Project construction noise criteria should take into account the existing noise environment, the absolute noise levels during construction activities, the duration of the construction, and the adjacent land uses. While it is not the purpose of this manual to specify standardized criteria for construction noise impact, the following guidelines can be considered reasonable criteria for assessment. If these criteria are exceeded, there may be adverse community reaction.

Procedures for assessing construction noise are presented in Section 7.1. Procedures for assessing construction vibration are presented in Section 7.2.

7.1 Construction Noise Assessment

Noise impacts from construction may vary greatly depending on the duration and complexity of the project. The key elements of the Construction Noise Assessment procedure and recommended workflow are as follows.

Step 1: Determine Level of Construction Noise Assessment**Step 2:** Use a Qualitative Construction Noise Assessment to Estimate Construction Noise**Step 3:** Use a Quantitative Construction Noise Assessment to Estimate Construction Noise**Step 4:** Assess Construction Noise Impact**Step 5:** Determine Construction Noise Mitigation Measures

If there is uncertainty in how to determine the appropriate level of assessment, contact the FTA Regional office.

Step 1: Determine Level of Construction Noise Assessment

Determine the appropriate level of assessment based on the scale and type of the project and depending on the stage of environmental review.

Consider the following factors:

- Scale of the project
- Proximity of noise-sensitive sites to the construction zones
- Number of noise-sensitive receivers in the project area
- Duration of construction activities near noise-sensitive receivers
- Schedule, including the construction days, hours, and time periods
- Method (e.g., cut-and-cover vs. bored tunneling)
- Concern about construction noise expressed in comments by the general public (e.g., through scoping or public meetings)

Ia. Determine if an assessment is required – Construction Noise Assessments are not required for many small projects including:

- Installation of safety features like grade-crossing signals;
- Track improvements within the ROW; or
- Erecting small buildings and facilities which are similar in scale to the surrounding development.

For small projects like these, include descriptions in the environmental document of the length of construction, the loudest equipment to be used, the expected truck access routes, the avoidance of nighttime activity, and any other relevant planned construction method.

Ib. Determine whether a qualitative or quantitative assessment is required

- **Qualitative Construction Noise Assessment –** Qualitative Construction Noise Assessments may be required for projects with less than a month of construction time in a noise-sensitive area. See Step 2 for more information on Qualitative Construction Noise Assessments.

- **Quantitative Construction Noise Assessments** – Quantitative Construction Noise Assessments may be required for projects with a month or more of construction in noise-sensitive areas or if particularly noisy equipment will be involved. See Step 3 for more information on Quantitative Construction Noise Assessments.

Step 2: Use a Qualitative Construction Noise Assessment to Estimate Construction Noise

Use a qualitative construction noise assessment to estimate construction noise for appropriate projects per Section 7.1, Step 1b.

Provide qualitative descriptions in the environmental document of the following elements:

- Duration of construction (both overall and at specific locations)
- Equipment expected to be used (e.g., noisiest equipment)
- Schedule with limits on times of operation (e.g., daytime use only)
- Monitoring of noise
- Forum for communicating with the public
- Commitments to limit noise levels to certain levels, including any local ordinances that apply
- Consideration of application of noise control treatments used successfully in other projects

Effective community outreach and relations are important for these projects. Disseminate information to the public early regarding the kinds of construction equipment, expected noise levels, and durations to forewarn potentially affected neighbors about the temporary inconvenience. Including a general description of the variation of noise levels during a typical construction day may also be helpful.

Note that the construction criteria in Step 4 do not apply to qualitative assessments.

Step 3: Use a Quantitative Construction Noise Assessment to Estimate Construction Noise

Use a quantitative construction noise assessment to estimate construction noise for appropriate projects per Section 7.1, Step 1b.

For Quantitative Construction Noise Assessments, follow the recommended procedure in this step and include a description of the planned construction methods and any basic measures that have been identified to reduce the potential impact, such as prohibiting the noisiest construction activities during the nighttime, in the environmental document. It may be prudent, however, to defer final decisions on noise control measures until the project and construction plans are defined in greater detail during the engineering phase.

- **Noise Source Levels from Typical Construction Equipment and Operations** – The noise levels generated by construction

equipment vary greatly on factors such as the type of equipment, the equipment model, the operation being performed, and the condition of the equipment. Typically, the dominant source of noise from most construction equipment is the engine, often a diesel engine, which usually does not have sufficient muffling. In other cases, such as impact pile-driving or pavement-breaking, noise generated by the process dominates. Construction equipment can be considered to operate in the following two modes for Construction Noise Assessments:

- **Stationary** – Stationary equipment operates in one location for one or more days at a time, with either a fixed power operation (pumps, generators, compressors) or a variable noise operation (pile drivers, pavement breakers).
- **Mobile** – Mobile equipment moves around the construction site with power applied in cyclic fashion (bulldozers, loaders), or to and from the site (trucks). Movement around the site is considered in the construction noise prediction procedure.

Variation in power imposes additional complexity in characterizing the noise source level from mobile equipment. Describe the noise at a reference distance from the equipment operating at full power and adjusting it based on the duty cycle of the activity to determine the $L_{eq(t)}$ of the operation.

Typical noise levels from representative equipment are included in Table 7-1. The levels are based on an EPA Report,⁽⁶¹⁾ measured data from railroad construction equipment taken during the 1976 Northeast Corridor Improvement Project, the FHWA Roadway Construction Noise Model, and other measured data.

For equipment that is not represented in Table 7-1, measure the noise levels according to the standard procedures for measuring the exterior noise levels for the certification of mobile and stationary construction equipment by the Society of Automotive Engineers.⁽⁶²⁾⁽⁶³⁾

Table 7-1 Construction Equipment Noise Emission Levels

Equipment	Typical Noise Level 50 ft from Source, dBA
Air Compressor	80
Backhoe	80
Ballast Equalizer	82
Ballast Tamper	83
Compactor	82
Concrete Mixer	85
Concrete Pump	82
Concrete Vibrator	76
Crane, Derrick	88
Crane, Mobile	83
Dozer	85
Generator	82
Grader	85
Impact Wrench	85
Jack Hammer	88
Loader	80
Paver	85
Pile-driver (Impact)	101
Pile-driver (Sonic)	95
Pneumatic Tool	85
Pump	77
Rail Saw	90
Rock Drill	95
Roller	85
Saw	76
Scarifier	83
Scraper	85
Shovel	82
Spike Driver	77
Tie Cutter	84
Tie Handler	80
Tie Insertter	85
Truck	84

3a. Use the metric $L_{eq(t)}$ to assess construction noise. This unit is appropriate because $L_{eq(t)}$ can be used to describe:

- Noise level from operation of each piece of equipment separately, and levels can be combined to represent the noise level from all equipment operating during a given period
- Noise level during an entire phase
- Average noise over all phases of the construction

3b. Use Eq. 7-1 to predict construction noise impact for major transit projects, considering the noise generated by the equipment and noise propagation due to distance. Calculate $L_{eq, equip}$ for all equipment individually, then use decibel addition to sum the $L_{Aeq, equip}$ for all equipment operating during the same time period. See Appendix B.1.1 for information on decibel addition.

$$L_{eq,eq\text{uip}} = L_{emission} + 10 \log(Adj_{Usage}) - 20 \log\left(\frac{D}{50}\right) - 10G \log\left(\frac{D}{50}\right) \quad \text{Eq. 7-1}$$

where:

- $L_{eq,eq\text{uip}}$ = $L_{eq(t)}$ at a receiver from the operation of a single piece of equipment over a specified time period, dBA
- $L_{emission}$ = noise emission level of the particular piece of equipment at the reference distance of 50 ft, dBA
- Adj_{Usage} = usage factor to account for the fraction of time that the equipment is in use over the specified time period
- D = distance from the receiver to the piece of equipment, ft
- G = a constant that accounts for topography and ground effects

Determine the quantities for Eq. 7-1 based on the level of assessment as described below.

- A general assessment of construction noise is warranted for projects in an early assessment stage when the equipment roster and schedule are undefined and only a rough estimate of construction noise levels is practical.
- A detailed analysis of construction noise is warranted when many noise-sensitive sites are adjacent to a construction project or where contractors are faced with stringent local ordinances or heightened public concerns expressed in early outreach efforts.

Complete the appropriate assessment for each phase of construction. Major construction projects are accomplished in several different phases. Each phase has a specific equipment mix, depending on the work to be accomplished during that phase. As a result of the equipment mix, each phase has its own noise characteristics; some phases have higher continuous noise levels than others, and some have higher impact noise levels than others.

Option A: General Assessment – Determine the quantities for Eq. 7-1 based on the following assumptions for a General Assessment of each phase of construction.

- **Noise emission level ($L_{emission}$)** – Determine the emission level at 50 ft according to noise from typical construction equipment described above and Table 7-1.
- **Usage factor (Adj_{Usage})** – Assume a usage factor of 1. This assumes a time period of one-hour with full power operation. Most construction equipment operates continuously for periods of one-hour or more during the construction period.

Therefore, $10 \log(Adj_{Usage}) = 0$ and can be omitted from the equation.

- **Distance (D)** – Assume that all equipment operates at the center of the project, or centerline for guideway or highway construction project.

- **Ground effect (G)** – $G = 0$ assuming free-field conditions and ignoring ground effects. If ground effects are of specific importance to the assessment, consider using the Detailed Analysis procedure.

Only determine the $L_{eq, equip}$ for the two noisiest pieces of equipment expected to be used in each phase of construction. Then, sum the levels for each phase of construction using decibel addition.

Option B: Detailed Analysis – Determine the quantities for Eq. 7-1 based on the following assumptions for a Detailed Analysis of each phase of construction. Alternatively, for detailed, long-term, and complex construction projects or projects near a particularly sensitive site, the FHWA’s Windows-based screening tool, “Roadway Construction Noise Model (RCNM),” can be used for the prediction of construction noise.⁽⁶⁴⁾

- **Noise emission level ($L_{emission}$)** – Measure or certify the noise emission level for each piece of equipment.
- **Usage factor (Adj_{Usage})** – Long-term construction project noise impact is based on a 30-day average L_{dn} , the times of day of construction activity (nighttime noise is penalized by 10 dB in residential areas), and the percentage of time the equipment is used during a period of time that will affect Adj_{Usage} .

For example, an 8-hour $L_{eq(t)}$ is determined by making Adj_{Usage} the percentage of time each individual piece of equipment operates under full power in that period. Similarly, the 30-day average L_{dn} is determined from the Adj_{Usage} expressed by the percentage of time the equipment is used during the daytime hours (7 a.m. to 10 p.m.) and nighttime (10 p.m. to 7 a.m.), separately, over a 30-day period. To account for increased sensitivity to nighttime noise, the nighttime noise levels are adjusted by 10 dB in the L_{dn} computation (see Appendix B.1.4.5).

- **Distance (D)** – Determine the location of each piece of equipment during operation and the distance to each receiver.
- **Ground effect (G)** – Use Table 4-26 in Section 4.5, Step 3 to calculate G to account for the site topography, natural and man-made barriers, and ground effects.

Compute the 8-hour $L_{eq(t)}$ ($L_{eq, equip(8hr)}$) and the 30-day average L_{dn} ($L_{dn, equip(30day)}$) for all equipment expected to be used in each phase of construction separately. Then, sum the levels for each phase of construction using Eq. 4-56 and Eq. 4-57 in Table 4-32.

Step 4: Assess Construction Noise Impact

Compare the predicted noise levels from the Quantitative Construction Noise Assessment with impact criteria to assess impact from construction noise for each phase of construction.

No standardized criteria have been developed for assessing construction noise impact. Consequently, criteria must be developed on a project-specific basis unless local ordinances apply. As stated earlier in this section, local noise ordinances are typically not very useful in evaluating construction noise. They usually relate to nuisance and hours of allowed activity, and sometimes specify limits in terms of maximum levels, but are generally not practical for assessing the impact of a construction project. Project construction noise criteria should account for the existing noise environment, the absolute noise levels during construction activities, the duration of the construction, and the adjacent land use. While it is not the purpose of this manual to specify standardized criteria for construction noise impact, the following guidelines can be considered reasonable criteria for assessment. If these criteria are exceeded, there may be adverse community reaction.

The construction impact guidelines are presented based on the level of quantitative assessment.

Option A: General Assessment – Compare the combined $L_{eq.equip(1hr)}$ for the two noisiest pieces of equipment for each phase of construction determined in Section 7.1, Step 3 to the criteria below. Then, identify locations where the level exceeds the criteria.

Table 7-2 General Assessment Construction Noise Criteria

Land Use	$L_{eq.equip(1hr)}$, dBA	
	Day	Night
Residential	90	80
Commercial	100	100
Industrial	100	100

Option B: Detailed Analysis – Compare the combined $L_{eq.equip(1hr)}$ and the combined $L_{dn.equip(30day)}$ for all equipment for each phase of construction determined in Section 7.1, Step 3 to the criteria below. Then, identify locations where the level exceeds the criteria.

Table 7-3 Detailed Analysis Construction Noise Criteria

Land Use	$L_{eq.equip(8hr)}$, dBA		$L_{dn.equip(30day)}$, dBA
	Day	Night	30-day Average
Residential	80	70	75
Commercial	85	85	80*
Industrial	90	90	85*

*Use a 24-hour $L_{eq(24hr)}$ instead of $L_{dn.equip(30day)}$.

Step 5: Determine Construction Noise Mitigation Measures

Evaluate the need for mitigation and select appropriate mitigation measures.

Where potential impacts have been identified according to Section 7.1, Step 4, evaluate appropriate control measures. Include descriptions of how each affected location will be treated with one or more mitigation measures in the environmental document.

5a. Determine the appropriate approach for construction noise control. Categories of approaches include:

- **Design considerations and project layout**
 - Construct noise barriers, such as temporary walls or piles of excavated material, between noisy activities and noise-sensitive receivers.
 - Re-route truck traffic away from residential streets. Select streets with the fewest homes if no alternatives are available.
 - Site equipment on the construction lot as far away from noise-sensitive sites as possible.
 - Construct walled enclosures around especially noisy activities or clusters of noisy equipment. For example, shields can be used around pavement breakers, and loaded vinyl curtains can be draped under elevated structures.
- **Sequence of operations**
 - Combine noisy operations to occur in the same time period. The total noise level produced will not be substantially greater than the level produced if the operations were performed separately.
 - Avoid nighttime activities. Sensitivity to noise increases during the nighttime hours in residential neighborhoods.
- **Alternative construction methods**
 - Avoid impact pile-driving where possible in noise-sensitive areas. Drilled piles or the use of a sonic/vibratory pile driver or push pile driver are quieter alternatives where the geological conditions permit their use.
 - Use specially-quieted equipment, such as quieted and enclosed air compressors and properly-working mufflers on all engines.
 - Select quieter demolition methods. For example, sawing bridge decks into sections that can be loaded onto trucks results in lower cumulative noise levels than impact demolition by pavement breakers.

Include descriptions of how each impacted location will be treated with one or more mitigation measures in the environmental impact assessment when possible.

5b. Describe and commit to a mitigation plan that will be developed later when the information is available to make final decisions (not often available during the project development phase) on all specific mitigation measures. This may be the case for large, complex projects. The objective of the plan should be to minimize construction noise using all reasonable (e.g., cost vs. benefit) and feasible (e.g., possible to construct) means available.

Components of a mitigation plan may include some or all of the following provisions, which should also be specified in construction contracts:

- **Equipment noise emission limits** – Equipment noise limits are absolute noise limits applied to generic classes of equipment at a reference distance (typically 50 ft). The limits should be set no higher than what is reasonably achievable for well-maintained equipment with effective mufflers. Lower limits that require source noise control may be appropriate for certain equipment when needed to minimize community noise impact, if reasonable and feasible. Provisions could also be included to require equipment noise certification testing prior to use on-site.
- **Lot-line construction noise limits** – Lot-line construction noise limits are noise limits that apply at the lot-line of specific noise-sensitive properties. The limits are typically specified in terms of both noise exposure (usually $L_{eq(t)}$ over a 20-30-minute period) and maximum noise level. They should be based on local noise ordinances if applicable, as well as pre-construction baseline noise levels (usually 3 to 5 dB above the baseline).
- **Operational and/or equipment restrictions** – It may be necessary to prohibit or restrict certain construction equipment and activities near residential areas during nighttime hours. This is particularly true for activities that generate tonal, impulsive, or repetitive sounds, such as back-up alarms, hoe ram demolition, and pile-driving.
- **Noise abatement requirements** – In some cases, specifications may be provided for particular noise control treatments based on the results of the design analysis and/or prior commitments made to the public by civic authorities. An example would be the requirement for a temporary noise barrier to shield a particular community area from noisy construction activities.
- **Noise monitoring plan requirements** – Plans can be developed for pre-project noise monitoring to establish baseline noise levels at sensitive locations, as well as for periodic equipment and lot-line noise monitoring during the construction period. The plan should outline the measurement and reporting methods that will be used to demonstrate compliance with the project noise limits.
- **Noise control plan requirements** – For major construction projects, preparation and submission of noise control plans on a periodic basis (e.g., every six months) are generally required. These plans should predict the construction noise at noise-sensitive receiver locations based on the proposed construction equipment and methods. If the analysis predicts that the specified noise limits will be exceeded, the plan should specify the mitigation measures that will be applied and should demonstrate the expected noise reductions these measures will achieve. The objective of this proactive approach is to minimize the

likelihood of community noise complaints by ensuring that any necessary mitigation measures are included in the construction plans.

- **Compliance enforcement program** – If construction noise is an issue in the community, it is important that a program be implemented to monitor contractor compliance with the noise control specifications and mitigation plan. It is recommended that this function be performed by a construction management team on behalf of the public agency.
- **Public information and complaint response procedures** – To maintain positive community relations, it is recommended to keep the public informed about the construction plans and efforts to minimize noise, and procedures should be established for prompt response and corrective action to noise complaints during construction.

Most of these provisions are appropriate for large-scale projects, where construction activity will continue for many months, if not years. The linked references contain more information on construction noise for major transportation projects.⁽⁶⁰⁾⁽⁶⁵⁾

7.2 Construction Vibration Assessment

Construction activity can result in varying degrees of ground vibration, depending on the equipment and methods employed. Operation of construction equipment causes ground vibrations that spread through the ground and diminish in strength with distance. Buildings founded on the soil near the construction site respond to these vibrations with varying results, ranging from no perceptible effects at the lowest levels, low rumbling sounds and perceptible vibrations at moderate levels, and slight damage at the highest levels.

While ground vibrations from construction activities do not often reach the levels that can damage structures, fragile buildings must receive special consideration. The construction vibration criteria include consideration of the building condition.

The key elements of the Construction Vibration Assessment procedures and recommended workflow are as follows:

- Step 1:** Determine level of construction vibration assessment
- Step 2:** Use a qualitative construction vibration assessment
- Step 3:** Use a quantitative construction vibration assessment
- Step 4:** Assess construction vibration impact
- Step 5:** Determine construction vibration mitigation measures

Step 1: Determine Level of Construction Vibration Assessment

Determine the appropriate level of assessment based on the scale and type of the project and the stage of environmental review.

Ia. Determine if an assessment is required.

Construction Vibration Assessments are not required for many small projects including:

- Installation of safety features like grade-crossing signals
- Track improvements within the ROW
- Erecting small buildings and facilities, which are similar in scale to the surrounding development

Ib. Determine whether a qualitative or quantitative assessment is required.

- **Qualitative Construction Vibration Assessment** – A qualitative construction vibration assessment is appropriate for projects where prolonged annoyance or damage from construction vibration is not expected. For example, equipment that generates little or no ground vibration—such as air compressors, light trucks, and hydraulic loaders—only require qualitative descriptions. See Section 7.2, Step 2 for more information on qualitative construction vibration assessments.
- **Quantitative Construction Vibration Assessment** – A quantitative construction vibration analysis is appropriate for projects where construction vibration may result in building damage or prolonged annoyance. For example, activities such as blasting, pile-driving, vibratory compaction, demolition, and drilling or excavation near sensitive structures require a quantitative analysis. See Section 7.2, Step 3 for more information on quantitative construction vibration assessments.

If there is uncertainty in how to determine the appropriate level of assessment, contact the FTA Regional office.

Step 2: Use a Qualitative Construction Vibration Assessment

Use a qualitative construction vibration assessment to estimate vibration for appropriate projects per Section 7.2, Step 1b.

Provide qualitative descriptions in the environmental document of the following elements:

- Duration of construction (both overall and at specific locations)
- Equipment expected to be used
- Description of how ground-borne vibration will be maintained at an acceptable level

Note that the criteria in Section 7.2, Step 4 do not apply to qualitative assessments.

Step 3: Use a Quantitative Construction Vibration Assessment

Use a quantitative construction vibration assessment to estimate vibration for appropriate projects per Section 7.2, Step 1b.

For quantitative construction vibration assessments, follow the recommended procedure in this step. Vibration source levels from typical construction equipment and operations are provided below, and procedures on how to estimate construction vibration for damage and annoyance are provided in Steps 3a and 3b, respectively.

- **Vibration Source Levels from Construction Equipment** – Table 7-4 presents average source levels in terms of velocity for various types of construction equipment measured under a wide variety of construction activities. The approximate rms vibration velocity levels were calculated from the PPV limits using a crest factor of 4, representing a PPV-rms difference of 12 dB. Note that although the table gives one level for each piece of equipment, there is considerable variation in reported ground vibration levels from construction activities. The data in Table 7-4 provide a reasonable estimate for a wide range of soil conditions.⁽⁶⁶⁾⁽⁶⁷⁾⁽⁶⁸⁾⁽⁶⁹⁾

Table 7-4 Vibration Source Levels for Construction Equipment

Equipment		PPV at 25 ft, in/sec	Approximate Lv* at 25 ft
Pile Driver (impact)	upper range	1.518	112
	typical	0.644	104
Pile Driver (sonic)	upper range	0.734	105
	typical	0.17	93
Clam shovel drop (slurry wall)		0.202	94
Hydromill (slurry wall)	in soil	0.008	66
	in rock	0.017	75
Vibratory Roller		0.21	94
Hoe Ram		0.089	87
Large bulldozer		0.089	87
Caisson drilling		0.089	87
Loaded trucks		0.076	86
Jackhammer		0.035	79
Small bulldozer		0.003	58

* RMS velocity in decibels, VdB re 1 micro-in/sec

3a. Damage Assessment

Assess for building damage for each piece of equipment individually.

Construction vibration is generally assessed in terms of peak particle velocity (PPV), as described in Section 5.1.

- Determine the vibration source level (PPV_{ref}) for each piece of equipment at a reference distance of 25 ft as described above and in Table 7-4.
- Use Eq. 7-2 to apply the propagation adjustment to the source reference level to account for the distance from the equipment to the receiver. Note that the equation is based on point sources with normal propagation conditions.

$$PPV_{equip} = PPV_{ref} \times \left(\frac{25}{D}\right)^{1.5} \quad \text{Eq. 7-2}$$

where:

$$\begin{aligned} PPV_{equip} &= \text{the peak particle velocity of the equipment} \\ &\quad \text{adjusted for distance, in/sec} \\ PPV_{ref} &= \text{the source reference vibration level at 25 ft,} \\ &\quad \text{in/sec} \\ D &= \text{distance from the equipment to the receiver, ft} \end{aligned}$$

3b. Annoyance Assessment

Assess for annoyance for each piece of equipment individually. Ground-borne vibration related to human annoyance is related to rms velocity levels, expressed in VdB as described in Section 5.1.

Estimate the vibration level (L_v) using Eq. 7-3.

$$L_{v.distance} = L_{vref} - 30 \log\left(\frac{D}{25}\right) \quad \text{Eq. 7-3}$$

where:

$$\begin{aligned} L_{v.distance} &= \text{the rms velocity level adjusted for distance, VdB} \\ L_{vref} &= \text{the source reference vibration level at 25 ft, VdB} \\ D &= \text{distance from the equipment to the receiver, ft} \end{aligned}$$

Step 4: Assess Construction Vibration Impact

Compare the predicted vibration levels from the Quantitative Construction Vibration Assessment with impact criteria to assess impact from construction vibration.

Assess potential damage effects from construction vibration for each piece of equipment individually. Note that equipment operating at the same time could increase vibration levels substantially, but predicting any increase could be difficult. The criteria presented in this section should be used during the environmental impact assessment phase to identify problem locations that must be addressed during the engineering phase.

Compare the PPV and approximate L_v for each piece of equipment determined in Section 7.2, Step 3 to the vibration damage criteria in Table 7-5, which is presented by building/structural category, to assess impact.⁽⁷⁰⁾⁽⁷¹⁾ The approximate rms vibration velocity levels were calculated from the PPV limits using a crest factor of 4.

Table 7-5 Construction Vibration Damage Criteria

Building/ Structural Category	PPV, in/sec	Approximate L_v*
I. Reinforced-concrete, steel or timber (no plaster)	0.5	102
II. Engineered concrete and masonry (no plaster)	0.3	98
III. Non-engineered timber and masonry buildings	0.2	94
IV. Buildings extremely susceptible to vibration damage	0.12	90

*RMS velocity in decibels, VdB re 1 micro-in/sec

Compare the L_v determined in Section 7.2, Step 3 to the criteria for the General Vibration Assessment in Section 6.2 to assess annoyance or interference with vibration-sensitive activities due to construction vibration.

Step 5: Determine Construction Vibration Mitigation Measures

Evaluate the need for mitigation and select appropriate mitigation measures where potential human impacts or building damage from construction vibration have been identified according to Section 7.2, Step 4.

5a. Determine the appropriate approach for construction vibration mitigation considering equipment location and processes.

- **Design considerations and project layout**
 - Route heavily-loaded trucks away from residential streets. Select streets with the fewest homes if no alternatives are available.
 - Operate earth-moving equipment on the construction lot as far away from vibration-sensitive sites as possible.
- **Sequence of operations**
 - Phase demolition, earth-moving, and ground-impacting operations so as not to occur in the same time period. Unlike noise, the total vibration level produced could be substantially less when each vibration source operates separately.
 - Avoid nighttime activities. Sensitivity to vibration increases during the nighttime hours in residential neighborhoods.
- **Alternative construction methods**
 - Carefully consider the use of impact pile-driving versus drilled piles or the use of a sonic/vibratory pile driver or push pile driver where those processes might create lower vibration levels if geological conditions permit their use.
 - Pile-driving is one of the greatest sources of vibration associated with equipment used during construction of a project. The source levels in Table 7-4 indicate that sonic pile drivers may provide substantial reduction of vibration levels compared to impact pile drivers. But, there are some additional vibration effects of sonic pile drivers that may limit their use in sensitive locations.
 - A sonic pile driver operates by continuously shaking the pile at a fixed frequency, literally vibrating it into the ground. Continuous operation at a fixed frequency may, however, be more

noticeable to nearby residents, even at lower vibration levels. Furthermore, the steady-state excitation of the ground may induce a growth in the resonant response of building components. Resonant response may be unacceptable in cases of fragile buildings or vibration-sensitive manufacturing processes. Impact pile drivers, however, produce a high vibration level for a short time (0.2 seconds) with sufficient time between impacts to allow any resonant response to decay.

- Select demolition methods involving little to no impact, where possible. For example, sawing bridge decks into sections that can be loaded onto trucks results in lower vibration levels than impact demolition by pavement breakers. Milling generates lower vibration levels than excavation using clam shell or chisel drops.
- Avoid vibratory rollers and packers near sensitive areas.

5b. Describe and commit to a mitigation plan that will be developed and implemented during the engineering and construction phase when the information available during the project development phase will not be sufficient to define specific construction vibration mitigation measures. The objective of the plan should be to minimize construction vibration damage using all reasonable and feasible means available. The plan should include the following components:

- A procedure for establishing threshold and limiting vibration values for potentially affected structures, based on an assessment of each structure's ability to withstand the loads and displacements due to construction vibrations
- A commitment to develop a vibration monitoring plan during the engineering phase and to implement a compliance monitoring program during construction

SECTION

8

Documentation of Noise and Vibration Assessment

The level of required documentation is determined according to the project class of action. Section 2.1 covers the appropriate class of action (EIS, EA, or CE) for different projects. If there is uncertainty in the appropriate level of documentation, contact the FTA Regional office.

The noise and vibration analysis must be articulated to the public in a clear, comprehensive manner for all levels of documentation. The technical data and information necessary to withstand scrutiny in the environmental review process must be documented in a way that remains intelligible to the public. Justification for all assumptions used in the analysis, such as selection of representative measurement sites and all baseline conditions, must be presented for review.

A separate technical report or memorandum is often prepared as a supplement to the environmental document. A technical report is appropriate in cases when including the data from the assessment would create an unreasonably long environmental document. The details of the analysis are important for establishing the basis for the assessment. Therefore, all details in the technical report should be contained in a well-organized format for easy access to the information.

For large-scale projects, the environmental document should contain a summary of the essential analysis information to provide subject matter context and the analysis findings. For these projects, separate technical reports are usually prepared as supplements to the EIS or EA and referred to in the environmental document. For smaller projects, or projects with minimal noise or vibration impact, all of the technical information may be presented in the environmental document itself or in a technical memorandum. Other projects might have no potential for noise or vibration impacts. For those projects, that environmental documentation should explain that no noise or vibration impacts are expected.

This section provides guidance on presenting the necessary noise and vibration information in the environmental document (Section 8.1) and the associated technical report (Section 8.2).

8.1 Environmental Document

In the environmental document, provide a summary of the comprehensive noise and vibration information from the technical report and emphasize the salient points of the analysis in a format and style that the public can understand. Smaller projects may have all of the technical information contained within the environmental document, so take special care in summarizing the technical details to convey the information adequately.

Step 1: Choose the Information to Include

Choose the appropriate noise and vibration analysis information to include based on the level of environmental review and the associated documentation.

Ia. Provide full disclosure of noise and vibration impacts in the environmental document, including identification of locations where impacts cannot be mitigated below the severe impact level. In general, an EIS describes significant impacts and plans to mitigate the impacts. For EAs, completion of the environmental review with a finding of no significant impact (FONSI) may depend on mitigation being considered for incorporation in the proposed project. The way mitigation is presented in the environmental document depends on the type of impact (noise or vibration) and the stage of project development and environmental review. Projects that meet the criteria of a CE may also require the completion of a noise and/or vibration analysis, and the results of such an analysis should be documented in a noise memo or the CE documentation.

Ib. Document noise impacts – Typically, airborne noise impacts can be accurately predicted during the environmental review. For projects that focus on a single alternative, noise impacts can be accurately identified in the draft environmental document. If mitigation is anticipated, then mitigation options should be explored in the EA or draft EIS; firm decisions on mitigation can be deferred to the final document. But for all projects, decisions on noise mitigation should be made before the final document is approved.

Ic. Document vibration impacts – Predicting vibration impacts accurately is more complex because ground-borne vibration may be strongly influenced by subsurface conditions. The geotechnical studies that reveal these conditions are normally undertaken during the engineering phase, after the environmental review process is complete. Therefore, the final environmental document will usually not be able to state with certainty whether mitigation is needed for ground-borne vibration and noise.

If the engineering phase is conducted at the same time as the final environmental document, report the results of the Detailed Vibration Analysis in the final environmental document. If the engineering phase is conducted after the final environmental document, report the results of the General Vibration Assessment in the final environmental document. If impact is determined, include a commitment in the final document to conduct a Detailed Vibration Analysis during the engineering phase to complete the impact assessment. Also, include a discussion on various control measures that could be used and the likelihood that the criteria could be met through the use of one or more of the measures. It may be possible to state a commitment in the final environmental document to adhere to the impact criteria for the Detailed Vibration Analysis, while deferring the selection of specific vibration control measures until the completion of detailed studies in the engineering phase. When work is conducted after FTA signs its final decision document (i.e., ROD, combined FEIS/ROD, or FONSI), additional documentation, such as a reevaluation of the previous decision, may be necessary. FTA recommends contacting the FTA Regional office directly in these situations.

Id. Describe mitigation measures in the decision document – After the decision document is approved, incorporate the mitigation measures by reference in the actual grant agreements signed by FTA and the project sponsor. The mitigation measures then become contractual conditions that must be adhered to by the project sponsor.

It is typically appropriate to include the following noise and vibration information in the environmental document, as described in Section 8.1:

- The existing conditions (affected environment)
- The direct impacts from operation (environmental consequences)
- The construction impacts (environmental consequences)

Step 2: Organize information in the Environmental Document

Include information in the following sections of the environmental document separating out the noise and vibration information.

2a. Existing Conditions (Affected Environment) – Describe the existing conditions (conditions without the project) in terms of the existing noise and vibration conditions in this section of the document. The primary function of this section is to establish the focus and baseline conditions for the discussion of environmental impacts. Include the following basic information and separate the noise and vibration sections.

- **Description of noise/vibration metrics, effects and typical levels** – Include a targeted summary of relevant information from Section 3 of this manual. This will serve as background for the discussions of noise/vibration levels and characteristics that will follow in later sections. Provide illustrative material to convey typical levels to the public.
- **Inventory of noise/vibration-sensitive sites** – Describe the approach for identifying noise- and vibration-sensitive sites as well as the identified sites and site descriptions. Use sufficient detail to demonstrate completeness. Document these results on a map.
- **Noise/vibration measurements** – Document the basis for selecting measurement sites, including tables of sites coordinated with maps showing locations of sites. Summarize the measurement approach and include the justification for the measurement procedures used.

Present measurement data in well-organized tables and figures with a summary and interpretation of measured data. Measurements are often included in the table of measurement sites described in the previous paragraph. In some cases, measurements may be supplemented or replaced by collected data relevant to the noise and vibration characteristics of the area. For example, soil information for estimating ground-borne vibration propagation characteristics may be available from other projects in the area.

A summary and interpretation of how the collected data define the project setting is fundamental to this section.

2b. Direct Impacts – Include the following in the discussion on direct impacts due to project operation:

- **Overview of approach** – Provide a targeted summary of relevant information on the assessment procedure for determining noise/vibration impacts as a framework for the following sections.
- **Estimated noise/vibration levels** – Provide a general description of prediction models used to estimate project noise/vibration levels. Describe any distinguishing features unique to the project, such as source levels associated with various technologies.

Describe the results of the predictions in general terms first, followed by a detailed accounting of predicted noise levels. Supplement this information with tables and illustrate by contours, cross-sections, or shaded mapping. If contours are included in a technical report, it is not necessary to repeat them in this section.

- **Criteria for noise/vibration impact** – Describe the impact criteria for the project in detail and reference the appropriate section in this manual. Include tables listing the criteria levels or the figures included in this manual.
- **Noise/vibration impact assessment** – Present the impact assessment in its own section or combined with the section above.

Describe the locations, as identified in the screening procedure, where noise/vibration impact is expected to occur without implementation of mitigation measures, based on the screening results, predicted future levels, existing levels, and application of the impact criteria.

Include inventory tables of impacted noise- and vibration-sensitive sites to quantify the impacts for all noise/vibration-sensitive sites included in the Affected Environment (Existing Conditions) as described in the Existing Conditions section above.

- **Noise/vibration mitigation measures** – Perhaps the greatest difference between the technical report and the environmental document is with mitigation. The technical report discusses mitigation options and recommendations, while the environmental document provides the vehicle for reaching decisions on appropriate mitigation measures.

Begin this section with a summary of the noise/vibration mitigation measures considered for the impacted locations. Describe the specific measures selected for implementation in detail. Also, include any

applicable, specific noise or vibration policies the project sponsor may have in place.

In cases where it is not possible to commit to a specific mitigation measure in the final environmental document, it may be possible to commit to a certain noise/vibration level. For example, the environmental document could include a commitment to meet or exceed the impact criteria specified in Sections 4.1 and 6.2.

- **Unavoidable adverse environmental effects** – If it is projected that adverse noise/vibration impacts will result after all reasonable abatement measures have been incorporated, identify these impacts in this section.

2c. Construction Impacts – Discuss construction impacts in the environmental document's section on construction impacts, if present. If, because of the scale of the project, the environmental document does not have a separate construction impacts section, then the construction impacts should be discussed with the rest of the resource impacts.

When a special section on construction noise/vibration impacts is included in the document, it should be organized according to the comprehensive outline on long-term impacts described above. For projects with relatively minor effects, include a brief summary of impact.

8.2 Technical Report on Noise and Vibration

The technical report is intended to present complete technical data and descriptions in a manner that can be understood by the general public, but is more technical than the information found in the environmental document. All necessary background information should be present in the technical report, including tables, maps, charts, drawings, and references that may be too detailed for the environmental document, but which are important in helping to draw conclusions about the project's noise and vibration impacts and mitigation options.

Include the following major subject headings and key information described below. If both noise and vibration have been assessed, include separate sections for noise and vibration with subsections for key information as described below. Additional details on documentation requirements for the technical report of non-standard procedures and methodologies are included in Appendix G.

- **Overview** – Include a brief description of the project and an overview of the noise/vibration concerns to highlight initial considerations in framing the scope of the study.
- **Inventory of Noise/Vibration-Sensitive Sites** – Describe the approach for identifying noise- and vibration-sensitive sites as well as the identified sites and site descriptions. Use sufficient detail to demonstrate completeness. Document results on a map.

- **Measurements of Existing Noise/Vibration Conditions**
 - Document the basis for selecting measurement sites, including tables of sites coordinated with maps showing locations of sites. Summarize the measurement approach with justification for the measurement procedures used.
 - If the measurement data are used to estimate existing conditions at other locations, include the rationale and the method of estimation. Describe measurement procedures in detail.
 - Include tables of measurement instruments documenting manufacturer, type, serial number, and date of most recent calibration by authorized testing laboratory. Document measurement periods, including the time of day and length of time at each site to demonstrate adequate representation of ambient conditions.
 - Present measurement data in well-organized tables and figures with a summary and interpretation of measured data.
- **Additional Measurements Related to the Project** – Include detailed description of measurements and results for projects that require specialized measurements at noise- and vibration-sensitive sites. Examples include:
 - Outdoor-to-indoor noise level reduction of homes
 - Transmission of vibration into concert halls and recording studios
 - Special source-level characterization
- **Predictions of Noise/Vibration from the Project**
 - Describe the prediction model used to estimate future project conditions and specific data used as input to the models. Reference the appropriate section in this manual. Document any change or extension to the models recommended in this manual, so that the validity of the adjustments can be confirmed. See Appendix G for more information.
 - Describe in detail the modeled scenarios and why the scenarios were chosen.
 - Tabulate computed levels and illustrate by contours, cross-sections, or shaded mapping. Illustrate noise/vibration impacts with base maps at a scale with enough detail to provide reference for the location.
- **Noise/Vibration Criteria**
 - Describe the impact criteria for the project in detail and reference the appropriate section in this manual. Include tables specifying the criteria levels or the figures included in this manual.
 - If construction noise and/or vibration assessments were conducted, include the construction criteria in a separate section with the construction assessment details. See below for more information.

- **Noise/Vibration Impact Assessment**

- Describe the impact assessment according to the appropriate noise and/or vibration impact assessment sections in this manual.
- If an alternatives analysis was conducted, present a resulting impact inventory for each alternative mode or alignment in a format that allows comparison among alternatives.
- Tabulate the inventory according to the different types of affected noise- and vibration-sensitive sites. Present the results of the assessment both before and after mitigation.

- **Noise/Vibration Mitigation**

- Begin this section with a summary of all treatments considered, including those not carried to final consideration.
- Consider final candidate mitigation treatments separately and provide a description of the features of the treatment, including costs, expected benefit in reducing impacts, locations where the benefit would be realized, and a discussion of the practicality of alternative treatments.
- Include enough noise and vibration impact information to allow the project sponsor and FTA to reach decisions on mitigation prior to issuance of an environmental decision document.

- **Construction Noise/Vibration Impacts**

- Describe criteria adopted for construction noise or vibration if construction noise and/or vibration assessments were conducted.
- Describe the method used for predicting construction noise or vibration and include inputs to the models such as equipment roster by construction phase, equipment source levels, assumed usage factors, and other assumed site characteristics.
- Present predicted levels for noise- and vibration-sensitive sites and identify short-term impacts.
- In cases where construction impacts are identified, discuss feasible abatement methods using enough detail to allow construction contract documents to include mitigation measures.

- **References** – Provide references for all criteria, approaches, and data used in the analyses, as well as other reports related to the project that may be relied on for information, e.g., geotechnical reports.

Appendix A: Glossary of Terms

Terminology used through the manual is defined in this appendix.⁽⁴⁹⁾⁽⁷²⁾

A-weighting	A standardized filter used to alter the sensitivity of a sound level meter with respect to frequency so that the instrument is less sensitive at low and high frequencies where the human ear is less sensitive. Abbreviated as dBA.
Absolute Noise Impact	Noise that interferes with activities independent of existing noise levels and is expressed as a fixed level threshold.
Accelerometer	A transducer that converts vibratory motion to an electrical signal proportional to the acceleration of that motion.
Ambient	The pre-project background noise or vibration level, which is often used interchangeably with “existing noise” in this manual.
Amplitude	Difference between the extremes of an oscillating signal.
Alignment	The horizontal location of a railroad or transit system as described by curved and tangent track.
At-grade	Tracks on the ground surface.
Automated Guideway Transit (AGT)	Guided steel-wheel or rubber-tired transit passenger vehicles operating singly or in multi-car trains with a fully automated system on fixed-guideways along an exclusive ROW. AGT includes personal rapid transit, group rapid transit, and automated people mover systems.
Auxiliaries	The term applied to a number of separately driven machines, operated by power from the main engine or electric generation. They include the air compressor, radiator fan, traction motor blower, and air conditioning equipment.
Ballast mat	A 2- to 3-inch-thick elastomer mat placed under the normal track ballast on top of a rigid slab or packed sub-grade.
Ballast	Granular material placed on the trackbed for the purpose of holding the track in line and at surface.
Bus Rapid Transit (BRT)	A type of limited-stop bus operation that relies on technology to help speed up the service. Buses can operate on exclusive transitways, high-occupancy-vehicle lanes, expressways, or ordinary streets.
Catenary	On electric railroad and LRT systems, the term describing the overhead conductor that is contacted by the pantograph or trolley, and its support structure.
Commuter rail	Conventional passenger railroad serving areas surrounding an urban center. Most commuter railroads utilize locomotive-hauled coaches, often in push-pull configuration.
Consist	The total number and type of cars, locomotives, or transit vehicles in a trainset.
Continuous welded rail	A number of rails welded together to form unbroken lengths of track without gaps or joints.
Corrugated rail	A rough condition of alternating ridges and grooves which develops on the rail head in service.
Crest factor	The ratio of peak particle velocity to maximum RMS amplitude in an oscillating signal.
Criteria	Plural form of “criterion,” the relationship between a measure of exposure (e.g., sound or vibration level) and its corresponding effect.
Cross tie	The transverse member of the track structure to which the rails are spiked or otherwise fastened to provide proper gage and to cushion, distribute, and transmit the stresses of traffic through the ballast to the trackbed.
Crossover	Two turnouts with the track between the frogs arranged to form a continuous passage between two nearby and generally parallel tracks.
Cumulative	The summation of individual sounds into a single total value related to the effect over time.
Cut	A terrain feature typically created to allow for a trackbed to be at a lower level than the surrounding ground.

dB	See Decibel.
dBA	See A-weighting.
Decibel	The standard unit of measurement for sound pressure level and vibration level. Technically, a decibel is the unit of level which denotes the ratio between two quantities that are proportional to power; the number of decibels is 10 times the logarithm of this ratio. Abbreviated as dB.
DMU	Diesel-powered multiple unit. See Multiple Unit.
DNL	See L_{dn} .
Electrification	A term used to describe the installation of overhead wire or third rail power distribution facilities to enable operation of trains.
Embankment	A bank of earth, rock, or other material constructed above the natural ground surface.
Equivalent level	The level of a steady sound, which, in a stated time period and at a stated location, has the same sound energy as the time-varying sound. Also, written as L_{eq} .
Event	A passby of a vehicle (e.g., train, bus, or car) of any size consist.
Ferry boat	A transit mode comprised of vessels to carry passengers and/or vehicles over a body of water.
Fixed-guideway	A public transportation facility with a separate ROW for the exclusive use of public transportation and other high-occupancy vehicles.
Flange	The vertical projection along the inner rim of a wheel that serves, together with the corresponding projection of the mating wheel of a wheel set, to keep the wheel set on the track.
Floating slab	A special track support system for vibration isolation, consisting of concrete slabs supported on resilient elements, usually rubber or similar elastomer.
Force density	Force density is the force per root distance along the track in $\text{lb/ft}^{1/2}$. The force density level is the level in decibels of the force density relative to $1 \text{ lb/ft}^{1/2}$ and describes the vehicle force that excites the soil/rock surrounding the transit structure.
Frequency	The number of times that a periodically occurring quantity repeats itself in a specified period. With reference to noise and vibration signals, the number of cycles per second.
Frequency spectrum	Distribution of frequency components of a noise or vibration signal.
Frog	A track structure used at the intersection of two running rails to provide support for wheels and passageways for their flanges, thus permitting wheels on either rail to cross the other.
Gage (of track)	The distance between the rails on a track.
Grade crossing	The point where a rail line and a motor vehicle road intersect at the same vertical elevation.
Guideway	Supporting structure to form a track for rolling or magnetically-levitated vehicles.
Head-End Power (HEP)	A system of furnishing electric power for a complete railway train from a single generating plant in the locomotive.
Heavy rail	See Rail Rapid Transit.
Hertz (Hz)	The unit of acoustic or vibration frequency representing cycles per second.
Hourly average sound level	The time-averaged A-weighted sound level, over a 1-hour period, usually calculated between integral hours. Abbreviated as $L_{(1h)}$.
Hybrid Bus	A rubber-tired vehicle that features a hybrid diesel-electric propulsion system. A diesel engine runs an electric generator that powers the entire vehicle including electric drive motors that deliver power to the wheels.
Idle	The speed at which an engine runs when it is not under load.
Intermediate Capacity Transit (ICT)	A transit system with less capacity than rail rapid transit (RRT), but more capacity than typical bus operations. Examples of ICT include bus rapid transit (BRT), automated guideway transit (AGT), monorails, and trolleys.
Intermodal facility	Junction of two or more modes of transportation where transfers may occur.
Jointed rail	A system of joining rails with steel members designed to unite the abutting ends of contiguous rails.

$L_{(1h)}$	See Hourly Average Sound Level.
L_{dn}	Day-Night Sound Level. The sound exposure level for a 24-hour day calculated by adding the sound exposure level obtained during the daytime (7 a.m. to 10 p.m.) to 10 times the sound exposure level obtained during the nighttime (10 p.m. to 7 a.m.). This unit is used throughout the United States for environmental impact assessment. Also, written as DNL.
$L_{eq(1hr)}$	Equivalent Sound Level. The metric for cumulative noise exposure over a specific time interval is the equivalent sound level
Light Rail Transit (LRT)	A mode of public transit with tracked vehicles in multiple units operating in mixed traffic conditions on streets as well as sections of exclusive ROW. Vehicles are generally powered by electricity from overhead lines.
Locomotive	A self-propelled, non-revenue rail vehicle designed to convert electrical or mechanical energy into tractive effort to haul railway cars. See also Power Unit.
Main line	The principal line or lines of a railway.
Maglev	Magnetically-levitated vehicle; a vehicle or train of vehicles with guidance and propulsion provided by magnetic forces. Support can be provided by either an electrodynamic system wherein a moving vehicle is lifted by magnetic forces induced in the guideway or an electromagnetic system wherein the magnetic lifting forces are actively energized in the guideway.
Maximum sound level	The highest exponential-time-average sound level, in decibels, that occurs during a stated time period. Abbreviated as L_{max} . The standardized time periods are 1 second for L_{max} , slow, and 0.125 second for L_{max} , fast.
Metric	Measurement value or a quantitative descriptor used to identify a specific measure of sound level.
Monorail	Guided transit vehicles operating on or suspended from a single rail, beam, or tube.
Multimodal Project	In this manual, the term multimodal project is used to describe a project that includes changes to both transit and highway components in segments of the project.
Multiple Unit (MU)	A term referring to the practice of coupling two or more diesel-powered or electric-powered passenger cars together with provision for controlling the traction motors on all units from a single controller.
Noise	Any disagreeable or undesired sound or other audible disturbance.
Octave band	A standardized division of a frequency spectrum in which the interval between two divisions is a frequency ratio of 2.
One-third octave band	A standardized division of a frequency spectrum in which the octave bands are divided into thirds for more detailed information. The interval between center frequencies is a ratio of 1.25.
Pantograph	A device for collecting current from an overhead conductor (catenary), consisting of a jointed frame held up by springs or compressed air and having a current collector at the top.
Park-and-ride facility	A parking garage and/or lot used for parking passengers' automobiles while they use transit agency facilities and vehicles.
Peak factor	See Crest factor.
Plan-and-profile	Mapping used by transportation planners that shows two-dimensional plan views (x- and y- axes) on the same page as two-dimensional profiles (x- and z-axes) of a road or track.
Peak Particle Velocity (PPV)	The peak signal value of an oscillating vibration velocity waveform. Usually expressed in inches/second in the United States.
Peak-to-Peak (P-P) Value	Of an oscillating quantity, the algebraic difference between the extreme values of the quantity.
Power unit	A self-propelled vehicle, running on rails and having one or more electric motors that drive the wheels and thereby propel the locomotive and train. The motors obtain electrical energy either from a rail laid near, but insulated from, the track rails, or from a wire suspended above the track. Contact with the overhead wire is made by a pantograph mounted on top of the unit.
Project segment	Portions of a project with similar characteristics.

Pure tone	Sound of a single frequency.
Radius of curvature	A measure of the severity of a curve in a track structure based on the length of the radius of a circle that would be formed if the curve were continued.
Rail	A rolled steel shape, commonly a T-section, designed to be laid end to end in two parallel lines on cross ties or other suitable supports to form a track for railway rolling stock.
Rail Rapid Transit (RRT)	Often called “Heavy Rail Transit.” A mode of public transit with tracked vehicles in multiple units operating in exclusive rights-of-way. Trains are generally powered by electricity from a third rail alongside the track.
Receiver	A stationary far-field position at which noise or vibration levels are specified.
Relative Noise Impact	Noise increase above existing levels.
Resonance frequency	The phenomenon that occurs in a structure under conditions of forced vibration such that any change in frequency of excitation results in a decrease in response.
Right-of-Way	Abbreviated as ROW. Lands or rights used or held for railroad or transit operation.
Root Mean Square (rms)	The square root of the mean-square value of an oscillating waveform, where the mean-square value is obtained by squaring the value of amplitudes at each instant of time and then averaging these values over the sample time.
RMS Velocity Level (LV)	See Vibration Velocity Level.
SEL	See Sound Exposure Level.
Sound Exposure Level	The level of sound accumulated over a given time interval or event. Technically, the sound exposure level is the level of the time-integrated mean square A-weighted sound for a stated time interval or event, with a reference time of one second. Abbreviated as SEL.
Sound	A physical disturbance in a medium that is capable of being detected by the human ear.
Spectrum	See Frequency Spectrum.
Sub-ballast	Any material of a superior character, which is spread on the finished subgrade of the roadbed and below the top-ballast, to provide better drainage, prevent upheaval by frost, and better distribute the load over the roadbed.
Subgrade	The finished surface of the roadbed below the ballast and track.
Suburban bus	A bus similar to an intercity bus with high-backed seats but no luggage compartment, often used in express mode to city centers from suburban locations.
Switch	A track structure used to divert rolling stock from one track to another.
Tangent track	Track without curvature.
Track	An assembly of rail, ties, and fastenings over which cars, locomotives, and trains are moved.
Traction motor	A specially designed direct current series-wound motor mounted on the trucks of locomotives and self-propelled cars to drive the axles.
Trainset	A group of coupled cars including at least one power unit.
Transducer	Device designed to receive an input signal of a given kind (motion, pressure, heat, etc.) and to provide an output signal of a different kind (electrical voltage, amperage, etc.) in such a manner that desired characteristics of the input signal appear in the output signal for measurement purposes.
Transfer mobility	Transfer mobility is the complex velocity response produced by a point force as a function of frequency and represents the relationship between a vibration source that excites the ground and the resulting vibration of the ground surface.
Transit center	A fixed location where passengers interchange from one route or vehicle to another.
Trolley bus	A rubber-tired, electrically-powered bus operating on city streets drawing power from overhead lines.
Truck	The complete assembly of parts including wheels, axles, bearings, side frames, bolster, brake rigging, springs, and all associated connecting components, the function of which is to provide support, mobility, and guidance to a railroad car or locomotive.
Trunk line	See Mainline. The mainline of a commuter railroad where the branch line traffic is combined.

Turnout	An arrangement of a switch and a frog with closure rails, by means of which rolling stock may be diverted from one track to another.
VdB	See Vibration Velocity Level.
Vibration Velocity Level (LV)	Ten times the common logarithm of the ratio of the square of the amplitude of the RMS vibration velocity to the square of the amplitude of the reference RMS vibration velocity. The reference velocity in the United States is one micro-inch per second. Abbreviated as VdB.
Vibration	An oscillation wherein the quantity is a parameter that defines the motion of a mechanical system.
Wheel flat	A localized flat area on a steel wheel of a rail vehicle, usually caused by skidding on steel rails, causing a discontinuity in the wheel radius.
Wheel squeal	The noise produced by wheel-rail interaction, particularly on curves where the radius of curvature is smaller than allowed by the separation of the axles in a wheel set.

Additional, relevant acoustic terminology and formulas are defined in ANSI S1.1-1994 (49).

Appendix B: Fundamentals of Noise

Noise is generally considered to be unwanted sound. Sound is what we hear when our ears are exposed to small pressure fluctuations in the air. There are many ways in which pressure fluctuations are generated, but typically they are caused by vibrating movement of a solid object. This manual uses the terms noise and sound interchangeably because there is no physical difference between them. Noise can be described in terms of three variables: amplitude (loud or soft); frequency (pitch); and time pattern (variability).

B.1 Amplitude

The loudness of a sound is described by the sound wave's amplitude of pressure fluctuations above and below atmospheric pressure. Pressure is measured in Pascals. The mean value of the positive and negative pressure fluctuations is the static atmospheric pressure and is not a useful metric of sound. However, the effective magnitude of the sound pressure in a sound wave can be expressed by the rms of the oscillating pressure. See Figure B-1 for an illustration of the rms pressure.

The rms pressure is calculated according to Eq. B-1. The values of sound pressure are squared and time-averaged to smooth out variations. The rms pressure is the square root of this time-averaged value.

$$P_{rms} = \sqrt{\frac{1}{N} \sum_{i=1}^N P_i^2} \quad \text{Eq. B-1}$$

where:

P_{rms} = sound pressure
 P_i = individual sound pressure
 N = number of samples
 $i = 1$ = index of summation

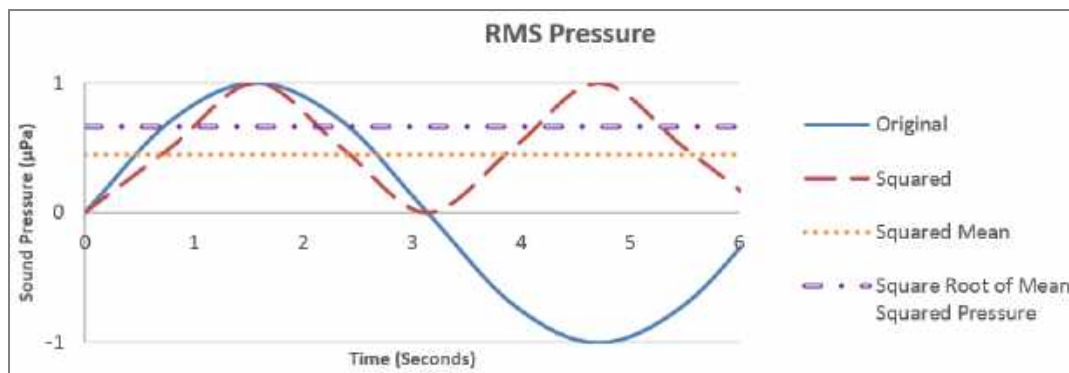


Figure B-1 RMS Pressure Illustration

Most humans with typical or average hearing can perceive sounds ranging from approximately 20 microPascals to 20 million microPascals or more. Because of the difficulty in dealing with such an extreme range of numbers, acousticians use a logarithmic scale to describe sound levels. Acousticians use a compressed scale based on logarithms of the ratios of the sound energy contained in the wave related to the square of sound pressures instead of the sound pressures themselves, resulting in the “sound pressure level” in decibels (dB). The ‘B’ in dB is always capitalized because the unit is named after Alexander Graham Bell, a leading 19th century innovator in communication.

Sound pressure level (L_p) is defined as:

$$L_p = 10 \log_{10} \left(\frac{p_{rms}^2}{p_{ref}^2} \right); \text{ or}$$

$$L_p = 20 \log_{10} \left(\frac{p_{rms}}{p_{ref}} \right) \text{ dB} \quad \text{Eq. B-2}$$

where

$$\begin{aligned} L_p &= \text{sound pressure level, dB} \\ p_{rms} &= \text{RMS sound pressure} \\ p_{ref} &= 20 \text{ microPascals} \end{aligned}$$

Inserting the range of sound pressure values mentioned above into Eq. B-2 results in a typical quietest sound at 20 microPascals at 0 dB. A typical loudest sound of 20 million microPascals is 120 dB.

B.1.1 Decibel Addition

The combination of two or more sound pressure levels at a single location requires decibel addition, which is the addition of logarithmic quantities of sound energy (P_{rms}^2).

To add sound energy from multiple, unique sources, add the sound energy as shown Eq. B-3.

$$L_p = 10 \log_{10} \left(\frac{P_1^2 + P_2^2 + \dots + P_n^2}{P_{ref}^2} \right) \quad \text{Eq. B-3}$$

where

$$\begin{aligned} L_p &= \text{sound pressure level, dB} \\ P_1, P_2, P_n &= \text{individual source RMS sound pressures to add} \\ P_{ref} &= 20 \text{ microPascals} \end{aligned}$$

A doubling of identical sound sources results in a 3-dB increase, as shown mathematically below.

$$\begin{aligned} L_p &= 10 \log_{10} \left(2 \frac{p_{rms}^2}{p_{ref}^2} \right) \\ &= 10 \log_{10} \left(\frac{p_{rms}^2}{p_{ref}^2} \right) + 10 \log_{10} (2) \\ &= 10 \log_{10} \left(\frac{p_{rms}^2}{p_{ref}^2} \right) + 3 \end{aligned}$$

To add decibel levels (instead of sound energy) use the following equation:

$$L_p = 10 \log_{10} \left(\sum_{i=1}^N 10^{(L_i/10)} \right)$$

where

L_p = sound pressure level, dB
 N = number of samples
 i = index of summation
 L_i = individual sound pressure levels, dB
 L_p = sound pressure level, dB
 L_1, L_2, L_n = individual source sound pressure levels to add

The equation above can be rewritten as follows:

$$L_p = 10 \log_{10} (10^{\frac{L_1}{10}} + 10^{\frac{L_2}{10}} + \dots + 10^{\frac{L_n}{10}}) \quad \text{Eq. B-4}$$

where

L_1, L_2, L_n = individual source sound pressure levels to add

Decibel addition can be quickly approximated using Figure B-2.

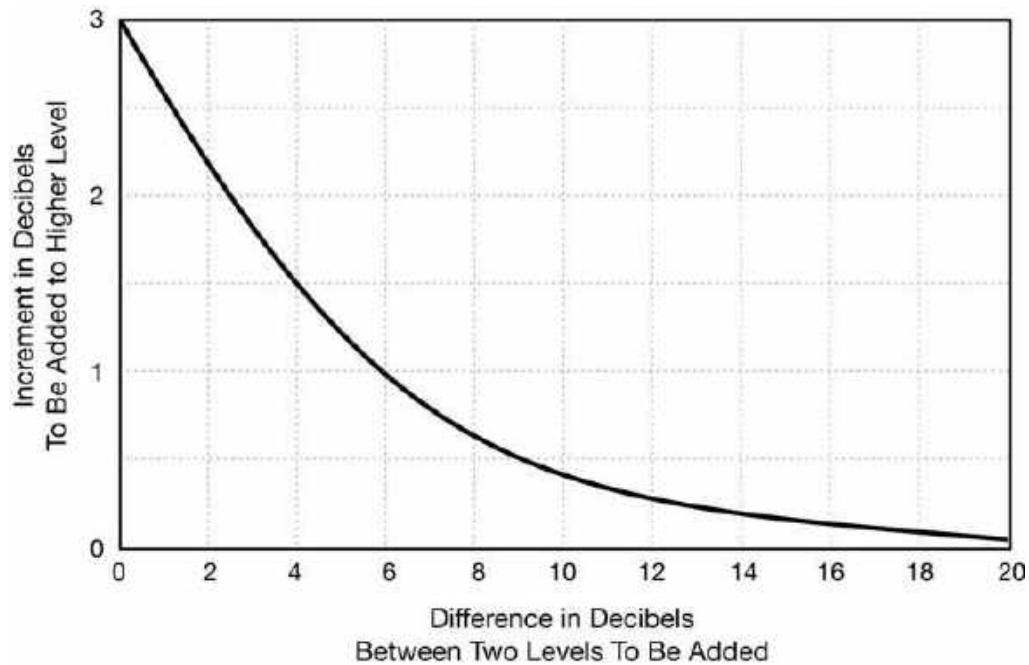


Figure B-2 Graph for Approximate Decibel Addition

Example B-1 Decibel Addition – Identical Buses

Decibel Addition

What is the combined sound pressure level of two identical buses if the noise from one bus resulted in a sound pressure level of 70 dB?

Since a doubling of identical sound sources results in a 3-dB increase:

$$\begin{aligned} L_p &= 70 + 3 \\ &= 73 \text{ dB} \end{aligned}$$

Example B-2 Decibel Addition – Two Sources

Decibel Addition

What is the combined sound pressure level of 64 dB and 60 dB?

Using Eq. B-4:

$$\begin{aligned} L_p &= 10 \log_{10}(10^{64/10} + 10^{60/10}) \\ &= 65.5 \text{ dB} \end{aligned}$$

Using Figure B-2:

The x-axis values represent the difference between the two sound levels, 64 and 60 dB. The difference between the sound levels in this example is 4. The point on the curve corresponding to 4 on the x-axis is 1.5. The y-axis values represent the increment that is added to the higher level.

$$\begin{aligned} L_p &= 64 + 1.5 \\ &= 65.5 \text{ dB} \end{aligned}$$

B.1.2 Frequency

Sound is a fluctuation of air pressure. The number of times the fluctuation occurs in one second is called its frequency. In acoustics, frequency is quantified in cycles per second, or Hertz (Hz). The hearing for a typical human covers the frequency range from 20 Hz to 20,000 Hz.

Some sounds, like whistles, are associated with a single frequency; this type of sound is called a pure tone. However, most often, noise is made up of many frequencies, called a spectrum. Analyzing a noise spectrum allows for identification of dominant frequency ranges and can assist in identifying noise sources. Often a frequency spectrum is divided into standardized frequency bands for analysis. Most commonly, the frequency bands for transit analyses are octave bands (where the interval between two divisions is a frequency ratio of 2) and one-third octave bands (where the interval between center frequencies is a ratio of 1.25).⁽⁷³⁾

If the spectrum associated with a transit noise source is dominated by many low-frequency components, the noise will have a characteristic like the rumble of thunder; this is often associated with noise from a subway. Mid-range frequencies are often associated with wheel/rail noise, and high frequencies may be associated with wheel squeal due to sharp curves on a track.

The spectrum in Figure B-3 illustrates the full range of acoustical frequencies that can occur near a transit system. In this example, the noise spectrum was measured near a train on an elevated steel structure with a sharp curve.

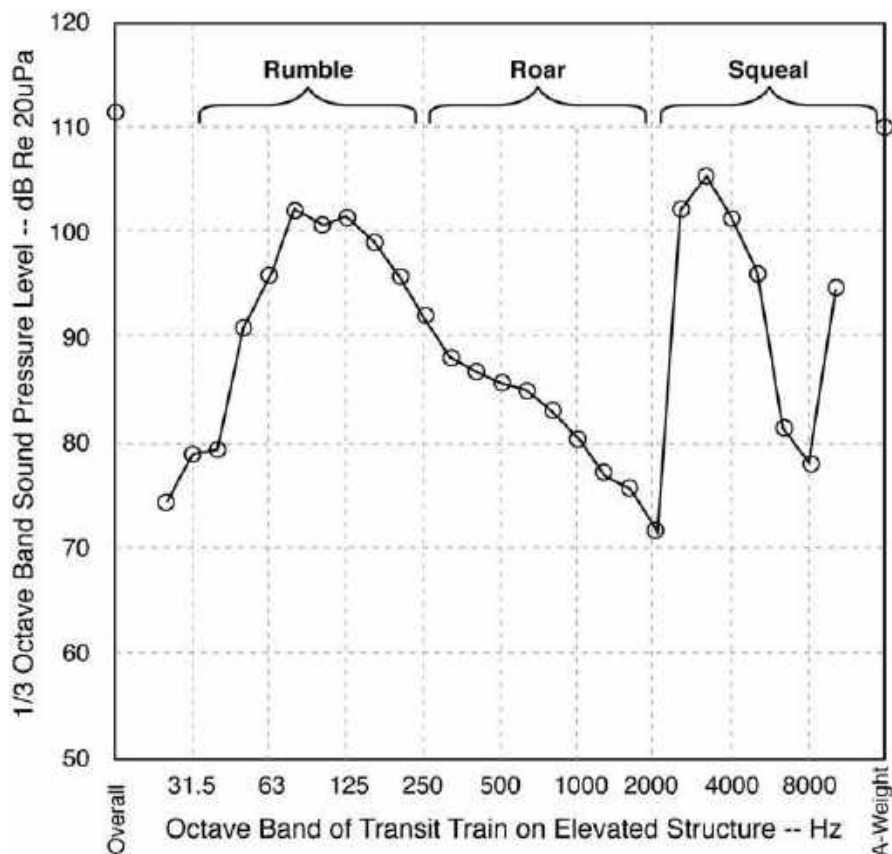


Figure B-3 Noise Spectrum of Transit Train on Curve and Elevated Structure

The human auditory system does not respond equally to all frequencies of sound. For sounds normally heard in our environment, low frequencies below 250 Hz and frequencies above 10,000 Hz are generally considered less audible than the frequencies in between. This is because our ears are less sensitive in those areas. To better represent human hearing, frequency response functions were developed to characterize the way people respond to different frequencies. These are referred to as A-, B-, and C-weighted curves and represent human auditory response to normal, very loud, and extremely loud sound levels, respectively. Environmental noise is generally considered to be in the normal sound level range; and, therefore, the A-weighted sound level is considered best to represent the human response.

The A-weighting curve is shown in Figure B-4. This curve illustrates that sounds at 50 Hz would have to be amplified by 30 dB to be perceived as loud as a sound at 1000 Hz at normal sound levels.

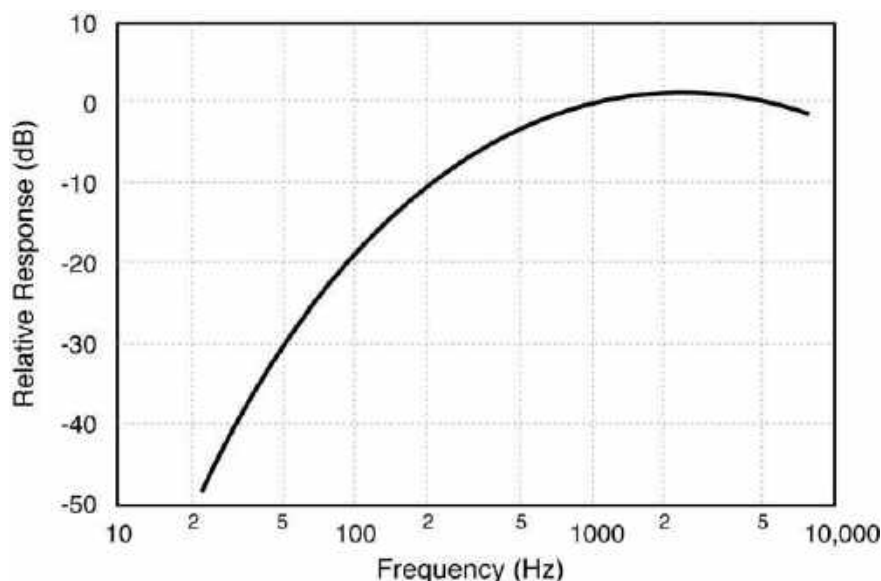


Figure B-4 A-Weighting Curve

Low frequencies have longer wavelengths of sound (cycles are less frequent) and, conversely, high frequencies have shorter wavelengths (cycles are more frequent). The size of the wavelength in feet is dependent on frequency and speed of sound as follows:

$$f\lambda = c$$

Eq. B-5

where

- f = frequency in cycles per second, Hz
- λ = wavelength, ft
- c = speed of sound, ft/sec

The speed of sound in air varies with temperature; but at standard conditions, it is approximately 1000 ft per second. Therefore, at standard conditions, a frequency of 1000 Hz has a wavelength of 1 foot and a frequency of 50 Hz has a wavelength of 20 ft. The scale of these waves explains, in part, the reason humans perceive sounds of 1000 Hz better than those of 50 Hz. A wavelength of 1 foot is similar to the size of a person's head; whereas, a wavelength of 20 ft is similar to dimensions associated with a house, which is why low-frequency sounds (such as those from an idling locomotive) are sometimes not attenuated by walls and windows of a home. These sounds transmit indoors with relatively little reduction in strength.

B.1.3 Time Pattern

The third important characteristic of noise is its variation in time. Environmental noise is considered to be a combination of all outdoor noise sources. When combined, sources such as distant traffic, wind in trees, and distant industrial or farming activities often create a low-level background noise in which no particular individual source is identifiable. Background noise is often relatively constant from moment to moment, but varies slowly over time as natural forces change or as human activity follows its daily cycle. In addition to this low-level, slowly varying background noise, a succession of identifiable noisy events of relatively brief duration may be added. These events may include single-vehicle passbys, aircraft flyovers,

screeching of brakes, and other short-term events, which all cause the noise level to substantially fluctuate from moment to moment.

It is possible to describe these fluctuating noises in the environment using single-number metrics to allow for manageable measurements, computations, and impact assessment. The search for adequate single-number noise metrics has encompassed hundreds of attitudinal surveys and laboratory experiments in addition to decades of practical experience with many alternative metrics.

B.1.4 Noise Metrics

The noise metrics referred to in this manual are described in the sections below.

B.1.4.1 A-weighted Sound Level: The Basic Noise Unit

The basic noise unit for transit noise is the A-weighted sound level and is described in ANSI S1.1-1994 (49). It describes the noise level at the receiver at any moment in time and can be read directly from noise-monitoring equipment when frequency weighting is set to A-weighting. Figure B-5 shows examples of typical A-weighted sound levels for both transit and non-transit sources, ranging from approximately 30 dBA (very quiet) to 90 dBA (very loud).

The unit dBA denotes the decibel level is A-weighted. The letter "A" indicates that the sound has been filtered to reduce the strength of very low and very high-frequency sounds to emulate the human response to sound levels as described in Appendix B.1.2. This allows for events that are out of the range of human hearing, such as high-frequency dog whistles and low-frequency seismic disturbances, to be filtered out. On average, each A-weighted sound level increase of 10 dB corresponds to an approximate doubling of subjective loudness.

A-weighted sound levels are adopted as the basic noise unit for transit noise impact assessments because they:

- Can be measured easily,
- Approximate the human ear's sensitivity to sounds of different frequencies,
- Match attitudinal-survey tests of annoyance better than other basic units,
- Have been in use since the early 1930s, and
- Are endorsed as the proper basic unit for environmental noise by most agencies concerned with community noise throughout the world.

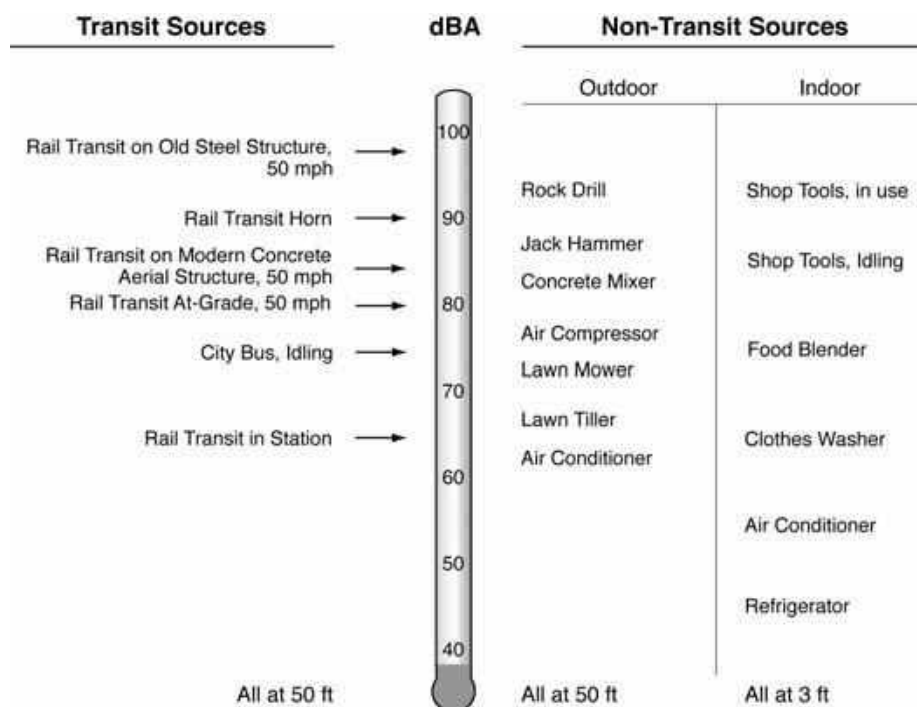


Figure B-5 Typical A-weighted Sound Levels

B.1.4.2 Maximum Sound Level (L_{\max}) During a Single Noise Event

As a transit vehicle approaches, passes by, and then recedes into the distance, the A-weighted sound level rises, reaches a maximum, and then fades into the background noise. The maximum A-weighted sound level reached during this passby is called the maximum sound level, ⁽⁴⁹⁾ abbreviated here as L_{\max} . L_{\max} is illustrated in Figure B-6 where time is plotted horizontally, and A-weighted sound level is plotted vertically.

Although L_{\max} is commonly used in vehicle-noise specifications,^{xvi} it is not used for transit environmental noise impact assessment. L_{\max} does not include the number and duration of transit events, which are important for assessing people's reactions to noise. It also cannot be normalized to a one-hour or 24-hour cumulative measure of impact, and therefore, is not conducive to comparison among different transportation modes. For example, cumulative noise metrics commonly used in highway noise assessments are $L_{\text{eq}}(1\text{hr})$ and L_{10} , the noise level exceeded for 10 percent of the peak hour.

^{xvi} For noise compliance tests of transient sources, such as moving transit vehicles under controlled conditions with smooth wheel and rail conditions, L_{\max} is typically measured with the sound level meter's time weighting set to "fast." However, for tests of continuous or stationary transit sources, it is usually more appropriate to use the "slow" setting. When set to "slow," sound level meters ignore some of the very-transient fluctuations, which are negligible when assessing the overall noise level.

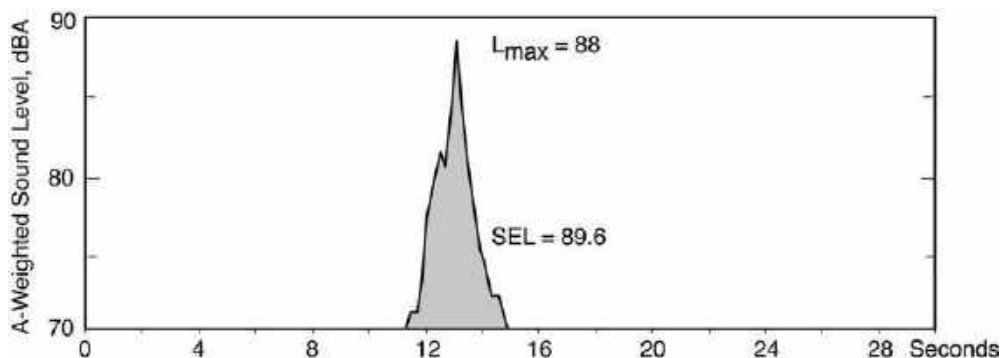


Figure B-6 Typical Transit-Vehicle Passby

B.1.4.3 Sound Exposure Level (SEL): Exposure from a Single Noise Event

Sound exposure level, abbreviated here as SEL, is the cumulative noise exposure from a single noise event, normalized to one second (49). SEL contains the same overall sound energy as the actual varying sound energy during the event. It is the primary metric for the measurement of transit vehicle noise emissions and an intermediate metric in the measurement and calculation of both $L_{eq}(1hr)$ and L_{dn} . The SEL metric is A-weighted and is expressed in the unit dBA.

This concept is illustrated in Figure B-6 and Figure B-7 where the shaded regions are the sound exposure during an event. The example in Figure B-6 is a transit-vehicle passby and Figure B-7 is an example of a fixed-transit facility as a transit bus is started, warmed up, and then driven away. For this event, the noise exposure is large due to duration of the event.

SEL is an A-weighted cumulative measure that is referenced to one second. Louder events have greater SELs than quieter events, and events of longer duration have greater SELs than shorter events. This is generally consistent with community response to noise. Noise events of longer duration are considered more disruptive than events of shorter duration with equal maximum A-weighted sound levels.

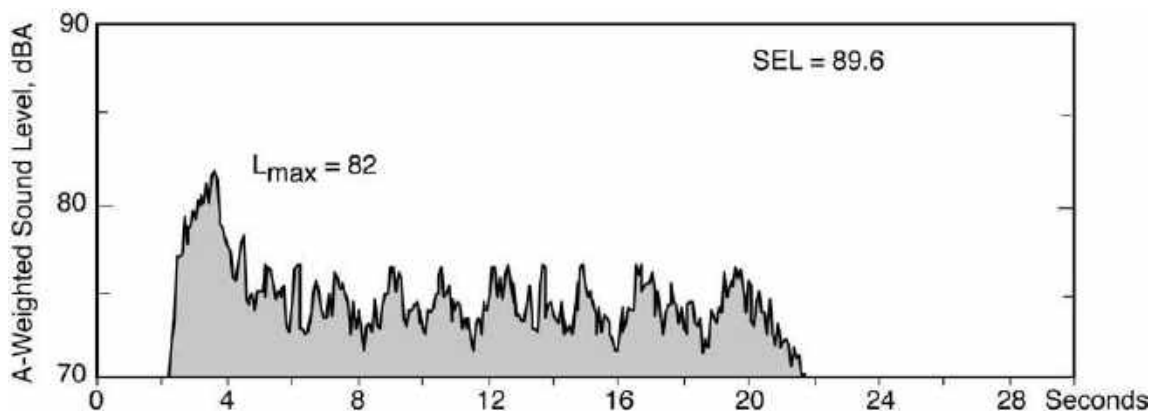


Figure B-7 Typical Fixed-Facility Noise Event

Conceptually, the sound exposure level can be expressed as:

$$SEL = 10\log_{10}\left(\frac{\text{Total sound energy}}{\text{during the event}}\right)$$

Mathematically, the sound exposure level is computed as follows:

$$SEL = 10\log_{10}\left(\sum_{i=1}^N 10^{(L_i/10)}\right) \quad \text{Eq. B-6}$$

where

- SEL = Sound exposure level, dBA
- N = number of samples
- i = index of summation
- L_i = individual A-weighted sound level, dBA

The events shown in Figure B-6 and Figure B-7 are compared graphically in Figure B-8 using a logarithmic vertical scale. The shaded zones in these figures indicate noise exposure over time. The actual event shows the noise exposure over the time of the event, and the equivalent SEL shows the total noise exposure normalized to one second. Note that events 1 and 2 in Figure B-8 have different time periods and noise levels throughout the event, but the same resulting SEL.

SEL is used in transit noise analyses because it:

1. Accounts for both the duration and amplitude of an event,
2. Allows a uniform assessment method for both transit-vehicle passbys and fixed-facility noise events, and
3. Can be used to calculate the one-hour and 24-hour cumulative metrics for comparison across different transportation modes.

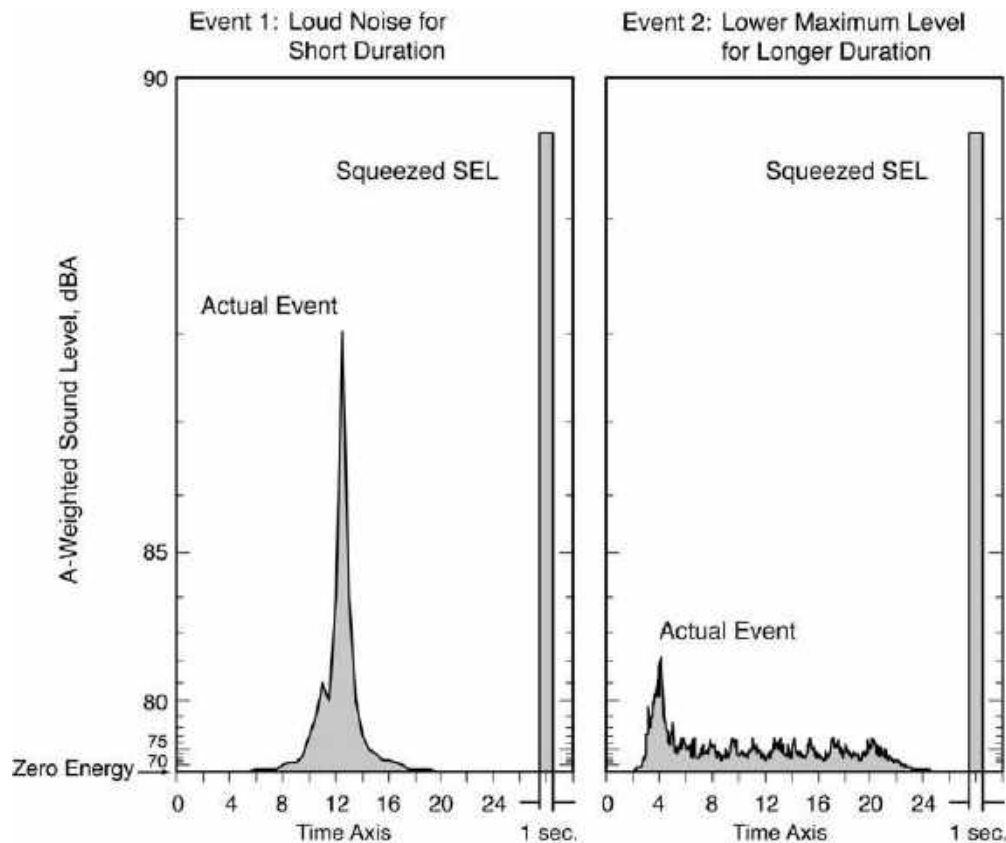


Figure B-8 An Energy View of Noise Events

B.1.4.4 Equivalent Sound Level ($L_{eq(t)}$)

The metric for cumulative noise exposure over a specific time interval is the equivalent sound level (49). It is a single decibel value that accounts for total sound energy from all sound levels over a specified time interval (or time period). The time period associated with the equivalent sound level metric can vary for different types of analyses. This metric is abbreviated as $L_{eq(t)}$, where “t” is the duration of the time period. $L_{eq(t)}$ represents a hypothetical constant sound level and contains the same overall sound energy as the actual varying sound energy during the time period “t”. For most transit noise analyses, an A-weighted, hourly equivalent sound level is used, abbreviated here as $L_{eq(1hr)}$. $L_{eq(1hr)}$ is expressed in the unit, dBA.

Figure B-9 shows examples of typical unmitigated hourly $L_{eq(1hr)}$'s, both for transit and non-transit sources ranging from 40 (quiet) to 80 dB (loud). Note that these $L_{eq(1hr)}$'s depend upon both the number of events during the hour as well as each event's duration, which is affected by vehicle speed. For example, doubling the number of events during the hour will increase the $L_{eq(1hr)}$ by 3 decibels, as will doubling the duration of each individual event.

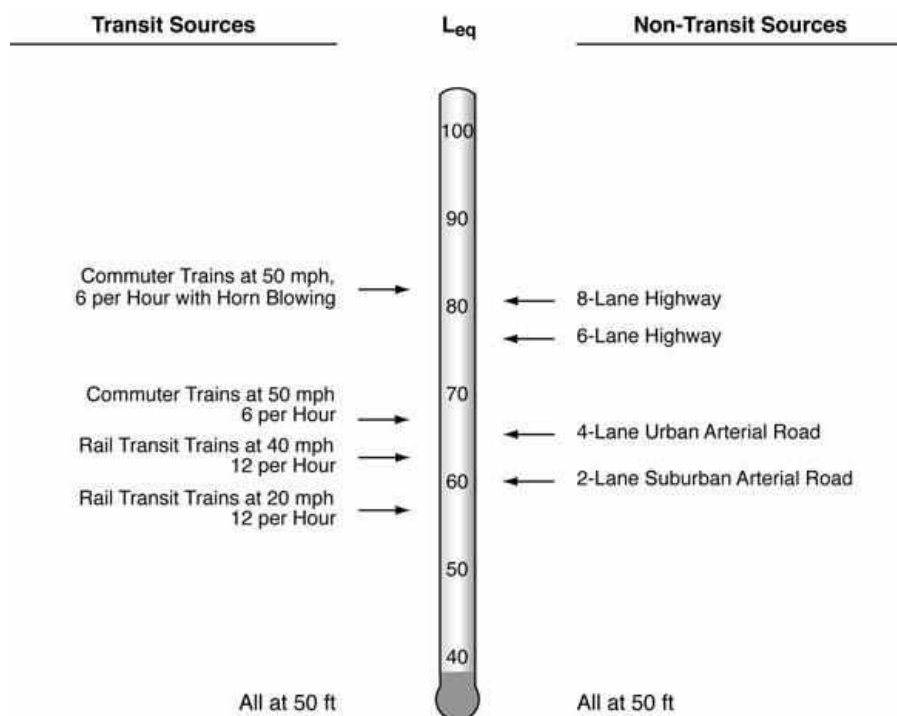


Figure B-9 Typical Hourly $L_{eq(1hr)}$'s

An example of sound levels over time for a single noise event such as a train passing on nearby tracks is illustrated in the top frame of Figure B-10. As the train approaches, passes by, and then recedes into the distance, the A-weighted sound level rises, reaches a maximum, and then fades into the background noise. The equivalent sound level is shown for three different time periods Figure B-10. The area under the curve in this top frame is the noise that reaches the receiver (noise exposure) over this five-minute period. The center frame of the figure shows sound levels over the one-hour period, including the five-minute period from the top frame. The area under the curve represents the noise exposure for one hour. The bottom frame shows sound levels over a full 24-hour period and is discussed in Appendix B.1.4.5.

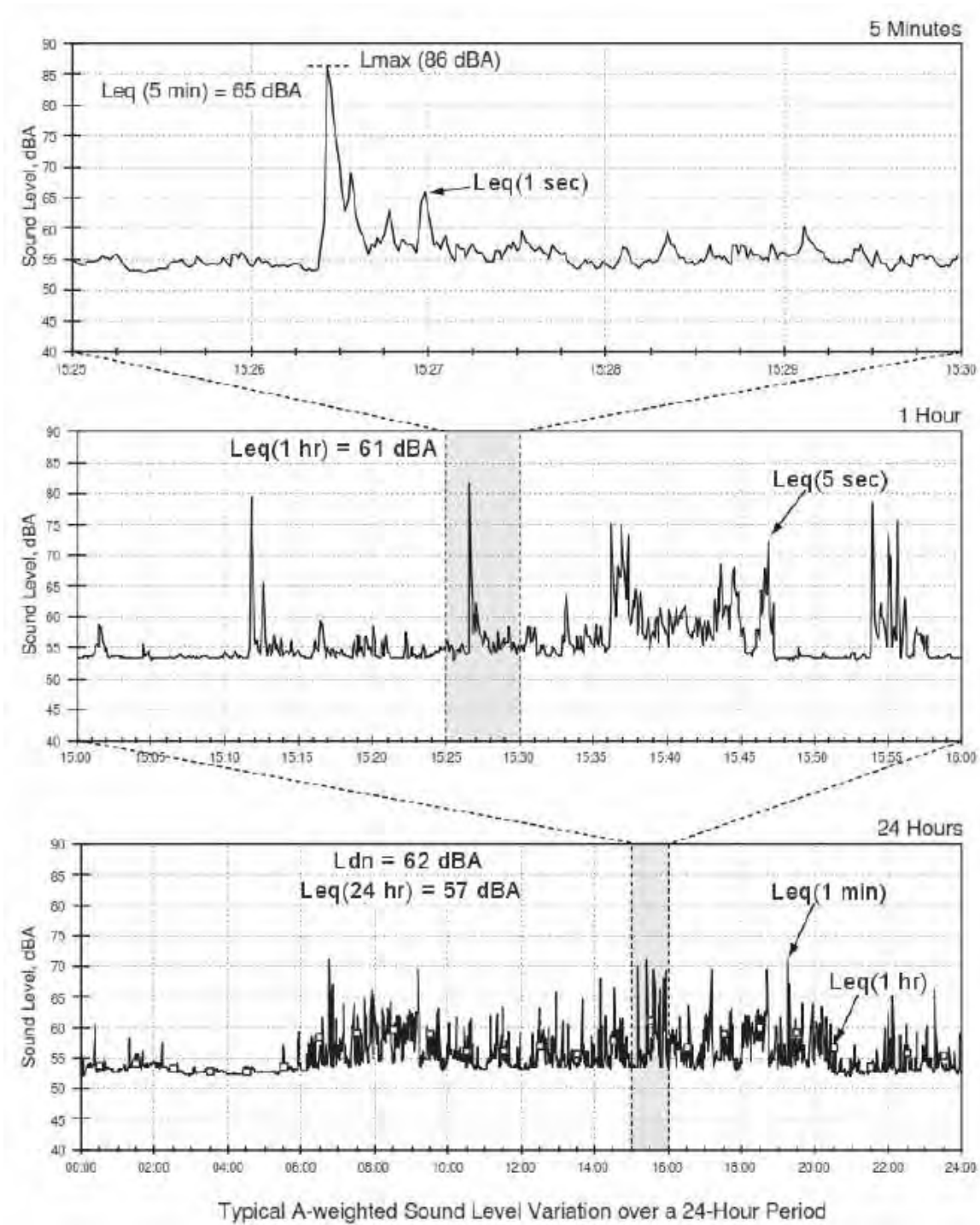


Figure B-10 Example A-weighted Sound Level Time Histories

Conceptually, the equivalent sound level can be expressed as:

$$L_{eq}(t) = 10 \log_{10} \left(\frac{\text{Total Sound Energy}}{\text{Time Period}} \right)$$

Mathematically, the equation is as follows:

$$L_{eq}(t) = 10 \log_{10} \left(\frac{1}{T} \sum_{i=1}^N 10^{(L_i/10)} \right)$$

where

$L_{eq}(t)$ = equivalent sound level of time period “t”, dBA
 T = time period, sec (3600 for an hourly $L_{eq}(1hr)$)
 N = number of samples, sec (3600 for an hourly $L_{eq}(1hr)$)
 i = index of summation
 L_i = individual A-weighted sound level, dBA

The equation above can be rewritten as follows for a one-hour time period:

$$L_{eq}(1h) = 10 \log_{10} [Total Sound Energy in 1 hr] - 35.6 \quad \text{Eq. B-7}$$

where

35.6 = numerical adjustment for a time period of 1 hour ($10 \log_{10}(t)$)

The sound energy is totaled over a full hour (3600 seconds) and is accumulated for all noise events during that hour. When computing the equivalent sound level for a time period other than one hour, T is modified in the equation to the duration of the time period in seconds. The numerical adjustment (35.6) accounts for time period of interest, in this case, one hour.

An alternate way for computing $L_{eq}(1hr)$ for a series of transit-noise events using sound exposure levels can be expressed conceptually as follows:

$$L_{eq}(1h) = 10 \log_{10} \left(\frac{Energy Sum of}{all SELs} \right) - 35.6$$

Mathematically, the equation is as follows:

$$L_{eq}(t) = 10 \log_{10} \left(\frac{1}{T} \sum_{i=1}^N 10^{(SEL_i/10)} \right) \quad \text{Eq. B-8}$$

where

$L_{eq}(t)$ = equivalent sound level of time period “t”, dBA
 T = time period, sec (3600 for an hourly $L_{eq}(1hr)$)
 N = number of sample, sec (3600 for an hourly $L_{eq}(1hr)$)
 i = index of summation
 SEL = individual sound exposure level, dBA

Hourly $L_{eq}(1hr)$ is adopted as the measure of cumulative noise impact for non-residential land uses (those not involving sleep) because $L_{eq}(1hr)$:

- Correlates well with speech interference in conversation and on the telephone – as well as interruption of TV, radio, and music enjoyment;
- Increases with the duration of transit events;
- Accounts for the number of transit events over the hour, which is also important to people's reactions; and

- Is used by the Federal Highway Administration in assessing highway-traffic noise impact. (Thus, this noise metric can be used for directly comparing and contrasting highway, transit, and multimodal alternatives).

B.1.4.5 Day-Night Sound Level (L_{dn}): 24-Hour Exposure from All Events

The metric for cumulative 24-hour exposure is the Day-Night Sound Level, ⁽⁴⁹⁾ abbreviated here as L_{dn} . It is a single, A-weighted decibel value that accounts for total sound energy from all sound sources over 24 hours and is expressed in the unit, dBA. Events between 10 p.m. and 7 a.m. are increased by 10 dB to account for people's greater nighttime sensitivity to noise.

Figure B-11 shows examples of typical L_{dn} 's, both for transit and non-transit sources, ranging from 50 to 80 dB, where 50 is considered a quiet 24-hour period and 80 a loud 24-hour period. Note that these L_{dn} 's depend upon the number of events during day and night separately, including each event's duration, which is affected by vehicle speed.

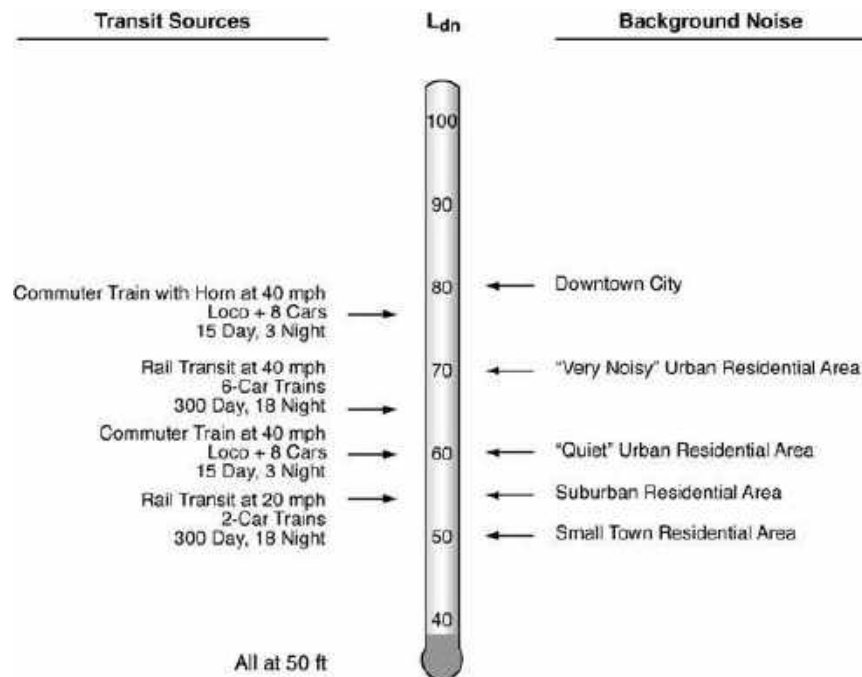


Figure B- 11 Typical L_{dn} 's

An example of sound level variation over 24 hours is visualized in the bottom frame of Figure B-10. The area under the curve represents the receiver's noise exposure over the 24 hours. Note that some vehicle passbys occur at night, when the background noise is typically lower and the 10 dB adjustment is applied.

Conceptually, the day-night level can be expressed as:

$$L_{dn} = 10 \log_{10} \left(\frac{\text{Total Sound Energy}_{\text{Day}}}{\text{Time Period}_{\text{Day}} (\text{seconds})} + \frac{n_{adj,n} \times \text{Total Sound Energy}_{\text{Night}}}{\text{Time Period}_{\text{Night}} (\text{seconds})} \right)$$

Mathematically, the equation is as follows:

$$L_{dn} = 10 \log_{10} \left(\frac{1}{T_d} \sum_{i=1}^N t_i \times 10^{(L_{d,i}/10)} + \frac{1}{T_n} \sum_{j=1}^M t_j \times 10^{((L_{n,j} + n_{adj,n})/10)} \right) \quad \text{Eq. B-9}$$

where

L_{dn}	= cumulative 24-hour exposure (day-night sound level), dBA
T_d	= time period during the daytime, between 7 a.m. and 10 p.m. sec (54,000)
N	= number of samples during the daytime (54,000)
i	= index of summation
t_i	= time interval of measurements in seconds (1)
$L_{d,i}$	= individual A-weighted sound level during the daytime, dBA
T_n	= time period during the nighttime, between 10 p.m. and 7 p.m. sec (32,400)
M	= number of samples during the nighttime (32,400)
j	= index of summation
t_j	= time interval of measurements, sec (1)
$L_{n,j}$	= individual A-weighted sound level during the nighttime, dBA
$n_{adj,n}$	= nighttime noise adjustment (10 dB)

The equation above can be rewritten as follows:

$$L_{dn} = 10 \log_{10} \left[(15 * \text{Total Sound Energy}_{\text{Day}}) + (9 * n_{adj,n} * \text{Total Sound Energy}_{\text{Night}}) \right] - 49.4$$

The sound energy is totaled over a full 24 hours, and the sound energy is accumulated from all noise events during that time period. The numerical adjustment (49.4) accounts for time period of interest, in this case, 24 hours.

An alternative way of computing L_{dn} from twenty-four hourly $L_{eq(1hr)}$'s can be expressed conceptually as follows:

$$L_{dn} = 10 \log_{10} \left(\frac{\text{Energy sum of daytime, hourly Leqs} + (n_{adj,n} * \text{Energy sum of nighttime, hourly Leqs})}{\text{Time period (seconds)}} \right)$$

The equation above can be rewritten as:

$$L_{dn} = 10 \log_{10} \left(\frac{\text{Energy sum of daytime, hourly Leqs} + (n_{adj,n} * \text{Energy sum of nighttime, hourly Leqs})}{\left(\frac{86400}{3600} \right)} \right)$$

The equation above can be reduced further and rewritten as:

$$L_{dn} = 10 \log_{10} \left(\text{Energy sum of daytime, hourly Leqs} + (n_{adj,n} * \text{Energy sum of nighttime, hourly Leqs}) \right) - 13.8 \quad \text{Eq. B-10}$$

L_{dn} due to a series of transit-noise events can also be computed in terms of SEL. The equation below assumes that transit noise dominates the 24-hour noise environment, where nighttime SELs are increased by 10 dB before totaling:

$$L_{dn} = 10 \log_{10} \left(\frac{\text{Energy sum of}}{\text{all daytime SELs}} + (n_{adj,n} * \frac{\text{Energy sum of}}{\text{all nighttime SELs}}) \right) - 49.4 \quad \text{Eq. B-11}$$

L_{dn} is adopted as the measure of cumulative noise impact for residential land uses (those involving sleep), because it:

- Correlates well with the results of attitudinal surveys of residential noise impact
- Increases with the duration of transit events
- Accounts for the number of transit events over the full twenty-four hours
- Accounts for the increased sensitivity to noise at night, when most people are asleep
- Allows composite measurements to capture all sources of community noise combined
- Allow quantitative comparison of transit noise with other community noises
- Is the designated metric of choice of other Federal agencies (e.g., HUD, FAA, and EPA) and has wide international acceptance

Appendix C: Background for Transit Noise Impact Criteria

The noise criteria presented in Section 4.1 of this manual have been developed based on well-documented criteria and research on human response to community noise. The primary goals in developing the noise criteria were to ensure that the impact limits are firmly founded in scientific studies, realistically based on noise levels associated with new transit projects, and represent a reasonable balance between community benefit and project costs. This appendix provides background information on the development of these criteria.

C.1 Relevant Literature

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

1. **U.S. EPA's "Levels Document"**⁽⁷⁴⁾

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. **Committee on Hearing, Bioacoustics and Biomechanics (CHABA) Working Group 69, "Guidelines for Preparing Environmental Impact Statements on Noise"**⁽⁷⁵⁾

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 Transportation Association (APTA) Guidelines for Design of Rapid Transit Facilities**⁽⁷⁶⁾

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; but the metric used in the APTA Guidelines is not appropriate for environmental assessment purposes.

The APTA Guidelines criteria are in terms of L_{max} for conventional RRT 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 RRT operations with 5 to 10 minute headways. Therefore, the APTA criteria are questionable for assessing the noise impact of other transit modes that 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. **Synthesis of Social Surveys on Noise Annoyance**⁽⁷⁷⁾

In 1978, Theodore J. Schultz, an internationally known acoustical scientist, synthesized the results of a large number of social surveys concerning annoyance due to transportation noise. A group of these surveys were remarkably consistent, 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 3-7) 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% when L_{dn} is approximately 90 dBA. Most importantly, 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. For example, 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, confirming the shape of the original Schultz curve ⁽¹²⁾.

5. HUD's Standards⁽¹⁹⁾

HUD 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 acceptability standards define 65 dB (L_{dn}) as the threshold for a normally unacceptable living environment (moderate impact for FTA) and 75 dB (L_{dn}) as the threshold for an unacceptable living environment (severe impact for FTA).

C.2 Basis for Noise Impact Criteria Curves

The lower curve in Figure 4-2 represents the onset of moderate impact and 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."⁽⁷²⁾
- The conclusion by EPA and others that a 5 dB increase in L_{dn} or $L_{eq(1hr)}$ is the minimum required for a change in community reaction.
- The research concludes 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 (Figure 3-7).

The increase in noise level from an existing ambient level of 50 dBA to a cumulative level of 55 dBA because of a project is found to cause minimal impact, with 2% of people highly annoyed, as described in the bullets above. This is considered the lowest threshold where impact starts to occur. Therefore, for an existing ambient noise level of 50 dBA, the curve representing the onset of moderate impact is at 53 dBA, the combination of which yields a cumulative level of 55 dBA by decibel addition. The remainder of the lower curve in Figure 4-2 was determined from the annoyance curve (Figure 3-7) by allowing a fixed 2% increase in annoyance at other levels of existing ambient noise. As cumulative noise increases, the increment to attain the same 2% increase in highly annoyed people is smaller. 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 a 2% increase of highly annoyed people at an existing ambient noise level of 70 dBA.

The upper curve in Figure 4-2 represents the onset of severe impact based on a total noise level, corresponding to a higher degree of impact. The severe noise impact curve is based on the following considerations:

- HUD defines an L_{dn} of 65 as the onset of a normally unacceptable noise zone (moderate impact for FTA) in its environmental noise standards ⁽¹⁹⁾. FAA considers that residential land uses are not compatible with noise environments where L_{dn} is greater than 65 dBA ⁽²⁰⁾.

- An increase of 5 dB in L_{dn} or $L_{eq(t)}$ is commonly assumed as the minimum required increase for a change in community reaction.
- The research concludes that an increase of 5 dB in L_{dn} or $L_{eq(t)}$ represents a 6.5% increase in the number of people highly annoyed (Figure 3-7).

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 the level at which severe impact starts to occur with a 6.5% increase in the number of people highly annoyed as described in the bullets above. Therefore, for an existing ambient noise level of 60 dBA, the curve representing the onset of severe impact is at 63 dBA, the combination of which yields a cumulative level of 65 dBA by decibel addition. The remainder of the upper curve in Figure 4-2 was determined from the annoyance curve (Figure 3-7) by allowing a fixed increase of 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, moderate impact for land use categories 1 and 2 is considered to occur whenever the transit L_{dn} equals or exceeds 65 dBA, and severe impact occurs whenever the transit 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 approximately 45 dBA). This is a conservative limit that reflects the lack of social survey data on people's reactions to noise at such low ambient levels. Like the FHWA approach in assessing the relative impact of a highway project, the transit noise criteria include limits on noise increase of 10 dB and 15 dB for moderate impact and severe impact, respectively, relative to the existing noise level.

Note 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 dB 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 4-2. Aside from active parks, which are clearly less sensitive to noise than category 1 and 2 sites, category 3 sites include primarily indoor activities. Therefore, the criteria account for some noise reduction from the building structure.

C.3 Equations for Noise Impact Criteria Curves

The equations for the noise impact criteria curves shown in Figure 4-2 are included in this section. These equations may be useful when performing the noise assessment methodology using spreadsheets, computer programs, or other analysis tools. Otherwise, such mathematical detail is generally not necessary to implement the criteria, and direct use of Figure 4-2 is adequate and less time-consuming.

A total of four continuous curves are included in the criteria, creating two threshold curves for moderate and severe impact for category 1 and 2, and two curves for category 3 (See Table C-1). 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, each one is defined by a set of three discrete equations. These equations are approximately continuous at the transition points. The following is a description of the three equations:

- 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 limited to 10 dB and 15 dB for moderate 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 Appendix C.2. This curve is a third-order, polynomial approximation derived from the Schultz curve⁽⁷⁵⁾ and covers the range of noise exposure encountered in most populated areas. This curve is used for determining noise impact in most cases for transit projects.
- The third equation 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, the absolute limit is 65 dBA for moderate impact and 70 dBA for severe impact. For land use category 3, the absolute limit is 75 dBA for moderate impact and 80 dBA for severe impact.

Table C-1 Threshold of Moderate and Severe Impacts

<u>Threshold of Moderate Impact</u>			
Category 1 and 2			
$L_p = 71.662 - 1.164L_E + 0.018L_E^2 - 4.088 \times 10^{-5}L_E^3,$		$\begin{array}{l} 11.450 + 0.953L_E, \quad L_E < 42 \\ 42 \leq L_E \leq 71 \\ 65, \quad L_E > 71 \end{array}$	Eq. C- 12
Category 3			
$L_p = 76.662 - 1.164L_E + 0.018L_E^2 - 4.088 \times 10^{-5}L_E^3,$		$\begin{array}{l} 16.450 + 0.953L_E, \quad L_E < 42 \\ 42 \leq L_E \leq 71 \\ 70, \quad L_E > 71 \end{array}$	Eq. C- 13
<u>Threshold of Severe Impact</u>			
Category 1 and 2			
$L_p = 96.725 - 1.992L_E + 3.02 \times 10^{-2}L_E^2 - 1.043 \times 10^{-4}L_E^3,$		$\begin{array}{l} 17.322 + 0.940L_E, \quad L_E < 44 \\ 44 \leq L_E \leq 77 \\ 75, \quad L_E > 77 \end{array}$	Eq. C- 14
Category 3			
$L_p = 101.725 - 1.992L_E + 3.02 \times 10^{-2}L_E^2 - 1.043 \times 10^{-4}L_E^3,$		$\begin{array}{l} 22.322 + 0.940L_E, \quad L_E < 44 \\ 44 \leq L_E \leq 77 \\ 80, \quad L_E > 77 \end{array}$	Eq. C- 15
L_E = the existing noise exposure in terms of L_{dn} or $L_{eq(1hr)}$ L_p = the project noise exposure which determines impact in terms of L_{dn} or $L_{eq(1hr)}$			

Appendix D: Clustering Receivers of Interest

This appendix supplements the information in Section 4.5 on clustering receivers of interest.

The general approach to selecting noise-sensitive receivers in the study area is included in Section 4.5, Step 1. General guidelines are as follows:

- Select the following types of receivers to evaluate individually:
 - Every major noise-sensitive public building
 - Every isolated residence
 - Every relatively small outdoor noise-sensitive area
- Residential neighborhoods and relatively large outdoor noise-sensitive areas can often be clustered and represented by a single receiver.

Clustering similar receivers reduces the number of computations needed later, especially for large-scale projects where a greater number of noise-sensitive sites may be affected. For this approach to be effective, it is essential that the representative receiver accurately represents the noise environment of the cluster.

The major steps in clustering receivers include:

1. First, cluster receivers according to approximately equal exposure to the primary project noise source. These areas typically run parallel to a linear project or circle major stationary sources relative to the proposed project.
2. Next, cluster receivers according to major sources of ambient noise. These areas typically run parallel to or encircle major sources of ambient noise.
3. Then, cluster receivers according to changes in the project layout or operations along the corridor.
4. Finally, select a representative receiver for each cluster.

The major steps are expanded below and include instructions on how to draw cluster boundaries on a map.

- I. **Boundaries along the proposed project** – Draw cluster boundaries along the proposed project as described below to separate clusters based on distance from the project. Draw these cluster boundaries for the project sources listed as major in Table 4-19.

Within both residential and noise-sensitive outdoor areas:

- **Primary project source**

Draw cluster boundaries at the following distances from the near edge of the primary project source: 0 ft, 50 ft, 100 ft, 200 ft, 400 ft, and 800 ft. For linear sources, such as a rail line, draw these boundaries as lines parallel to the proposed ROW line. For stationary sources, draw these boundaries as approximate circles around the source, starting at the property line.

Do not extend boundaries beyond the noise study area, identified in the Noise Screening Procedure in Section 4.3 or the General Noise Assessment of Section 4.4.

- **Remaining project sources** – Repeat the process for the primary project source for all other project listed as major in Table 4-19, such as substations and crossing signals. If several project sources are located approximately together, only consider one source, since the others would produce approximately the same boundary.

It is good practice to optimize the number of clusters for a project to simplify the procedure.

Where rows of buildings parallel the transit corridor:

- Ensure that cluster boundaries fall between the following rows of buildings, counting back away from the proposed project:
 - Between rows 1 and 2
 - Between rows 2 and 3
 - Between rows 3 and 4
 - Add cluster boundaries between these rows if not already included.
2. **Boundaries along sources of ambient noise** – Draw cluster boundaries along all major sources of ambient noise based upon distance from these sources, as described below.
 - Draw cluster boundaries along all interstates and major roadway arterials at the following distances from the near edge of the roadway: 0 ft, 100 ft, 200 ft, and 500 ft.
 - Draw cluster boundaries along all other roadways that have state or county numbering at 0 ft and 100 ft from the near edge of the roadway.
 - For all major industrial sources of noise, draw cluster boundaries that encircle the source at the following distances from the near property line of the source: 0 ft, 100 ft, 200 ft, and 400 ft.
 3. **Boundaries based on changes in project layout or operations** – Further subdivision is needed to account for changes in project noise where proposed project layout or operating conditions change considerably along the corridor. Draw a cluster boundary perpendicular to the corridor extending straight outward to both sides at the following locations:
 - Where parallel tracks previously separated by more than approximately 100 ft are moved closer together
 - Approximately where speed and/or throttle are reduced when approaching stations and where steady service speed is reached after departing stations
 - Approximately 200 ft up and down the line from grade crossing bells
 - At transitions from jointed to welded rail
 - At transitions from one type of cross section to another including on structure, on fill, at-grade and in cut
 - At transitions from open terrain to heavily wooded terrain
 - At transitions between areas free of locomotive horn noise and areas subject to this noise source
 - Any other positions along the line where project noise is expected to change considerably, such as up and down the line from tight curves where wheels may squeal
 4. **Selection of a representative receiver from each cluster** – Determine a representative receiver for each cluster boundary drawn in the steps above.
 - **Residential clusters**
Select a representative receiver within the cluster at the house closest to the proposed project. If this receiver is not the clear choice, select the receiver furthest from major sources of ambient noise.
 - **Outdoor noise-sensitive clusters (e.g., urban park or amphitheater)**

Select a representative receiver within the cluster at the closest point of active noise-sensitive use. If this receiver is not the clear choice, select the receiver farther from major sources of ambient noise.

Note that some clusters may fall between areas with receivers of interest. This could occur when operational changes or track layouts change in an open, undeveloped area. Retain these clusters. Do not merge them with adjacent clusters. Do not select a representative receiver of interest from them.

Example D-1 Clustering Receivers

Receivers of Interest and Clustering Receivers

In this hypothetical situation, a new rail transit line, labeled "new rail line" in Figure D-1, is proposed along a major urban street with commercial land use. A residential area is located adjacent to the commercial strip, located approximately one-half block from the proposed transit alignment. A major arterial, labeled "highway," crosses the alignment.

Cluster Receivers Along the Primary Project Source

Primary Project Source

The primary project source in this example is the new rail line. Boundaries are first drawn at distances of 0 ft from the right-of-way line (edge of the street in this example), 50 ft, 100 ft, 200 ft, 400 ft, and 800 ft, (Figure D-1). Distances are labeled at the top of the figure.

This is proposed to be a constant speed section of track, so there are no changes in boundaries due to changes in operations along the corridor. Moreover, no other project sources are shown here, but if there had been a station with a parking lot, lines would have been drawn enveloping the station site at the specified distances from the property line.

Rows of Buildings Parallel to the Transit Corridor

This example includes rows of buildings parallel to the transit corridor. The first set of boundary lines satisfies the requirement that cluster boundaries fall between rows 1 and 2, and between rows 2 and 3, but there is no line between rows 4 and 5. Consequently, a cluster boundary labeled "R" at the top of the figure has been drawn between the 4th and 5th row of buildings.

Cluster Receivers Along the Primary Project Source

The roadway arterial (labeled "highway") is the only major source of ambient noise shown.

Cluster boundaries are drawn at 0 ft, 100 ft, 200 ft and 500 ft from the near edge of the roadway on both sides. These lines are shown with distances labeled at the side of the figure.

Select a Representative Receiver from Each Cluster

Representative receivers are shown as filled circles in Figure D-1. Note that the receivers labeled with "REC" are primarily for use in Appendix E.

Locate receiver, "REC 3". Note that this cluster is located at the outer edge of influence from the major source ("highway") where local street traffic is the dominant source for ambient noise (in practice, this would be verified by a measurement).

"REC 3" is chosen to represent this cluster because it is among the houses closest to the proposed project source in this cluster and it is in the middle of the block affected by the dominant local street. Ambient noise levels at one end of the cluster may be influenced more by the highway and the other end may be affected more by the cross street, but the majority of the cluster would be represented by receiver site "REC 3."

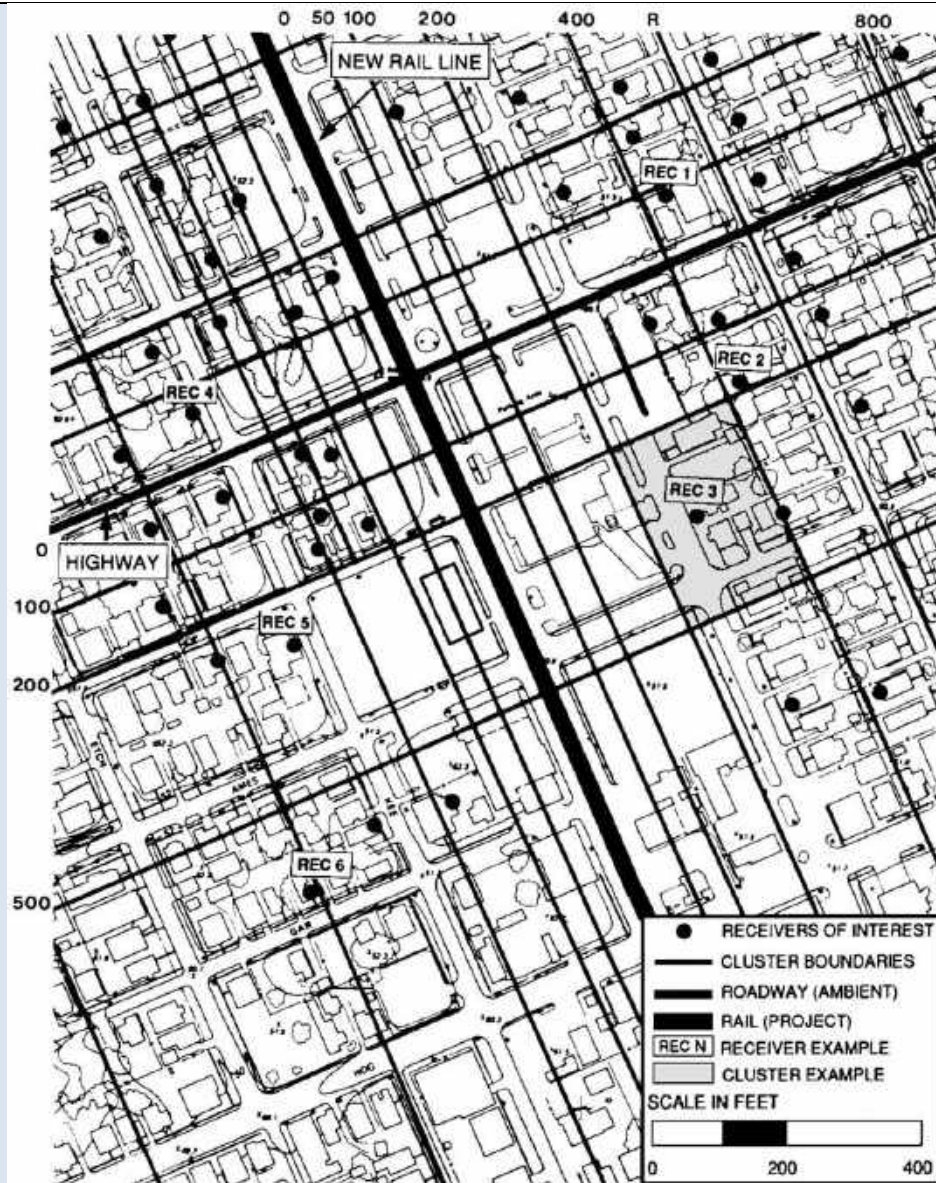


Figure D-1 Example of Receiver Map Showing Cluster Boundaries

Appendix E: Determining Existing Noise

Different options of determining existing noise, including full measurement, computation from partial measurements, and tabular look-up, are described in Section 4.5, Step 5. This appendix provides additional details associated with each method and examples of when each method could be used.

Additional details on the methods for estimating existing noise are provided below:

Option 1: $L_{eq(1hr)}$ measurement (non-residential) – Full one-hour measurements are recommended to determine existing noise for non-residential receivers of interest. These measurements are preferred over all other options and will accurately represent the $L_{eq(1hr)}$. The following procedures apply to these full-duration measurements:

- Measure $L_{eq(1hr)}$ at the receiver of interest during a typical hour of use on two non-successive days. Choose the hour in which maximum project activity will occur. The $L_{eq(1hr)}$ will be accurately represented using this method. Typically, measuring between noon Monday and noon Friday is recommended, but weekend days may be more appropriate for places of worship.
- Position the measurement microphone for all sites as shown in Figure 4-19, considering relative orientation of project and ambient sources. Position the microphone in a location that is somewhat shielded from the ambient source to measure the ambient noise at these locations at the quietest area on the property.
- Conduct all measurements in accordance with good engineering practice.

Option 2: L_{dn} measurement (residential) – Full 24-hour measurements are recommended to determine ambient noise for residential receivers of interest. These measurements are preferred over all other options and will accurately represent the L_{dn} . The following procedures apply to these full-duration measurements:

- Measure a full 24-hour L_{dn} at the receiver of interest for a single weekday (generally between noon Monday and noon Friday).
- Position the measurement microphone for all sites as shown in Figure 4-19 considering relative orientation of project and ambient sources. Position the microphone in a location that is somewhat shielded from the ambient source to measure the ambient noise at these locations at the quietest area on the property.
- Conduct all measurements in accordance with good engineering practice.

Option 3: L_{dn} computation of L_{dn} from 3 partial $L_{eq(1hr)}$ measurements (residential) – An alternative way to determine L_{dn} is to measure $L_{eq(1hr)}$ for three typical hours of the day, then compute the L_{dn} from these three $L_{eq(1hr)}$ measurements. This method is less precise than its full-duration measurement. The following procedures apply to this partial-duration measurement method for L_{dn} :

- Measure the $L_{eq(1hr)}$ during each of the following time periods:
 - During peak-hour roadway traffic
 - Midday, between the morning and afternoon roadway-traffic peak hours
 - During late night between midnight and 5 a.m.
- Position the measurement microphone for all sites as shown in Figure 4-19 considering relative orientation of project and ambient sources. Position the microphone in a location that is somewhat shielded from the ambient source to measure the ambient noise at these locations at the quietest area on the property.
- Conduct all measurements in accordance with good engineering practice.
- Compute the L_{dn} using the equation below

$$L_{dn} \approx 10\log(3 \times 10^{\frac{L_{eq,peakhour}-2}{10}} + 12 \times 10^{\frac{L_{eq,midday}-2}{10}} + 9 \times 10^{\frac{L_{eq,latenight}+8}{10}}) - 13.8 \quad \text{Eq. E-1}$$

The resulting L_{dn} will be slightly underestimated due to the adjustment to the measured levels in these equations. This underestimation is intended to compensate for the reduced precision of the computed L_{dn} . If using this method, a minimum time duration of one hour should be used for each measurement period in computing an L_{dn} .

Option 4: Computation of L_{dn} from 1 partial $L_{eq(1hr)}$ measurement (residential) – L_{dn} can also be determined by measuring $L_{eq(1hr)}$ for one hour of the day, and then computing L_{dn} from the $L_{eq(1hr)}$. This method is less precise than computing L_{dn} from 3 $L_{eq(1hr)}$ measurements. This method may be useful for projects with are many sites assessed by the General Noise Assessment. This method may also be appropriate when determining if a particular receiver of interest represents a cluster in a Detailed Noise Analysis. The following procedures apply to this partial-duration measurement option for L_{dn} :

- Measure the $L_{eq(1hr)}$ for the loudest hour of project-related activity during hours of noise sensitivity. If this hour is not selected, other hours may be used with the understanding that the estimate is less precise.
- Position the measurement microphone for all sites as shown in Figure 4-19, considering relative orientation of project and ambient sources. Position the microphone in a location that is somewhat shielded from the ambient source to measure the ambient noise at these locations at the quietest area on the property.
- Conduct all measurements in accordance with good engineering practice.
- Convert the measured hourly $L_{eq(1hr)}$ to L_{dn} with the appropriate equation below.

For measurements between 7 a.m. and 7 p.m.:

$$L_{dn} \approx L_{eq} - 2 \quad \text{Eq. E-2}$$

For measurements between 7 p.m. and 10 p.m.:

$$L_{dn} \approx L_{eq} + 3 \quad \text{Eq. E-3}$$

For measurements between 10 p.m. and 7 a.m.:

$$L_{dn} \approx L_{eq} + 8 \quad \text{Eq. E-4}$$

The resulting L_{dn} will be moderately underestimated due to the use of the adjustment constants in these equations. This underestimation is intended to compensate for the reduced precision of the computed L_{dn} . If using this method, a minimum time duration of one hour should be used for each measurement period in computing an L_{dn} .

Option 5: Computation of $L_{eq(1hr)}$ or L_{dn} from $L_{eq(1hr)}$ or L_{dn} of a comparable site (all land uses) – Computing $L_{eq(1hr)}$ or L_{dn} from the $L_{eq(1hr)}$ or L_{dn} of a comparable site where the ambient noise is dominated by the same source that is comparable in precision to Option 4. This method can be used to characterize noise in several neighborhoods by using a single representative receiver. It is critical that the measurement site has a similar noise environment to all areas represented. If measurements made by others are available and the sites are equivalent, the existing measurements can be used to reduce the amount of project noise monitoring. The following procedures apply to this method of determining of ambient noise:

- Choose another receiver that is comparable to the receiver (CompRec) of interest with the following:
 - The same source of dominant ambient noise

- The ambient level of the comparable receiver was measured according to Option 1 or Option 2 above
- The ambient measurement at the comparable receiver was made in direct view of the major source of ambient noise, unshielded by noise barriers, terrain, rows of buildings, or dense tree zones
- Determine the following from a plan or aerial photograph:
 - The distance ($D_{CompRec}$) from the comparable receiver to the near edge of the ambient source
 - The distance (D_{Rec}) from this receiver of interest to the near edge of the ambient source
- Determine the number of rows of buildings (N) that intervene between the receiver of interest and the ambient source.
- Compute the ambient level at the receiver of interest (Rec) with the appropriate equation below

If roadway sources dominate:

$$L_{Rec} \approx L_{CompRec} - 15\log\left(\frac{D_{Rec}}{D_{CompRec}}\right) - 3N \quad \text{Eq. E-5}$$

If other sources dominate:

$$L_{Rec} \approx L_{CompRec} - 25\log\left(\frac{D_{Rec}}{D_{CompRec}}\right) - 3N \quad \text{Eq. E-6}$$

The resulting L_{Rec} will be moderately underestimated. This underestimation is intended to compensate for the reduced precision of the computed L_{dn} .

Option 6: Estimation of L_{dn} by table look-up (all land uses) – The least precise way to determine the ambient noise is to estimate the level using a table. A tabular look-up can be used to establish baseline conditions for a General Noise Assessment if a noise measurement cannot be made. This method should not be used for a Detailed Noise Analysis. The following instruction applies to this method of determining of ambient noise:

Estimate either the $L_{eq(1hr)}$ or the L_{dn} using Table 4-17 based on distance from major roadways, rail lines, or upon population densities. In general, these tabulated values are substantially underestimated.

The underestimation is intended to compensate for the reduced precision of the estimated ambients.

Examples – Examples of when each method of determining existing noise may be appropriate are provided below using the example from Appendix D. Existing noise at the receivers labeled “REC” in Figure D-I could be estimated as follows:

- **Option 1: $L_{eq(1hr)}$ measurement** – Existing noise at REC 1 is due to the highway at the side of this church. $L_{eq(1hr)}$ can be measured during a typical church hour.
- **Option 2: L_{dn} measurement** – Existing noise at the residence REC 2 is due to a combination of the highway and local streets. L_{dn} can be measured for a full 24-hours.
- **Option 3: L_{dn} computation of L_{dn} from 3 partial $L_{eq(1hr)}$ measurements** – Existing noise at the residence REC 3 is due to the street in front of this residence. L_{dn} can be computed from three $L_{eq(1hr)}$ measurements.

- **Option 4: Computation of L_{dn} from 1 partial $L_{eq(1hr)}$ measurement** – Existing noise at the residence REC 4 is due to the highway. Because the highway has a predictable diurnal pattern, L_{dn} can be computed from one $L_{eq(1hr)}$ measurement.
- **Option 5: Computation of L_{dn} from L_{dn} of a comparable site** – Existing noise at the residence REC 5 is due to Kee Street. REC 3 is also affected by local street traffic and is a comparable distance from the highway. L_{dn} for REC 5 can be computed based on the L_{dn} at REC-3.
- **Option 6: Estimation of L_{dn} by table look-up** – Existing noise at the residence REC 6 is due to local traffic. L_{dn} can be estimated by tables based on population density along this corridor.

Appendix F: Computing Source Levels from Measurements

This appendix contains the procedures for computing source reference levels (SEL_{ref}) from source measurements in cases where the source reference tables in Section 4.5, Step 2 indicate measurements are preferred, data are not available for the source of interest, or more precise data are required than available in the table.

Close-by source measurements for vehicle passbys may capture either the vehicle's sound exposure level (SEL) or maximum noise level (L_{max}). Both metrics can be measured directly by commonly available sound level meters. While the L_{max} metric is not used for transit noise impact assessments, it can be used to compute SEL source reference levels. L_{max} measurements are often available from transit-equipment manufacturers and some transit system equipment specifications may limit close-by L_{max} levels.

Close-by source measurements for stationary sources capture the source's SEL over one source event, where the event duration may be chosen based on measurement convenience. The duration will factor out of the computation when the measured value is converted to reference operating conditions.

This manual does not specify elaborate methods for undertaking the close-by source measurements, but rather, provides general processes. It is required that all measurements conform to good engineering practice, guided by the standards of the American National Standards Institute and other such organizations (27, 28, 29).

This appendix presents information according to noise source as follows:

- Appendix F.1: Highway and rail vehicle passbys for vehicles of the same type
- Appendix F.2: Stationary sources
- Appendix F.3: L_{max} for single train passbys (for trains of mixed consists)

F. 1 Highway and Rail Vehicle Passbys

This section provides information on appropriate conditions for vehicle passby measurements, instructions on converting measurements made under non-reference conditions to source reference levels, and examples of these computations.

The following conditions are required for vehicle passbys, in addition to good engineering practice:

- Measured vehicles must be representative of project vehicles in all aspects, including representative acceleration and speed conditions for buses.
- Track must be relatively free of corrugations and train wheels relatively free of flats, unless these conditions are typical of the proposed project.
- Road surfaces must be smooth and dry, unless these conditions are typical of the proposed project.
- Perpendicular distance between the measurement position and the source's centerline must be 100 ft or less.
- Vehicle speed must be 30 mph or greater, unless typical project speeds are less than that.
- No noise barriers, terrain, buildings, or dense tree zones may break the lines-of-sight between the source and the measurement position.

When close-by source measurements are made under non-reference conditions, use the instructions below and the equations in Table F-1 to convert the measured values to source reference levels. For rail vehicles, measure/convert a group of locomotives or a group of cars separately. This computation requires that all measured vehicles be of the same type. For trains of mixed consists, see Appendix F.3.

SEL measured for a highway-vehicle passby, or a passby of a group of identical rail vehicles

- Collect the following input information:
 - SEL_{meas} , the measured SEL for the vehicle passby
 - N , the consist of the measured group of rail cars or group of locomotives
 - T , the average throttle setting of the measured diesel-powered locomotive(s)
 - S_{meas} , the measured passby speed, in miles per hour
 - D_{meas} , the closest distance between the measurement position and the source, in feet
- Compute the Source Reference Level SEL_{ref} , using Eq. F-1.

L_{max} measured for a passby of a group of identical rail vehicles

- Collect the following input information:
 - L_{max} , measured for the group passby
 - N , the consist of the measured group of rail cars or group of locomotives
 - T , the average throttle setting of the measured diesel-powered locomotive(s)
 - S_{meas} , the measured passby speed, in miles per hour
 - D_{meas} , the closest distance between the measurement position and the source, in feet
 - L_{meas} , the total length of the measured group of locomotives or group of rail cars, in feet
- Compute the Source Reference Level SEL_{ref} , using either Eq. F-2 or Eq. F-3, as appropriate, for locomotives or rail cars.

L_{max} measured for a highway-vehicle passby

- Collect the following input information:
 - L_{max} , measured for the highway-vehicle passby
 - S_{meas} , the vehicle speed, in miles per hour
 - D_{meas} , the closest distance between the measurement position and the source, in feet
- Compute the Source Reference Level, SEL_{ref} , using Eq. F-4.

Table F-1 Conversion to Source Reference Levels at 50 ft – Highway and Rail Sources

Measured	Source	Equation	
SEL	Vehicle passby	$SEL_{ref} = SEL_{meas} + 10\log(\frac{S_{meas}}{50}) + 10\log(\frac{D_{meas}}{50}) + C_{consist} + C_{emissions}$	Eq. F-1
L _{max}	Rail-vehicle passby, locomotives only	$SEL_{ref} = L_{Amax} + 10\log(\frac{L_{meas}}{50}) + 10\log(\frac{D_{meas}}{50}) - 10\log(2\alpha) + C_{consist} + C_{emissions} + 3.3$	Eq. F-2
	Rail-vehicle passby, cars only	$SEL_{ref} = L_{Amax} + 10\log(\frac{L_{meas}}{50}) + 10\log(\frac{D_{meas}}{50}) - 10\log[2\alpha + \sin(2\alpha)] + C_{consist} + C_{emissions} + 3.3$	Eq. F-3
	Highway-vehicle passby	$SEL_{ref} = L_{Amax} + 20\log(\frac{D_{meas}}{50}) + C_{emissions} + 3.3$	Eq. F-4
<p> S_{meas} = speed of measured vehicle(s), mph D_{meas} = closest distance between measurement position and source, ft $C_{consist}$ = 0 for buses and automobiles –10log(N_{cars}) for locomotives and rail cars where N is the number of locomotives or rail cars in the measured group $C_{emissions}$ = 0 for $T < 6$ for locomotives –2 (T-5) for $T \geq 6$ where T is average throttle setting of measured diesel – electric locomotive(s) $-30\log(\frac{S_{meas}}{50})$ for rail cars $-25\log(\frac{S_{meas}}{50})$ for buses $-38.1\log(\frac{S_{meas}}{50})$ for automobiles E_{meas} = event duration of measurement, sec L_{meas} = total length of measured group of locomotives or rail cars, ft α = $\arctan(\frac{L_{meas}}{2D_{meas}})$, rad </p>			

Example F-1 Calculate SEL_{ref} – Locomotives

Computation of SEL_{ref} from SEL Measurement of Fixed-guideway Source

SEL was measured for a passby of two diesel-powered locomotives with the following conditions:

$$\begin{aligned} SEL_{meas} &= 90 \text{ dBA} \\ N_{cars} &= 2 \\ T &= 6 \\ S_{meas} &= 55 \text{ mph} \\ D_{meas} &= 65 \text{ ft} \end{aligned}$$

Compute the source reference level using Eq. F-1.

$$\begin{aligned} SEL_{ref} &= SEL_{meas} + 10\log\left(\frac{S_{meas}}{50}\right) + 10\log\left(\frac{D_{meas}}{50}\right) + C_{consist} + C_{emissions} \\ &= 90 + 10\log\left(\frac{55}{50}\right) + 10\log\left(\frac{65}{50}\right) - 10\log(2) + (-2(6 - 5)) \\ &= 86.5 \text{ dBA} \end{aligned}$$

Example F-2 Calculate SEL_{ref} – Rail Cars

Computation of SEL_{ref} from L_{max} Measurement of Fixed-Guideway Source

L_{max} was measured for a passby of a 4-car consist of 70-ft long rail cars with the following conditions:

$$\begin{aligned} L_{max} &= 90 \text{ dBA} \\ N_{cars} &= 4 \\ S_{meas} &= 70 \text{ mph} \\ D_{meas} &= 65 \text{ ft} \\ L_{meas} &= 280 \text{ ft} \\ \alpha &= 1.14 \end{aligned}$$

Compute the source reference level using Eq. F-3.

$$\begin{aligned} SEL_{ref} &= L_{Amax} + 10\log\left(\frac{L_{meas}}{50}\right) + 10\log\left(\frac{D_{meas}}{50}\right) - 10\log[2\alpha + \sin(2\alpha)] + C_{consist} + C_{emissions} + 3.3 \\ &= 90 + 10\log\left(\frac{280}{50}\right) + 10\log\left(\frac{65}{50}\right) - 10\log[2(1.14) + \sin(2(1.14))] - 10\log(4) - 30\log\left(\frac{70}{50}\right) + 3.3 \\ &= 86.7 \text{ dBA} \end{aligned}$$

Example F-3 Calculate SEL_{ref} – Bus

Computation of SEL_{ref} from L_{max} Measurement of Highway Vehicle Source

L_{max} was measured for a bus with the following conditions:

$$\begin{aligned} L_{\max} &= 78 \text{ dBA} \\ D_{\text{meas}} &= 80 \text{ ft} \\ S_{\text{meas}} &= 40 \text{ mph} \end{aligned}$$

Compute the source reference level using Eq. F-4

$$\begin{aligned} SEL_{\text{ref}} &= L_{\max} + 20\log\left(\frac{D_{\text{meas}}}{50}\right) + C_{\text{emissions}} + 3.3 \\ &= 78 + 20\log\left(\frac{80}{50}\right) - 25\log\left(\frac{40}{50}\right) + 3.3 \\ &= 87.8 \text{ dBA} \end{aligned}$$

F.2 Stationary Sources

This section provides information on appropriate conditions for stationary source measurements, instructions on converting measurements made under non-reference conditions to source reference levels, and an example of this type of computation.

The following conditions are required for stationary sources, in addition to good engineering practice:

- Measured source operations must be representative of project operations in all aspects.
- The following ratio must be 2 or less, and the distance to the closest source component must be 200 ft or less.

$$\frac{\text{Distance to the farthest source component}}{\text{Distance to the closest source component}}$$

If both conditions cannot simultaneously be met, separate close-by measurements of individual components of this source must be made, for which these distance conditions can be met.

- The following ratio must be 2 or less:

$$\frac{\text{Lateral length of the source area}}{\text{Distance to the closest source component}}$$

The lateral length of the source area is measured perpendicular to the general line-of-sight between source and measurement positions.

If this condition cannot be met, then make separate close-by measurements of individual components of this source, for which this condition can be met.

- No noise barriers, terrain, buildings, or dense tree zones may break the lines-of-sight between the source and the measurement position.

When close-by source measurements are made under non-reference conditions, use the instructions below and the equation in Table F- 2 to convert the measured values to source reference levels.

SEL was measured for a stationary noise source

- Collect the following input information:
 - SEL_{meas} , the measured SEL for the noise source, for whatever source "event" is convenient to measure
 - E_{meas} , the event duration, in seconds
 - D_{meas} , the closest distance between the measurement position and the source, in feet
- Compute the source reference level, SEL_{ref} using Eq. F- 5.

Table F-2 Conversion to Source Reference Levels at 50 ft - Stationary Sources

Measured	Source	Equation	
SEL	Stationary noise source	$SEL_{ref} = SEL_{meas} - 10\log\left(\frac{E_{meas}}{3600}\right) + 20\log\left(\frac{D_{meas}}{50}\right)$	Eq. F- 5
S_{meas} = speed of measured vehicle(s), in miles per hour E_{meas} = event duration of measurement, in seconds D_{meas} = closest distance between measurement position and source, in feet			

Example F-4 Calculate SEL_{ref} – Signal Crossing

Computation of SEL_{ref} from SEL Measurement of Stationary Source

SEL was measured for a signal crossing with the following conditions:

$SEL_{meas} = 70$ dBA
 $E_{meas} = 10$ sec
 $D_{meas} = 65$ ft

Compute the source reference level using Eq. F-5.

$$\begin{aligned}
 SEL_{ref} &= SEL_{meas} - 10\log\left(\frac{E_{meas}}{3600}\right) + 20\log\left(\frac{D_{meas}}{50}\right) \\
 &= 70 - 10\log\left(\frac{10}{3600}\right) + 20\log\left(\frac{65}{50}\right) \\
 &= 97.8 \text{ dBA}
 \end{aligned}$$

F.3 L_{max} for Single Train Passby

This section provides procedures for the computation of L_{max} for a single train passby. This procedure can be used to characterize trains of mixed consists using L_{max} . Follow the instructions below.

- Collect the following input information:
 - SEL_{ref} , from Section 4.5, specific to both the locomotive type and car type of the train
 - N_{loco} , the number of locomotives in the train
 - N_{cars} , the number of cars in the train
 - L_{loco} , the total length of the train's locomotive(s), in feet (or N_{loco} unit length)
 - L_{cars} , the total length of the train's set of rail car(s), in feet (or N_{cars} unit length)
 - S , the train speed, in miles per hour
 - D , the closest distance between the receiver of interest and the train, in feet
- Use the equations in Table F-3 to compute the following:
 - $L_{max,loco}$ for the locomotive(s) using Eq. F-6

- $L_{\max, \text{cars}}$ for the rail car(s) using the Eq. F-7
- $L_{\max, \text{total}}$, the larger L_{\max} from the locomotives(s) and rail car(s) is the L_{\max} for the total train passby, see Eq. F- 8.

Table F-3 Conversion to L_{\max} at the Receiver, for a Single Train Passby

Source	Equation	
Locomotives	$L_{\max, \text{Loco}} = SEL_{\text{locos}} + 10 \log \left(\frac{S}{50} \right) - 10 \log \left(\frac{L}{50} \right) + 10 \log(2 \alpha) - 3.3$	Eq. F-6
Rail Cars	$L_{\max, \text{Rcars}} = SEL_{\text{Rcars}} + 10 \log \left(\frac{S}{50} \right) - 10 \log \left(\frac{L}{50} \right) + 10 \log(2 \alpha + \sin(2 \alpha)) - 3.3$	Eq. F-7
Total Train	$L_{\max, \text{total}} = \max(L_{\max, \text{Loco}} \text{ or } L_{\max, \text{RCars}})$	Eq. F-8
<p>L = total length of measured group of locomotive(s) or rail car(s), ft</p> <p>S = vehicle speed, mph</p> <p>$\alpha = \arctan \left(\frac{L}{2D} \right)$, rad</p> <p>$D$ = closest distance between receiver and source, ft</p>		

Example F-5 Calculate L_{\max} – Train Passby

Computation of L_{\max} for Train Passby

Calculate the L_{\max} of commuter train at receiver of interest according to the following conditions:

$$\begin{aligned} \text{SEL}_{\text{ref}} &= 92 \text{ dBA for locomotives} \\ &= 82 \text{ dBA for rail cars} \\ N_{\text{Loco}} &= 1 \\ N_{\text{Cars}} &= 6 \\ S &= 43 \text{ miles per hour} \\ D &= 125 \text{ ft} \\ \alpha_{\text{locos}} &= 0.27 \\ \alpha_{\text{cars}} &= 1.03 \end{aligned}$$

The locomotive and rail cars each have a unit length (L) of 70 ft.

Determine the total length of the locomotive and rail cars.

$$\begin{aligned} L_{\text{Loco}} &= 70 \text{ ft} \\ L_{\text{cars}} &= 420 \text{ ft} \end{aligned}$$

Compute L_{\max} for the locomotive using Eq. F-6:

$$\begin{aligned} L_{\max, \text{Loco}} &= \text{SEL}_{\text{Loco}} + 10 \log \left(\frac{S}{50} \right) - 10 \log \left(\frac{L}{50} \right) + 10 \log(2 \alpha) - 3.3 \\ &= 92 + 10 \log \left(\frac{43}{50} \right) - 10 \log \left(\frac{70}{50} \right) + 10 \log(2 \times 0.27) - 3.3 \\ &= 84.0 \text{ dBA} \end{aligned}$$

Compute L_{\max} for the rail cars using Eq. F-7:

$$\begin{aligned} L_{\max, \text{Rcars}} &= \text{SEL}_{\text{Rcars}} + 10 \log \left(\frac{S}{50} \right) - 10 \log \left(\frac{L}{50} \right) + 10 \log(2 \alpha + \sin(2 \alpha)) - 3.3 \\ &= 82 + 10 \log \left(\frac{43}{50} \right) - 10 \log \left(\frac{420}{50} \right) + 10 \log((2 \times 1.03) + \sin(2 \times 1.03)) - 3.3 \\ &= 73.5 \text{ dBA} \end{aligned}$$

Find the total L_{\max} for the train passby using Eq. F-8.

$$\begin{aligned} L_{\max, \text{total}} &= \max(L_{\max, \text{Loco}} \text{ or } L_{\max, \text{Rcars}}) \\ &= 84.0 \text{ dBA} \end{aligned}$$

Appendix G: Non-Standard Modeling Procedures and Methodology

This manual provides guidance for preparing and reviewing the noise and vibration sections of environmental documents, as well as FTA-approved methods and procedures to determine the level of noise and vibration impact resulting from most federally-funded transit projects. Situations may arise, however, that are not explicitly covered in this manual. Professional judgment may be used to extend the basic methods to cover these cases, when appropriate. It is important to note that each project is unique and must be evaluated on a case-by-case basis. This appendix provides procedures for the use of non-standard noise and vibration modeling procedures and methodologies on public transportation projects.

Submittal Procedure – The procedure for using non-standard modeling procedures and methodology is as follows:

1. The transit project manager should contact the FTA Regional office to discuss the proposed methods and/or data not described in this manual prior to use of the non-standard approach.
2. The non-standard methodology should be documented according to the guidelines below as part of the technical report described in Section 8.2.

Examples of Methods that Require Communication and Documentation – The following noise and vibration analysis methods and data require communication with the FTA Regional office and documentation:

- Non-standard transit noise and vibration modeling and analysis methods not described in this manual (including non-standard adjustments, computations, and assumptions). This includes modifications to standard FTA noise and vibration methods.
- Non-standard transit noise and vibration reference data not described in this manual (including measured data, substitution data, data at non-standard reference distances and/or speeds, new transit noise sources, and transit noise sources operating in non-standard conditions).
- Non-standard transit noise and vibration impact criteria not described in this manual, including the maximum sound pressure level metric.
- Non-standard methods of evaluating construction noise, including non-standard construction noise impact criteria.
- Other noise modeling tools besides the FTA Noise Impact Assessment Spreadsheet or Traffic Noise Model (TNM®) for highway noise modeling, such as the development of a finite element method model.
- Any transit noise and vibration analysis that involves an impact area or noise source that is controversial.

Documentation Guidelines – The use of non-standard noise and vibration analysis methods or data requires the following documentation components in a technical memorandum attached to the environmental document:

- **Background**
Briefly describe the transit project for which non-default methods or data are needed. State the dominant noise sources, type of analysis, and the impact criteria. Include any additional relevant information.

- **Statement of Benefit**

Briefly describe the benefit of the non-default noise and vibration methods or data to the transit project. Describe the appropriateness of the non-default methods or data, as well as why the standard method or data are insufficient or problematic.

- **Non-standard Data Description**

Describe the non-standard noise or vibration data in detail. Include source type, manufacturer, reference conditions (speed, distance, and operational conditions), name of data supplier, and a date associated with data development/measurement. For measured noise or vibration data, provide corresponding data documentation (such as a data measurement or a development report). For substitution data, a comparison between the non-standard data and corresponding standard data should be provided. Furthermore, if outside sources recommend the use of the non-standard data (such as a technical society, a standards organization, or a vehicle manufacturer), references for those recommendations should be included.

- **Non-standard Methods Description**

Describe the non-standard noise or vibration analysis method in detail. This should include a detailed description and derivation of the method (including data used in the development of the method), a description of the usage of the method, and a comparison between the non-standard method and the corresponding standard method in the context of the transit analysis. If the method has been validated against measurement data, a description of that validation analysis should be provided. If the method is derived from another source (such as a different transportation noise or vibration method), provide corresponding documentation for that source. A description of how the method is conservative (for example, estimating the worst-case scenario) or some discussion on the probability of exceeding the predicted level should be provided. Furthermore, if outside sources recommend the use of the non-standard method (such as a technical society or standards organization), references for those recommendations should be included.

- **Non-standard Tools Description**

Describe in detail any non-standard noise or vibration models that have not been explicitly recommended in this manual. This should include a detailed description of the tool (including data used, the computations implemented in the tool, any modifications or adjustments to the tool or the corresponding data, and the usage of the tool), a description of the validation of the tool (including reference documentation and validation analyses), and a comparison between the non-standard tool and the equivalent standard tool in the context of the transit analysis. Quantitative comparisons, such as the standard deviation of the non-standard tool and an estimate of the least mean square of differences between the standard and non-standard tools, should be provided and explained. A description of how the method is conservative (for example, estimating the worst-case scenario) or some discussion on the probability of exceeding the predicted level should be provided. If outside sources recommend the use of the non-standard tool (such as a technical society or standards organization), references for those recommendations should be included.

ENDNOTES

- ¹ Regulations for Implementing the Procedural Provisions of the National Environmental Policy Act, Council on Environmental Quality, 40 CFR parts 1500-1508, 1978.
- ² National Environmental Policy Act of 1969, United States Congress, 42 U.S.C §4331, 1969.
- ³ U.S. Department of Transportation, Federal Transit Administration and Federal Highway Administration, "Environmental Impact and Related Procedures," Final Rule, 52 *Federal Register* 32646-32669, January 2014 (23 CFR part 771).
- ⁴ U.S. Department of Transportation, Federal Transit Administration and Federal Highway Administration, "Planning Assistance and Standards." Final Rule, 58 *Federal Register* 58064, June 2014 (23 CFR part 450).
- ⁵ U.S. Environmental Protection Agency, "Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety," Report No. 550/9-74-004, Washington DC, March 1974.
- ⁶ Federal Interagency Committee on Urban Noise, "Guidelines for Considering Noise in Land Use Planning and Control," Environmental Protection Agency, the Department of Transportation, the Department of Housing and Urban Development, the Department of Defense, and the Veterans Administration, Washington DC, June 1980.
- ⁷ U.S. Department of Housing and Urban Development, "Environmental Criteria and Standards of the Department of Housing and Urban Development," Final Rule, 44 *Federal Register* 40861, Washington DC, 12 July 1979 (24 CFR part 51).
- ⁸ American National Standards Institute, "Compatible Land Use With Respect to Noise," Standard S3.23-1980, New York NY, May 1980.
- ⁹ American National Standards Institute, "Quantities and Procedures for Description and Measurement of Environmental Sound," ANSI S12.9-1998/Part 5, New York. NY, January 1998.
- ¹⁰ T. J. Schultz, "Noise Rating Criteria for Elevated Rapid Transit Structures," U.S. Department of Transportation, Report No. UMTA-MA-06-0099-79-3, Washington DC, May 1979.
- ¹¹ T. J. Schultz, "Synthesis of Social Surveys on Noise Annoyance," *Journal of the Acoustical Society of America*, Vol. 63, No. 8, August 1978.
- ¹² S. Fidell, D.S. Barber, 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.
- ¹³ S. Fidel, "The Schultz Curve 25-years Later: A Research Perspective," *Journal of the Acoustical Society of America*, Vol. 114, No. 6, Pt. 1, December 2003.
- ¹⁴ "High-Speed Ground Transportation Noise and Vibration Impact Assessment", DOT/FRA/ORD-12/15, U.S. Department of Transportation Federal Railroad Administration, 2012.
- ¹⁵ National Historic Preservation Act, Section 106; P.L. 89-665, 15 October 1966.
- ¹⁶ The Department of Transportation Act of 1966, Section 4(f); P.L. 89-670, 15 October 1966.
- ¹⁷ U.S. Department of Transportation, Federal Transit Administration and Federal Highway Administration, "Protection of Historic Properties." Final Rule, 65 *Federal Register* 77725, July 2013 (36 CFR 800).

-
- ¹⁸ “Eligibility and Justification Requirements for Noise Insulation Projects,” Program Guidance Letter 12-09, November 2012. https://www.faa.gov/airports/aip/guidance_letters/historical_guidance_letters/media/aip-pgl-2012-09-noise-insulation.pdf.
- ¹⁹ U.S. Department of Housing and Urban Development, “Environmental Criteria and Standards”, Vol. 12, July 1979; amended by 49 *Federal Register* 880, 6 January 1984 (24CFR part 51).
- ²⁰ U.S. Department of Transportation, Federal Aviation Administration, “Federal Aviation Regulations Part 150: Airport Noise Compatibility Planning,” January 1981.
- ²¹ U.S. Department of Transportation, Federal Railroad Administration, “Use of Locomotive Horns at Public Highway-Rail Grade Crossings.” Final Rule, 70 *Federal Register* 21844, October 2013 (49 CFR 222).
- ²² U.S. Department of Transportation, Federal Highway Administration, “FHWA Traffic Noise Model User’s Guide,” Report No. FHWA-PD-96-009, Washington, DC, January 1998. Also, “FHWA Traffic Noise Model User’s Guide (Version 2.5 Addendum),” April 2004.
- ²³ J.C. Ross, C.E. Hanson, R.V. Hartz, “Houston Southeast Corridor Environmental Impact Statement BRT Noise and Vibration Assessment,” technical memorandum prepared by Harris Miller Miller & Hanson for Metropolitan Transit Authority of Harris County Houston, Texas, September 20, 2005.
- ²⁴ U.S. Environmental Protection Agency, “Population Distribution of the United States as a Function of Outdoor Noise Level,” Report No. 550/9-74-009, June 1974.
- ²⁵ T. M. Johnson, “The Importance of Vehicle Throttle Setting Information for Rail Transit Noise Impact Assessments,” *Proc. Inter-Noise 2012*, New York, NY, August 2012.
- ²⁶ U.S. Department of Transportation, Federal Highway Administration, “FHWA Highway Traffic Noise Prediction Model,” FHWA-RD-77-108, December 1978.
- ²⁷ American National Standards Institute, “American National Standard Quantities and Procedures for Description and Measurement of Environmental Sound, Part 4: Noise Assessment and Prediction of Long-term Community Response,” ANSI 12.9-1996, New York, 1996.
- ²⁸ C. Harris, “Handbook of Acoustical Measurements and Noise Control.”
- ²⁹ International Organization for Standardization “Acoustics -- Attenuation of sound during propagation outdoors -- Part 2: General method of calculation.” ISO 9613-2.
- ³⁰ American Society for Testing and Materials, “Standard Guide for Measurement of Outdoor A-weighted Sound Levels,” E 1014-84, Philadelphia, 1984.
- ³¹ American National Standards Institute, “Method for the Measurement of Sound Pressure Levels,” ANSI S1. 13-1971(R1976), New York, 1971.
- ³² U.S. Department of Transportation, Federal Highway Administration, “Measurement of Highway-Related Noise,” FHWA-PD-96-046, May 1996.
- ³³ J.T. Nelson, “Wheel/Rail Noise Control Manual,” Transportation Cooperative Research Report No. 23, Transportation Research Board, Washington, DC, 1997.
- ³⁴ “Challenges in Maintaining Quiet Streetcar and Light Rail Systems,” Session No. 409, Transportation Research Board Annual Meeting, Washington DC, January 2014.

-
- ³⁵ U.S. Department of Transportation, Federal Railroad Administration, "Use of Locomotive Horns at Highway-Rail Grade Crossing," Final Rule, 70 *Federal Register* 21844, April 27, 2005 (49 CFR 222).
- ³⁶ "Interim Final Rule for the Use of Locomotive Horns at Highway-Rail Grade Crossings," Federal Railroad Administration, Final Environmental Impact Statement, December 2003.
- ³⁷ T.A. Busch, R.E. Nugent, "A Reduced-Scale Railway Noise Barrier's Insertion Loss and Absorption Coefficients: Comparison of Field Measurements and Predictions," *Journal of Sound and Vibration*, 749-759, October 2003.
- ³⁸ U.S. Department of Transportation, Federal Highway Administration, "Highway Noise Barrier Design Package," August 2000.
- ³⁹ "High-Speed Ground Transportation Noise and Vibration Impact Assessment," DOT/FRA/ORD-12/15, U.S. Department of Transportation Federal Railroad Administration, 2012.
- ⁴⁰ American National Standards Institute, "Guide to Evaluation of Human Exposure to Vibration in Buildings," ANSI S3.29-1983 (ASA 48-1983).
- ⁴¹ International Organization for Standardization, "Evaluation of Human Exposure to Whole-Body Vibration, Part 2: Continuous and Shock-Induced Vibrations in Buildings (1-80Hz)," ISO-2631-2, 1989.
- ⁴² International Organization for Standardization, "Mechanical Vibration and Shock: Evaluation of Human Exposure to Whole Body Vibration: Part 2 – Vibration in Buildings (1 to 80 Hz)," ISO-2631-2, 2003.
- ⁴³ J. T. Nelson, H. J. Saurenman, "State-of-the-Art Review: Prediction and Control of Ground-borne Noise and Vibration from Rail Transit Trains," U.S. Department of Transportation, Urban Mass Transportation Administration, Report No. UMTA-MA-06-0049-83-4, DOT-TSC-UMTA-83-3, December 1983.
- ⁴⁴ Y. Tokita, "Vibration Pollution Problems in Japan," *Inter-Noise 75*, Sendai, Japan, 1975. (pp. 465-472)
- ⁴⁵ J. A. Zapfe, H. Saurenman, S. Fidell, "Ground-Borne Noise and Vibration in Buildings Caused by Rail Transit," Transportation Research Board, Final Report for TCRP Project D-12, December 2009.
- ⁴⁶ J.T. Nelson, H.J. Saurenman, G.P. Wilson, "Handbook of Urban Rail Noise and Vibration Control," prepared under contract to U.S./DOT Transportation Systems Center, Report No. UMTA-MA-06-0099-82-2, February 1982.
- ⁴⁷ International Organization for Standardization, "Mechanical Vibration – Ground-borne Noise and Vibration Arising from Rail Systems," ISO/FDIS 14837-1:2005.
- ⁴⁸ Institute of Environmental Sciences and Technology, "Considerations in Clean Room Design," RR-CC012. 3, 2015.
- ⁴⁹ U.S. Department of Transportation, Volpe National Transportation Systems Center, "Vibration Characteristics of the Transrapid TR08 Maglev System," Report No. DOT-VNTSC-FRA-02-06, March 2002.
- ⁵⁰ S. McKenna, "A Study of Build Amplification from Ground-Borne Vibration," *Noise-Con 2011*, Portland, Oregon, July 25-27, 2011.
- ⁵¹ American National Standards Institute, "Acoustical Terminology," ANSI S1.1-1994.
- ⁵² J.T. Nelson, H.J. Saurenman, "A Prediction Procedure for Rail Transportation Ground-Borne Noise and Vibration," *Transportation Research Record*, 1143, August 1988.

-
- ⁵³ J. T. Nelson, "Tri-Met Track Vibration Isolation Tests," Final Report for Portland Tri-Met, October 1998.
- ⁵⁴ J.T. Nelson, H.J. Saurenman, "Ground-Borne Vibration Tests with MARTA C-Car," report prepared for Metropolitan Atlanta Rapid Transit Authority, November 16, 1981.
- ⁵⁵ H.J. Saurenman, "Preliminary Results of Ground-Borne Vibration Tests with BRRT/Miami Vehicle," technical memorandum prepared for US DOT/Transportation Systems Center, contract DOT-TSC-1796, 8 February 1983.
- ⁵⁶ H.J. Saurenman, "Ground-borne Vibration Tests with NFTA Prototype Vehicle at the Transportation Test Center," technical memorandum prepared for Transportation Test Center, Project No. P-83-C-01078, 3 August 1983.
- ⁵⁷ H.J. Saurenman, "Noise and Vibration Tests with Portland Tri-Met Prototype Vehicle at the Transportation Test Center," technical memorandum prepared for Transportation Test Center, Project No. P-83-C-02649, 26 March 1984.
- ⁵⁸ R.A. Carman, D.L. Watry, "Measured Vibration Reduction Performance of Ballast Mat Installation for Light Rail Vehicles on Embedded Track," APTA, 1997 Rapid Transit Conference of the APTA, V. 3-Way & Structures and Construction (1997-8).
- ⁵⁹ D.A. Towers, "Evaluation of the Ground-Borne Vibration Reduction Properties of Tire Derived Aggregate Installed on the Denver RTD Light Rail System," Harris Miller Miller and Hanson Inc., 2012.
- ⁶⁰ F. E. Richert, J. R. Hall, *Vibrations of Soils and Foundations*, Prentice-Hall, Inc., Englewood Cliffs, NJ, 1970.
- ⁶¹ U.S. Environmental Protection Agency, "Noise from Construction Equipment and Operations, Building Equipment and Home Appliances," NTID300.1, 31 December 1971.
- ⁶² Society of Automotive Engineers, "Exterior Sound Level Measurement Procedure for Powered Mobile Construction Equipment," SAE Recommended Practice J88a, 1976.
- ⁶³ Society of Automotive Engineers, "Sound Levels for Engine Powered Equipment," SAE Standard J952b, 1976.
- ⁶⁴ U.S. Department of Transportation, Federal Highway Administration, "FHWA Roadway Construction Noise Model User's Guide," FHWA-HEP-05-054, January 2006. Available at http://www.fhwa.dot.gov/environment/noise/construction_noise/rcnm/.
- ⁶⁵ E. Thalheimer, "Construction noise control program and mitigation strategy at the Central Artery/Tunnel Project," Noise Control Eng. J. 48(5), September–October 2000, 157-165).
- ⁶⁶ U.S. Department of Transportation, Federal Highway Administration. "Highway Construction Noise Handbook," FHWA-HEP-06-015, August 2006.
- ⁶⁷ D.J. Martin, "Ground Vibrations from Impact Pile Driving during Road Construction," Supplementary Report 544, United Kingdom Department of the Environment, Department of Transport, Transport and Road Research Laboratory, 1980.
- ⁶⁸ J.F. Wiss, "Vibrations during Construction Operations," *Journal of Construction Division, Proc. American Society of Civil Engineers*, 100, No. CO3, 239-246, September 1974.
- ⁶⁹ J.F. Wiss, "Damage Effects of Pile Driving Vibrations," *Highway Research Record*, No. 155, Highway Research Board, 1967.

-
- ⁷⁰ D.A. Towers, "Ground-borne Vibration from Slurry Wall Trench Excavation for the Central Artery/Tunnel Project Using Hydromill Technology," *Proc. InterNoise 95*, Newport Beach, CA, July 1995.
- ⁷¹ Swiss Consultants for Road Construction Association, "Effects of Vibration on Construction," VSS-SN640-312a, Zurich, Switzerland, April 1992.
- ⁷² American Public Transportation Association, *Public Transportation Factbook*, 55th Edition, March 2004.
- ⁷³ American National Standards Institute, "Preferred Frequencies, Frequency Levels and Band Numbers for Acoustical Measurements," ANSI S1.6-1984 (R2006).
- ⁷⁴ 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 No. 550/9-74-004, March 1974.
- ⁷⁵ 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.
- ⁷⁶ American Public Transit Association, "Noise and Vibration," 1981 Guidelines for Design of Rapid Transit Facilities, Section 2.7, 1981.
- ⁷⁷ T.J. Schultz, "Synthesis of Social Surveys on Noise Annoyance," *Journal of the Acoustical Society of America*, Vol. 64, No. 2, August 1978, 377-405.



U.S. Department of Transportation
Federal Transit Administration

U.S. Department of Transportation
Federal Transit Administration
East Building
1200 New Jersey Avenue, SE
Washington, DC 20590
<https://www.transit.dot.gov/about/research-innovation>

Exhibit 2



NTID300.1

**NOISE FROM CONSTRUCTION EQUIPMENT AND
OPERATIONS, BUILDING EQUIPMENT,
AND HOME APPLIANCES**

DECEMBER 31, 1971

U.S. Environmental Protection Agency
Washington, D.C. 20460

**NOISE FROM CONSTRUCTION EQUIPMENT AND
OPERATIONS, BUILDING EQUIPMENT,
AND HOME APPLIANCES**

DECEMBER 31, 1971

Prepared by

**BOLT, BERANEK AND NEWMAN
under
CONTRACT 68-04-0047**

for the

**U.S. Environmental Protection Agency
Office of Noise Abatement and Control
Washington, D.C. 20460**

This report has been approved for general availability. The contents of this report reflect the views of the contractor, who is responsible for the facts and the accuracy of the data presented herein, and do not necessarily reflect the official views or policy of EPA. This report does not constitute a standard, specification, or regulation.

TABLE OF CONTENTS

	<u>page</u>
PREFACE	iii
ACKNOWLEDGEMENTS	v
LIST OF FIGURES	x
LIST OF TABLES	xiii
SECTION 1. INTRODUCTION	1
1.1 Source Characterization	2
1.2 Impact Evaluation	3
1.3 Industry Assessment	5
SECTION 2. SOURCE CHARACTERIZATION	7
2.1 Construction Equipment and Operation	7
2.2 Home Appliances	27
2.3 Building Equipment	53
SECTION 3. IMPACT	62
3.1 Noise Level Criteria for Impact Evaluation	62
3.2 Construction Noise	70
3.3 Appliances	94
3.4 Projections of Construction and Appliance Noise to the Year 2000	119
SECTION 4. INDUSTRY EFFORTS	130
4.1 Introduction	130
4.2 Construction Industry Efforts	132
4.3 Building Equipment and Appliance Industry Efforts	144

TABLE OF CONTENTS *(Continued)*

	<u>page</u>
SECTION 5. CONCLUSIONS AND RECOMMENDATIONS	163
5.1 Conclusions	163
5.2 Recommendations	170
5.3 Economic Impact Studies	178
5.4 A Program of Public Support Development ..	180
5.5 Social Impact	182
REFERENCES	185
 APPENDIX A. DETAILED SOURCE CHARACTERIZATION	 A-1
A.1 Construction Equipment	A-1
A.2 Appliances	A-9
A.3 Typical Equipment in Buildings	A-22
REFERENCES	A-38
 APPENDIX B. IMPACT CONSIDERATIONS	 B-1
B.1 Interpretation of Impact Estimates	B-1
B.2 Discussion of Construction Data	B-3
B.3 Estimating the Extent of Public Works Construction Noise	B-6
B.4 Propagation Loss Model for Building Construction Sites in Metropolitan Areas	B-8
 APPENDIX C. SOUND LEVEL CONSIDERATIONS	 C-1
Noise - The Problem Stated	C-1
The Concern for Noise	C-2
What Are Manufacturers Doing About Noise?	C-4
The Complex Answers	C-5
Quieting Current Products	C-7

TABLE OF CONTENTS *(Continued)*

	<u>page</u>
Future Machine Quietness	C-7
Noise Standards and Regulations	C-8
APPENDIX D. NOISE CONTROL: REGULATION AND STANDARDS	D-1
D.1. Introduction	D-1
D.2. Construction Equipment	D-2
D.3. Noise Standards for Indoor and Outdoor Equipment for Home and Office Use	D-10

LIST OF FIGURES

	page
Figure 1. Construction Equipment Noise Ranges	11
2. Provisional Criteria Relating NPL to Community Noise Acceptability	17
3. A Summary of Noise Levels for Appliances Measured at a Distance of 3 ft	31
4. Sound Pressure Levels of Various Refrigerators (Measured at 3 ft)	32
5. Schematic View of a Typical Room Air Conditioner	36
6. Sound Pressure Levels From Air Conditioner on High Cool and High Fan Settings (Measured at 3 ft)	38
7. Sound Pressure Levels From Air Conditioner on Two Settings (Measured at 3 ft)	40
8. Graphic Level Recording and Octave Band Sound Pressure Levels of a Dishwasher	42
9. Sound Pressure Levels of Various Automatic Dishwashers During Wash Cycle (Measured at 3 ft)	43
10. Sound Pressure Levels From Four Food-Waste Disposers (Measured at 3 ft)	46
11. Sound Pressure Levels of Canister Vacuum Cleaners Operating on Wood or Tile Floors (Measured at 3 ft)	48
12. Sound Pressure Levels of Two Upright Vacuum Cleaners (Measured at 3 ft)	49
13. Time History of the Sound Pressure Level in the 250 Hz Octave Band for a Tank Water Closet	51

LIST OF FIGURES (Continued)

	page
Figure 14. Time History of Sound Pressure Level in 250 Hz Octave Band for a Flush Valve Water Closet	52
15. Range of Peak Octave Band Sound Pressure Levels in Rooms with Tank Type Water Closets.	54
16. Range of Peak Octave Band Sound Pressure Levels in Rooms with Flush Valve Water Closets	55
17. Range of Sound Levels in dB(A) Typical for Building Equipment at 3 ft	57
18. Cross-Section of a Typical Multistory Building Showing Building Equipment	59
19. Range of Building Equipment Noise Levels to Which People are Exposed	60
20. Construction Site Geometry and Attenuation Contours for a Stationary Population within Buildings	79
21. Percent of Households with Selected Noise-Producing Appliances and Tools	97
22. Estimated Percent Distribution of Major Appliances by Income Level	98
23. Noise Profiles From Appliance for Typical Households Per Week (at 3 ft)	105
24. Number of Building Construction Sites Projected to the Year 2000	123
25. Projected Change in Exposure to Construction Noise, Assuming No Change in Noise Levels ...	126
26. Projected Change in Exposure to Appliance Noise, Assuming No Change in Noise Levels ...	128
27. Cost of Noise Control vs Noise Reduction	172

LIST OF FIGURES (Continued)

		page
Figure A-1 through A-61.	Sound Pressure Levels for Various Appliances and Items of Construction Equipment..	A-39 thru A-99
B-1.	Linear and Area Distribution of Population in Municipalities (Based on Massachusetts and Pennsylvania Data)	B-11

LIST OF TABLES

	page
Table I-a. Typical Ranges of Noise Levels at Construction Sites With A 50 dB(A) Ambient Typical of Suburban Residential Areas	19
I-b. Typical Ranges of Noise Levels at Construction Sites With A 70 dB(A) Ambient Typical of Urban Areas	20
II. Noisiest Equipment Types Operating at Construction Sites	22
III. Noise Pollution Levels in dB(A) of Construction Sites, Various Equipment Quieting Strategies	24
IV. Immediate Abatement Potential of Construction Equipment	26
V. Noise Control for Construction Equipment ...	28
VI. Sources of Appliance Noise	34
VII. Exposure of Building Occupants to the Noise of Building Equipment	58
VIII. Estimates of Magnitudes of Noise Effects ...	63
IX. Metropolitan Regions Considered in Construction Noise Exposure Estimate; Statistics as of 1970	72
X. Annual Construction Activity - 1970	74
XI. Geographical Distribution of Working-Day Populations	76
XII. Number of People Per Day Passing A Construction Site	77
XIII. Level of Annual Construction Activity	78

LIST OF TABLES (Continued)

page

Table	XIV.	Distribution of Stationary Observers Relative to Attenuation Contours	80
	XV.	Average and Peak Exposure Levels to Construction Noise	82
	XVI.	Estimated Annual Passings of Construction Sites - All Metropolitan Regions	84
	XVII.	Order of Magnitude Estimates of Yearly Duration of Construction Noise Exposure	86
	XVIII.	Order-of-Magnitude Estimates of Construction Noise Exposure in Millions of Person-Hours Per Week	92
	XIX.	Order-of-Magnitude Estimates of Impact of Primary and Secondary Exposure to Construction Noise Expressed in Millions of Person-Hours Per Week	93
	XX.	Noncontrollable Household Noise Sources	95
	XXI.	Average Hours Per Day Spent on Household Work By 1296 Homemakers, According to Number of Children and Age of Youngest Child, Syracuse, New York Area, 1967-68	102
	XXII.	Appliance Usage Source Data	103
	XXIII.	Use of Noncontrollable Noise-Producing Appliances and Tools in Typical Households .	104
	XXIV.	Number of Individuals Exposed to Indicated Appliances	107
	XXV.	Estimated Number of Individuals Exposed to Domestic Appliance Noise	108
	XXVI.	Sound Pressure Levels of Home Appliances and Building Equipment Adjusted for Location of Exposure	109

LIST OF TABLES (Continued)

	page
Table XXVII. Order-of-Magnitude Estimates of the Extent and Duration of Exposure to Building Equipment and Home Appliances	110
XXVIII. Order-of-Magnitude Estimates of Exposure to Home Appliance and Building Equipment Noise Expressed in Millions of Person-Hours Per Week	120
A-1. Use of Equipment at Construction Sites	A-4
A-2. Usage Factors of Equipment in Domestic Housing Construction	A-5

1. INTRODUCTION

As a society evolves technologically, the sources of noise grow in number and kind. Noise levels increase and the effects of noise on society become increasingly severe. Concomitantly, society continually requires more machinery, operating at higher speeds with greater power output. Aircraft, for example, have continued to grow in number and noise level, creating almost intolerable conditions for populations living, working, and playing in the vicinity of airports. Trucks and construction equipment require increasingly powerful engines to enable a single operator to move more goods, materials, or earth faster and more economically. The thunder of these engines not only degrades the quality of life in our communities but also causes the operators to incur substantial levels of permanent hearing loss. A profusion of appliances that provide the energy needed to do everything from brushing our teeth and cooling our houses, to washing our dishes, disposing of our garbage, and cutting our grass often generate noise levels that interfere with conversation and disturb neighbors. Even the wilderness, once a refuge from hectic urban life, is now disturbed by the noise of trail bikes, all-terrain vehicles, and snowmobiles.

Given that noise is a serious environmental problem, some appropriate questions one might ask in seeking a comprehensive noise-control objective are: Precisely what are the sources of noise pollution? How many people are exposed to these sources and how are they affected? What can be done to control the noise output of offending sources? This report attempts to answer these questions for the specific categories of construction, home appliances, and building equipment.

1.1 Source Characterization

The two principal objectives in characterizing sources are (1) evaluating noise levels in quantitative terms that may be used to determine the impact on people and (2) obtaining the information needed to assess the noise reduction that can be achieved. Relating measurable aspects of sound to human response is difficult at best. Such impact criteria as speech interference, sleep interruption, and annoyance depend not only on the physical nature of sound such as level, spectral content, and degree of fluctuation but also on the nonphysical aspects of noise such as the information content or implications of the sound. A rattling piece of equipment is often annoying not because of the noise level but primarily because it indicates a malfunction requiring attention.

Several attempts have been made to include various aspects of noise in a single number related to annoyance. Most of these methods try to account for the unequal sensitivity of the human hearing mechanisms to different frequencies and some try to account for fluctuations of level with time. A single number which accounts rather well for the human ear's relative insensitivity to low and very high frequency sound is the A-weighted scale. This weighting has been found to correlate about as well with annoyance as other indices [1]; it is quite widely accepted and can be read on a meter. In this report, we use A-weighting [dB(A)] to characterize noise insofar as impact evaluations are concerned.

Noise spectra are of far more use than single number ratings for assessing the contribution from various components to total noise levels. Pure tones associated with integer multiples of speeds of rotating machinery often appear as identifiable spectral peaks. Exhaust noise from an internal combustion engine

typically contributes the dominant low-frequency component, whereas engine structural radiation and turbocharger whine usually generate the high-frequency levels. Hence, where possible, we provide noise spectra in octave or one-third octave bands.

Once sources have been characterized, we evaluate the abatement potential associated with each. Our evaluation is based on a somewhat broad analysis of the component contributions and to a great extent on judgment developed from experience with similar sources. For example, prior work with internal combustion engines enables us to estimate the benefit achievable from state-of-the-art mufflers or engine enclosures. We estimate our predictions of achievable abatement potential to be within ± 5 dB. A more accurate prediction of noise reduction would require detailed diagnosis of contributions from each source component and implementation of experimental noise-control treatment.

Because of the large number of sources evaluated (see Sec. 2), we place much detailed information (e.g., a number of noise spectra for sources whose impact is small) in Appendix A. Included in Appendix B is the background to the development of impact criteria and in Appendix D a discussion of existing standards.

1.2 Impact Evaluation

We evaluate the impact of noise on people, using two principal measures: intensity and extent. Clearly, it is important to know the levels to which a person may be exposed and the effects of this exposure. Thus, once the sources have been characterized and the relation of a listener to the source has been postulated, we estimate the physiological, psychological, and sociological effects of the noise. For example, permanent hearing damage is likely to occur for a significant percentage of the population

exposed to levels of 90 dB(A) for eight hours a day over an extended period of time. If the exposure time is short (e.g., 15 minutes a day), the noise may or may not contribute to hearing damage, but during exposure one cannot conduct an intelligible conversation. Exposure during evening hours to levels of noise that exceed approximately 70 dB(A) will usually lengthen the time one requires to go to sleep or will awaken someone who is already asleep -- especially if the noise is intermittent and the background level is low.

The extent of noise impact is as important as the intensity in assessing the magnitude of noise pollution since this measure gives some perspective to the contribution from various sources. A truly comprehensive assessment would involve a detailed social survey with extensive noise measurements and statistically significant samples from every stratum of society. Such a program would no doubt consume millions of dollars and several calendar years. Clearly, this approach is not feasible in the three-month time period available for this study, nor would it represent an entirely justifiable allocation of resources. The goal of determining the impact of noise can be viewed only as an intermediate step to solving the actual problem: reducing the noise exposure of our population. Hence, an order-of-magnitude assessment of impact is probably an adequate guide to the development of a noise-abatement program. What matters, for example, is that approximately six million workers on night shifts and children under four cannot sleep because of construction noise. One's approach to construction-noise abatement would probably not be different if the figure were two million or ten million. We therefore provide this impact evaluation, not by social survey, but by estimating (1) the noise levels to which people are exposed, (2) the effects of noise on these people, and (3) the number of people

exposed. These estimates are based on measured values of equipment noise, data on human response to noise, statistics of equipment utilization, and statistics of population distributions. The impact of construction, appliances, and building equipment is discussed in Sec. 3.

1.3 Industry Assessment

To bring about control of environmental noise, the EPA must have information not only about the technology of abatement but also about the nature of the industry it may be called upon to influence. An understanding of the pressures for and against noise control is helpful in assessing the extent to which an industry is likely to institute noise control measures on its own and how the industry will be affected if it is compelled to produce quieter products. For example, the principal impact of construction noise, other than hearing-damage risk to operators (who have been amazingly casual about their plight), is on the community rather than the purchaser. The community has been able to exert very little influence on the purchaser or the manufacturer, the result being that very little has been accomplished in quieting construction equipment. For example, diesel-powered equipment is sometimes advertised and sold without even mufflers. A small number of companies, however, have begun to produce quiet equipment; they attribute their recent success in the marketplace to certain local noise legislation and to the threat of such regulations spreading to other communities.

An example of the effects that noise regulations may have on business comes from the home appliance industry. An air-conditioner manufacturer has indicated that certain marketplace pressures inhibit him from implementing additional noise control in bottom-of-the-line items. He argues that more noise control

would increase the price of an item, thereby harming his competitive position. If all manufacturers were required to make their products quieter (and therefore more costly), one could argue that a segment of the population at lower income levels could no longer afford air-conditioners and would be deprived of that comfort.

By interviewing manufacturers of construction equipment, home appliances, and building equipment, we obtained their views of the relevance of noise control to their business. We found a substantial difference between the attitudes of people who manufacture construction equipment and those who manufacture appliances. The former, who find practically no marketplace demand for quiet equipment, are faced with the prospect of a mélange of state and city ordinances; they almost welcome "reasonable" federal standards. The latter find an increasing marketplace demand for quiet appliances and prefer not to see the implementation of federal standards or labeling requirements. Chapter 4 of this report contains an analysis of the pressures on industry to reduce (or not to reduce) noise levels, its response to these pressures, its present achievements, and its potential.

2. SOURCE CHARACTERIZATION

2.1 Construction Equipment and Operation

Construction has become a major noise problem in many cities and towns. The trend toward urban renewal and more high-rise structures has created an almost perpetual din on city streets. Equipment associated with construction projects is more numerous, and the time span for construction at a given site has lengthened. Residents very near a construction site may well plan on two years of intolerable noise levels as a high-rise structure is being built.

In this section, we consider the construction noise problem as it relates to residential and nonresidential buildings, city streets, and public works, because these kinds of project usually take place in areas where the number of people likely to be exposed is very high. Heavy construction, such as highways and civil works, has been omitted from our study because the vast bulk of this activity occurs in thinly populated areas where the noise affects very few people. We view construction as a process that can be categorized according to type and that consists of separate and distinct phases.

2.1.1 The construction process

The basic unit of construction activity is the construction site, which exists in both space and time. The temporal dimension consists of various sequential phases which change the character of the site's noise output as work progresses. These phases are discussed further below. In the case of building construction, the spatial character of the site is self-evident; in the case of sewers and roads, the extent of a site is taken, for reasons explained in Sec. 3.2, to be one standard city block or

about 1/8 of a mile. (That is, if a city reports 40 miles of sewer construction, we consider that project as consisting of 320 separate sites.)

Construction sites are typically classified in the fifteen categories in which construction data is reported by the U.S. Bureau of Census and various state and municipal bodies. The categories are:

- Residential buildings:
 - one- to four-family
 - Five-family and larger
- Nonresidential buildings:
 - Office, bank, professional
 - Hotel, motel, etc.
 - Hospitals and other institutions
 - Schools
 - Public works buildings
 - Industrial
 - Parking garages
 - Religious
 - Recreational
 - Store, mercantile
 - Service, repair station
- Municipal streets
- Public works (e.g., sewers, water mains).

For purposes of allocating construction effort among the different types of sites, it is possible to group the nonresidential sites into four larger categories which are differentiated by the cost of the average building in each category, as well as by the distribution of effort among the various construction

phases. These four groups, in order of decreasing average cost per building, are:

- Office buildings, hospitals, hotels
- Schools, public works buildings
- Industrial buildings, parking garages
- Stores, service stations, recreational buildings, and religious buildings.

Construction is carried out in several reasonably discrete steps, each of which has its own mix of equipment and consequently its own noise characteristics. The phases (some of which can be subdivided) are:

- *Building Construction*
 1. a. Clearing
 - b. Demolition
 - c. Site preparation
 2. Excavation
 3. Placing foundations
 4. a. Frame erection
 - b. Floors and roof
 - c. Skin and windows
 5. a. Finishing
 - b. Cleanup
- *City Streets*
 1. Clearing
 2. Removing old roadbed
 3. Reconditioning old roadbed
 4. Laying new subbase, paving
 5. Finishing and cleanup

- *Public Works*

1. Clearing
2. Excavation
3. Compacting trench floor
4. Pipe installation, filling trench
5. Finishing and cleanup.

Defining the construction phases as above allows us to account for the variation in site noise output with time. By inventorying the equipment which is to be found at each site in each phase, we can derive a representative source level for each phase by the process described below.

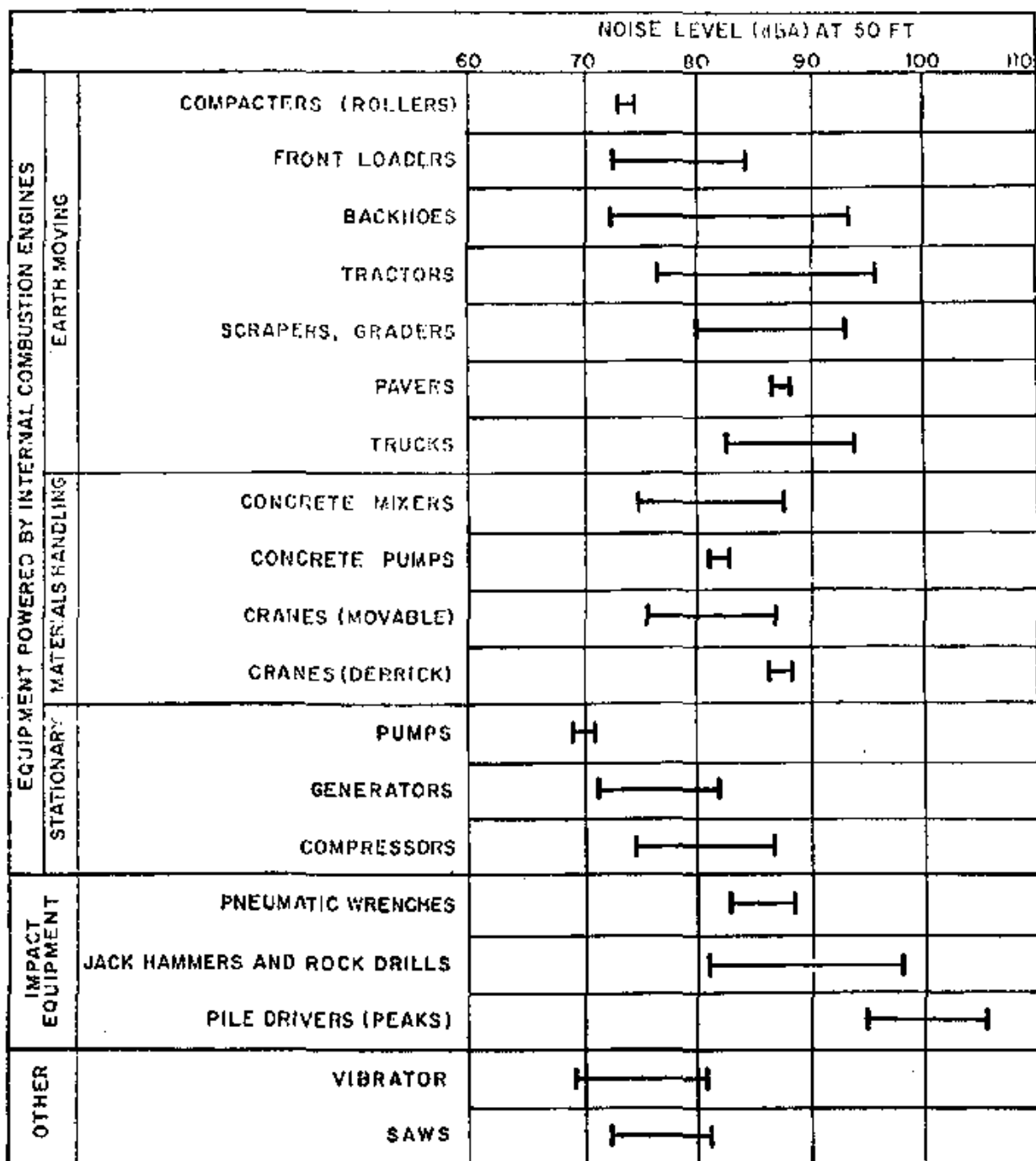
2.1.2 Equipment noise characteristics

Despite the variety in type and size of construction equipment, similarities in the dominant noise sources and in patterns of operation permit one to assign all equipment to a very limited number of categories. These categories are described below and are indicated in Fig. 1, together with corresponding noise level data. Corresponding spectra and the sources of this data are given in Appendix A.

Equipment Powered by Internal Combustion Engines

The most prevalent noise source in construction equipment is the prime mover, i.e., the internal combustion engine (usually of the diesel type) used to provide motive and/or operating power. Engine-powered equipment may be categorized according to its mobility and operating characteristics, as (1) earthmoving equipment (highly mobile), (2) handling equipment (partly mobile), and (3) stationary equipment.

Earthmoving equipment includes excavating machinery (backhoes, bulldozers, shovels, front loaders, etc.) and highway



Note: Based on Limited Available Data Samples

FIG. 1. CONSTRUCTION EQUIPMENT NOISE RANGES.

building equipment (compactors, scrapers, graders, pavers, etc.). Internal combustion engines are used for propulsion (either on wheels or tracks) and for powering working mechanisms (buckets, arms, trenchers, etc.). Engine power varies from about 50 hp to over 600 hp. Engine noise typically predominates, with exhaust noise usually being most significant and with inlet noise and structural noise being of secondary importance. Other sources of noise in this equipment include the mechanical and hydraulic transmission and actuation systems, and cooling fans (often very significant). Typical operating cycles may involve one or two minutes of full-power operation, followed by three or four minutes at lower power.

Noise levels at 50 ft from earthmoving equipment range from about 73 to 96 dB(A). The greatest and most direct potential for noise abatement here lies in quieting the engine by use of improved mufflers.

Engine-powered materials-handling equipment such as cranes, derricks, concrete mixers, and concrete pumps, is used in a more-or-less fixed location; mobility of this equipment over the ground is not part of its major work cycle. Although noise from the working process (such as the clanking of aggregate in the concrete mixing bin) often is the most "identifiable" noise component, the dominant source of noise generally is the prime mover. Noise levels at 50 ft range from about 75 to 90 dB(A). The greatest potential abatement for noise again lies in engine quieting, with treatment of power transmission and working mechanisms being of secondary importance.

Stationary equipment, such as pumps, electric power generators and air compressors, generally runs continuously at relatively constant power and speed. Noise levels at 50 ft range

from about 70 to 80 dB(A), with pumps typically at the low end of this range. Stationary equipment, because of its fixed location and constant speed and/or load operation, may be quieted more easily than mobile equipment; engine mufflers can be more effective, and use of enclosures becomes feasible. [In fact, noise from some air compressors, has already been reduced by about 10 dB(A) by use of appropriate enclosures.]

The greatest near-term abatement potential for all current equipment powered by internal combustion engines lies in the use of better exhaust mufflers, intake silencers, and engine enclosures (in conjunction with appropriate cooling system and fan design). Reductions of 5 to 10 dB(A) appear to be achievable, usually without great difficulty. Practical long-term abatement [of about 15 to 20 dB(A)] can probably be achieved by basic engine design changes. Of course, replacement of the internal combustion engine by a quieter prime mover, such as a gas turbine or electric motor, would eliminate the reciprocating-engine noise source altogether.

Impact Equipment and Tools

Conventional pile drivers are either steam-powered or diesel-powered; in both types, the impact of the hammer dropping onto the pile is the dominant noise component. With steam drivers, noise is also generated by the power supply (a boiler) and the release of steam at the head; with diesel drivers, noise is also generated by the combustion explosion that actuates the hammer. Noise levels are difficult to measure or standardize, because they are affected by pile type and length, but peak levels tend to be about 100 dB(A) (or higher) at 50 ft.

Impact-noise is absent in the so-called "sonic" (or vibratory) pile drivers. These do not use a drop hammer, but vibrate the pile at resonance. The noise associated with pile vibrations typically occurs around 150 Hz and is barely audible. The power source, which generally consists of two gasoline engines, is the primary noise source.

Abatement can be accomplished best by substituting use of a sonic pile driver for an impact machine where possible. (Unfortunately, sonic pile drivers are useful only for some soils.) Impact noise reduction at the source generally is very difficult. Substitution of nonimpact tools offers the best practical abatement potential; otherwise, reductions of perhaps 5 dB(A) may be obtained by use of enclosures.

Most impact tools, such as jack hammers, pavement breakers, and rock drills are pneumatically powered, but there are also hydraulic and electric models. The dominant sources of noise in pneumatic tools are the high-pressure exhaust and the impact of the tool bit against the work. Noise levels at 50 ft typically range from 80 to 97 dB(A).

An exhaust muffler on the compressed air exhaust can lower noise levels from the exhaust by up to about 10 dB(A). Pneumatic exhaust noise, of course, is absent in hydraulic or electric impact tools. Reduction of the impact noise from within a tool can be accomplished by means of an external jacket, which can contribute perhaps a 5 dB(A) reduction. Reduction of the noise due to impact between the tool and material being worked upon generally is difficult and requires acoustic barriers enclosing the work area and its immediate vicinity. Depending on the impacted structures, such barriers may reduce noise by 3 to 10 dB(A).

Small hand-held pneumatic tools, such as pneumatic wrenches, generate noise of levels between 84 and 88 dB(A) at 50 ft. The exhaust and the impact are the dominant noise sources. Because of the obvious weight and size limitations to which hand tools are subject, only small and light mufflers can be used with them, limiting the achievable noise reduction to 5 dB(A) at best. The best practical means for reducing the noise from impact tools consists of using other types of tools to accomplish the same functions.

2.1.3 Site noise characteristics

To characterize the noisiness - i.e., the average noise annoyance potential - of the various types of construction sites during each phase of construction, a Noise Pollution Level (NPL) was calculated for each type of site and each construction phase. The NPL used here was taken as the same measure that was used for similar evaluation of traffic noise [2]. The NPL (in dB) is defined as the sum of the A-weighted average sound pressure level and 2.56 times the standard deviation of the A-weighted sound pressure level*; thus, NPL accounts for the effect of steady noise, plus the annoyance due to fluctuations.

Although a thorough study relating NPL to subjective descriptors of annoyance (e.g., acceptable, unacceptable) has not been accomplished, a provisional interpretation of NPL in such terms can be suggested. On the basis of an evaluation of domestic and

*A-weighting refers to a standard weighting of the various frequency components, approximating the behavior of human hearing. The average sound pressure level is computed on the basis of the time-average root-mean-square sound pressure, whereas the standard deviation is calculated from the time-variation of the dB(A) values.

foreign social surveys and psycho-acoustic studies, the Department of Housing and Urban Development has adopted a set of "guideline criteria" [3] for outdoor noise levels in residential areas as shown in Fig. 2 [4]. According to this chart, the community noise situation is evaluated by comparing a measured distribution of A-weighted levels with the criteria curves. The situation is categorized by the region of least desirability penetrated by the actual noise distribution. Since this criterion is based on level distributions, the boundaries between regions of acceptability may be defined in terms of the NPL. Thus, the following descriptors of NPL values may be used in interpreting the site noise NPL levels used in the remainder of this report.

Clearly Acceptable: The noise exposure is such that both the indoor and outdoor environments are pleasant.

NPL less than 62 dB

Normally Acceptable: The noise exposure is great enough to be of some concern but common building constructions will make the indoor environment acceptable, even for sleeping quarters, and the outdoor environment will be reasonably pleasant for recreation and play.

NPL between 62 and
74 dB

Normally Unacceptable: The noise exposure is significantly more severe so that unusual and costly building constructions are necessary to ensure some tranquility indoors, and barriers must be erected between the site and prominent noise sources to make the outdoor environment tolerable.

NPL between 74 and
88 dB

Clearly Unacceptable: The noise exposure at the site is so severe that the construction costs to make the indoor environment acceptable would be prohibitive and the outdoor environment would still be intolerable.

NPL greater than
88 dB

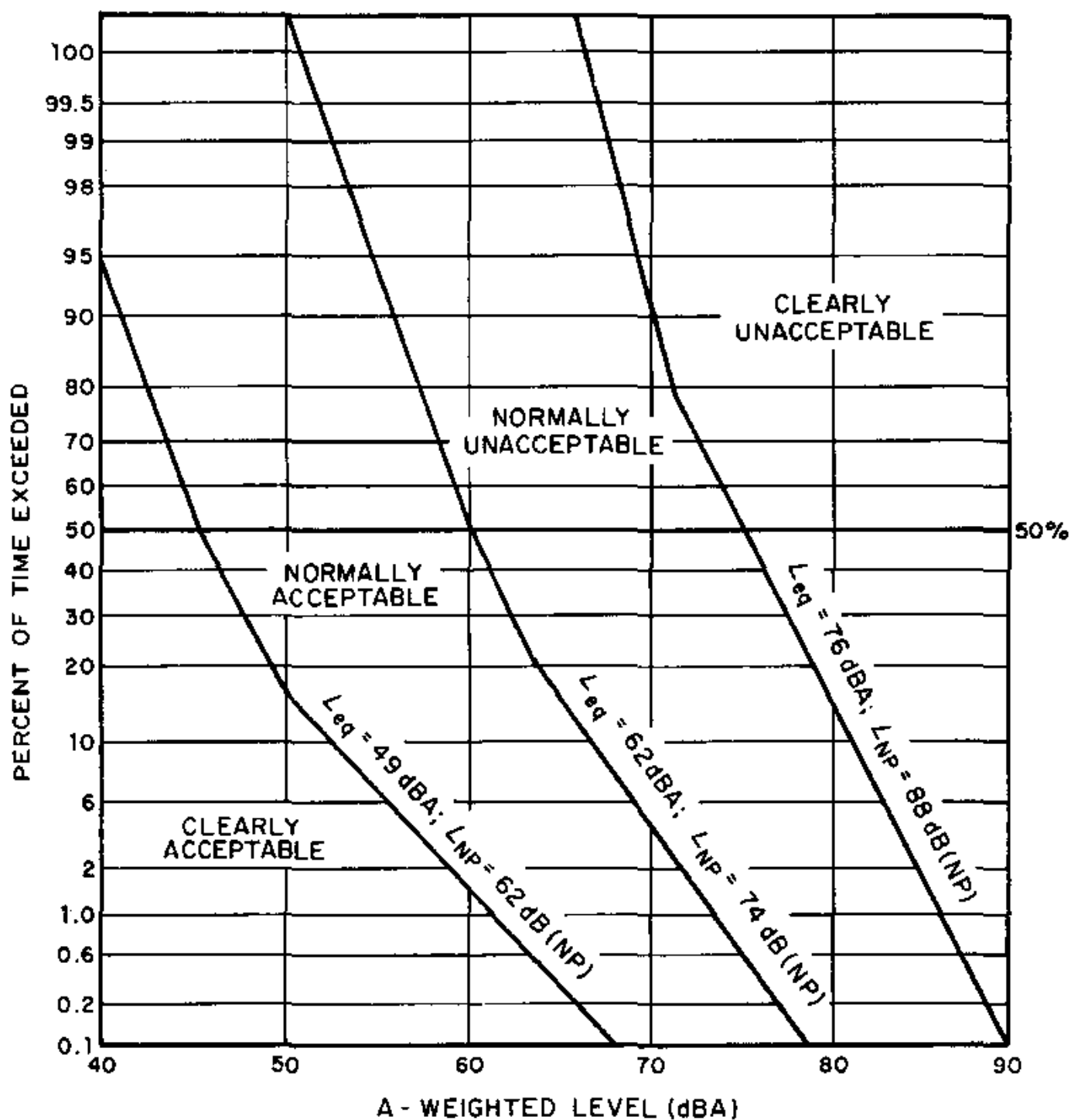


FIG. 2 PROVISIONAL CRITERIA RELATING NPL TO COMMUNITY NOISE ACCEPTABILITY

We must emphasize that these criteria have not been officially or unofficially adopted by HUD or any other government agency. They are presented here solely to enable the reader to interpret NPL values computed in this report.

The aforementioned averages of noise annoyance potential were calculated on the basis of information obtained on (1) the number of each item of equipment typically present at a site (in a given phase), (2) the length of the duty cycles of this equipment, and (3) the average noise levels during operation. For purposes of site characterization, the noisiest piece of equipment was assumed to be located at 50 ft from an observer, and all other equipment was assumed to be located at 200 ft from the observer; ambient noise, of levels depending on the surroundings of the site, was taken to be present in addition to the equipment noise. (Note that pile driver noise was not included in the NPL calculations, because its repetitive impact character makes its intrusion characteristics different from the more continuous noises for which the NPL concept was developed.) Clearly, this construction noise model is not entirely realistic; however, it may be expected to fulfill its intended purposes - that of yielding at least a relative measure of the noise annoyance associated with each type of site and phase for the most adverse conditions likely to be associated with each phase.

Table I shows NPLs calculated for each of five phases for each of four types of construction. For residential housing and public works construction, two NPL values are given in the table; one pertains to a noisy [70 dB(A)] background characteristic of urban conditions, the other to relatively quiet [50 dB(A)] ambient conditions found in suburban environments. As one may expect, the values indicated in the table reflect the fact that a given intruding noise is more annoying if it occurs in a quieter environment.

TABLE I-a. TYPICAL RANGES OF NOISE LEVELS AT CONSTRUCTION SITES WITH A
50 dB(A) AMBIENT TYPICAL OF SUBURBAN RESIDENTIAL AREAS

	Domestic Housing		Office Building, Hotel, Hospital School, Public Works		Industrial Parking Garage, Religious, Amusement & Recreations, Store, Service Station		Public Works Roads & Highways, Sewers, and Trenches		
	I	II	I	II	I	II	I	II	
Ground Clearing	83 8 103	83 15 122	84 7 101	84 16 123	84 9 106	83 16 124	84 8 103	84 8 104	Energy Average dB(A) Standard Deviation NPL
Excavation	88 8 109	75 14 111	89 6 105	79 2 85	89 6 105	71 2 77	88 7 106	78 3 86	Energy Average dB(A) Standard Deviation NPL
Foundations	81 10 107	81 17 124	78 3 84	78 3 86	77 4 87	77 5 90	88 8 108	88 8 108	Energy Average dB(A) Standard Deviation NPL
Erection	81 10 107	65 9 87	87 6 99	75 2 79	84 9 107	72 7 91	79 9 103	78 11 108	Energy Average dB(A) Standard Deviation NPL
Finishing	88 7 106	72 12 104	89 7 107	75 8 97	89 7 105	74 10 100	84 7 101	84 8 104	Energy Average dB(A) Standard Deviation NPL

I - All pertinent equipment present at site.
II - Minimum required equipment present at site.

TABLE 1-b. TYPICAL RANGES OF NOISE LEVELS AT CONSTRUCTION SITES WITH A
70 dB(A) AMBIENT TYPICAL OF URBAN AREAS

	Domestic Housing		Office Building, Hotel, Hospital School, Public Works		Industrial, Parking Garage, Religious, Amusement & Recreations, Store, Service Station		Public Works Roads & Highways, Sewers, and Trenches		
	I	II	I	II	I	II	I	II	
Ground Clearing	84 6 100	83 8 103	84 6 99	84 8 103	84 6 101	87 8 103	84 6 100	84 7 101	Energy Average dB(A) Standard Deviation NPL
Excavation	88 7 106	76 5 88	89 6 104	79 2 85	89 7 106	74 1 77	89 6 105	79 2 85	Energy Average dB(A) Standard Deviation NPL
Foundations	81 7 99	81 7 100	78 3 85	78 2 85	78 3 85	78 3 85	88 8 108	88 8 108	Energy Average dB(A) Standard Deviation NPL
Erection	82 6 97	71 1 75	85 5 97	76 1 79	85 7 103	74 2 80	79 3 88	79 4 88	Energy Average dB(A) Standard Deviation NPL
Finishing	88 7 106	74 4 84	89 6 104	76 4 86	89 6 104	75 3 84	84 6 100	84 6 100	Energy Average dB(A) Standard Deviation NPL

I - All pertinent equipment present at site.

II - Minimum required equipment present at site.

The NPL values shown in Table I obviously depend on the previously described model of site noise. For this model, the average sound pressure level depends strongly on the one or two noisiest pieces of equipment, whereas the standard deviation depends largely on the numbers and duty cycles of the less noisy equipment and on the ambient noise level.

As evident from Table I, in building construction, the initial ground clearing and excavation phases tend to be the noisiest, the subsequent foundation and erection phases tend to be somewhat less noisy, and the final finishing phase again tends to be relatively noisy. In public works construction, on the other hand, NPLs are more nearly the same for all phases, except that the erection phase tends to be less noisy.

Table II lists the two noisiest types of equipment for each site type and phase, together with the average A-weighted noise levels (at 50 ft) for this equipment. Inspection of this table indicates that rock drills, which typically are the noisiest equipment, are prevalent in the excavation and finishing phases; trucks, on the other hand, are somewhat less noisy than rock drills or similar equipment but are present in nearly all phases.

Effect of Equipment Quieting

To assess the effect of some quieting strategies on the previously described site noise model, we recalculated the NPL for three "strategies" for each type of site and each phase:

Strategy 1:

- Only the noisiest piece of equipment being quieted by 10 dB(A), with this equipment remaining at the previously specified 50 ft distance from the observer.

TABLE II. NOISIEST EQUIPMENT TYPES OPERATING AT CONSTRUCTION SITES*

		Construction Type							
		<u>Domestic Housing</u>		<u>Office Bldgs.</u>		<u>Industrial</u>		<u>Public Works</u>	
Construction Phase	Ground Clearing	Truck	(91)	Truck	(91)	Truck	(91)	Truck	(91)
		Scraper	(88)	Scraper	(88)	Scraper	(88)	Scraper	(88)
	Excavation	Rock Drill	(98)	Rock Drill	(98)	Rock Drill	(98)	Rock Drill	(98)
		Truck	(91)	Truck	(91)	Truck	(91)	Truck	(91)
	Foundations	Concrete Mixer	(85)	Jack Hammer	(88)	Jack Hammer	(88)	Truck	(91)
		Pneumatic Tools	(85)	Concrete Mixer	(85)	Concrete Mixer	(85)	Scraper	(88)
	Erection	Concrete Mixer	(85)	Derrick Crane	(88)	Derrick Crane	(88)	Paver	(89)
		Pneumatic Tools	(85)	Jack Hammer	(88)	Jack Hammer	(88)	Scraper	(88)
	Finishing	Rock Drill	(98)	Rock Drill	(98)	Rock Drill	(98)	Truck	(91)
		Truck	(91)	Truck	(91)	Truck	(91)	Paver	(89)

*Numbers in parentheses represent typical dB(A) levels at 50 ft. See Table I for definition of construction types.

Strategy 2:

- Only the noisiest piece of equipment being quieted by 10 dB(A), with this equipment moved to 200 ft and with the next noisiest equipment (unquieted) moved to 50 ft from the observer position

Strategy A:

- All items of equipment quieted by 10 dB(A).

The results of these calculations are shown in Table III, together with the NPL values previously obtained without any quieting (Strategy 0). It appears that quieting only the noisiest piece of equipment generally reduces the site NPL relatively little, if other types of equipment can also operate near the observer (compare Strategies 0 and 2). On the other hand, quieting the noisiest equipment and letting no others operate near the observer may result in significant reductions (compare Strategies 0 and 1). Of course, quieting all equipment (Strategy A) results in the lowest NPL values; however, these values are often only slightly lower than those obtained by quieting only the noisiest item (Strategy 1).

The site noise model used here initially assumes the noisiest equipment to be located nearest the observer. It can happen that quieting the noisiest equipment, moving it away from the observer, and moving the second noisiest equipment near the observer (Strategy 2) results in an *increase* in the NPL, if the second noisiest equipment is used more frequently than the noisiest. This peculiarity of the noise model, where equipment quieting seemingly increases the noise, is evident at several places in Table III.

TABLE III. NOISE POLLUTION LEVELS IN dB(A) OF CONSTRUCTION SITES,
VARIOUS EQUIPMENT QUIETING STRATEGIES*

		Domestic Housing								Office Building				Industrial				Public Works							
		Ambient				Urban				Rural				Urban				Urban				Rural			
		Quieting Strategy**				0	1	2	A	0	1	2	A	0	1	2	A	0	1	2	A	0	1	2	A
Construction Phase	Ground Clearing	100	88	98	85	103	91	101	94	99	86	96	85	101	87	97	85	100	84	87	85	103	87	91	91
	Excavation	106	93	109	92	109	93	111	100	104	91	105	91	106	92	103	91	105	91	98	92	106	92	99	95
	Foundation	99	81	81	81	107	86	83	96	85	80	94	76	85	82	98	76	108	87	96	90	108	89	96	99
	Erection	97	82	88	81	107	105	102	93	97	84	85	85	103	88	84	86	88	81	89	77	103	89	90	84
	Finishing	106	93	99	92	106	93	99	95	104	91	98	92	104	91	97	89	100	89	94	85	101	88	95	92

* See text for site noise model; see Table I for construction type and ambient noise definitions.

** 0 - No quieting

1 - Noisiest equipment, at 50 ft from observer, quieted by 10 dB(A).

2 - Noisiest equipment quieted by 10 dB(A) and moved to 200 ft from observer; second-noisiest equipment (not quieted) moved to 50 ft from observer.

A - All equipment quieted by 10 dB(A).

Other Means for Site Noise Control

The NPL generated by a construction site also may be reduced by means other than quieting the equipment:

- Replacement of individual operations and techniques by less noisy ones - e.g., using welding instead of riveting, mixing concrete offsite instead of onsite, and employing pre-fabricated structures instead of assembling them on site.
- Selecting the quietest of alternate items of equipment - e.g., electric instead of diesel-powered equipment, hydraulic tools instead of pneumatic impact tools.
- Scheduling of equipment operations to keep average levels low, to have noisiest operations coincide with times of highest ambient levels, and to keep noise levels relatively uniform in time; also, turning off idling equipment.
- Keeping noisy equipment as far as possible from site boundaries.
- Providing enclosures for stationary items of equipment and barriers around particularly noisy areas on the site or around the entire site.

Equipment Noise Reduction Potential

Table IV lists the present average noise levels in dB(A) for the various types of construction equipment discussed previously; also listed are the noise levels expected to be achievable in a relatively short time, with limited cost and performance penalties. In addition, the table shows the most significant noise sources for each type of equipment and assigns a numerical "usage" factor to each item, on the basis of which one can assess the significance of quieting of the various individual items. From

TABLE IV. IMMEDIATE ABATEMENT POTENTIAL OF
CONSTRUCTION EQUIPMENT

Equipment	Noise Level in dB(A) at 50 ft		Important Noise Sources ²	Usage ³
	Present	With Feasible Noise Control ¹		
Earthmoving				
front loader	79	75	E C F I H	.4
backhoes	85	75	E C F I H	.16
dozers	80	75	E C F I H	.4
tractors	80	75	E C F I W	.4
scrapers	88	80	E C F I W	.4
graders	85	75	E C F I W	.08
truck	91	75	E C F I T	.4
paver	89	80	E D F I	.1
Materials Handling				
concrete mixer	85	75	E C F W T	.4
concrete pump	82	75	E C H	.4
crane	83	75	E C F I T	.16
derrick	88	75	E C F I T	.16
Stationary				
pumps	76	75	E C	1.0
generators	78	75	E C	1.0
compressors	81	75	E C H I	1.0
Impact				
pile drivers	101	95	W P E	.04
jack hammers	88	75	P W E C	.1
rock drills	98	80	W E P	.04
pneumatic tools	86	80	P W E C	.16
Other				
saws	78	75	W	.04
vibrator	76	75	W E C	.4

Notes:

1. Estimated levels obtainable by selecting quieter procedures or machines and implementing noise control features requiring no major redesign or extreme cost.

2. In order of importance:

T Power Transmission System, Gearing	F Cooling Fan
C Engine Casing	W Tool-Work Interaction
E Engine Exhaust	H Hydraulics
P Pneumatic Exhaust	I Engine Intake

3. Percentage of time equipment is operating at noisiest mode in most used phase on site.

this table, one may determine that control of engine noise, and particularly of engine exhaust noise, will affect many items of equipment with high usage factors and thus should be given high priority.

Table V presents a brief listing of the noise control techniques applicable to the sources indicated in Table IV, together with an estimate of the noise reductions that may readily be achieved by means of these techniques.

2.2 Home Appliances

The use of convenient and sometimes necessary appliances constitutes a growing noise problem within the home. Almost without exception, appliances could be significantly quieter. However, manufacturers offer three primary arguments for opposing quieter redesign; they believe

- that the public associates the noise generated by a device with its power;
- that quieter appliances would be marketed at a price disadvantage and since the public has not objected to noise, that the public, in general, is satisfied;
- that since appliances are generally controlled by the operator, the option, as with air conditioners, "to have quiet or to be cool" is "option enough".

Yet, in keeping with the public's growing awareness of noise, many appliances are advertised as being "noiseless", "quiet", "vibration-free".

Although many manufacturers have made detailed acoustic measurements of the noise output of their appliances, very little data has been reported in the open literature. Some of the

TABLE V. NOISE CONTROL FOR CONSTRUCTION EQUIPMENT

<u>Source</u>	<u>Control Techniques</u>	<u>Probable Noise Reduction in dB(A)*</u>
Engine		
exhaust	improved muffler	10
casing	improved design of block enclosure	2 10
fan (cooling)	redesign silencers, ducts and mufflers	5 5
intake	silencers	5
Transmission	redesign, new materials enclosure	7 7
Hydraulics	redesign, new materials enclosure	7 10
Exhaust		
(pneumatic)	muffler	5-10
Tool-Work		
interaction	enclosure change in principle	7-20 10-30

*Note that noise reductions are not additive. Incremental reductions can be realized only by simultaneous quieting of all sources of equal strength.

literature (especially "nonacoustic" reporting) presents insufficient information to enable utilization of the reported measurements in this study. For example, in one report [5], the noise levels are described as being "recorded at operator's or housewife's normal ear distance"; for those appliances not requiring continual operation, the distance from the exposed person to the appliance is not specified. In other examples drawn from newspapers, trade journals, and magazines measurements are not qualified as to distance from the source, type of instrumentation, and weighting network (if any) that was used. In the following sections, only the literature found to be well-documented and considered accurate will be used in appropriate discussions.

2.2.1 Measurements

Because of the scarcity of reliable data, we measured the noise from thirty types of home appliances and eleven types of home shop tools. Sound levels were measured in dB(A) at a distance of 3 ft from the appliance and a height of 5 ft; this measurement position approximates the location of the operator's ear for those appliances requiring an operator. For those appliances not requiring an operator, this position represents noise levels in the vicinity of the appliance. Noise levels in the reverberant field of the room in which the appliance is being operated may be on the order of 2 to 3 dB(A) less than the measurement at 3 ft.

Noise levels in adjacent rooms with the interconnecting door open may be as much as 10 dB(A) less than the levels at 3 ft or as much as several dB(A) greater than the 3 ft levels, depending upon the details of the installation. For the appliances that are used near the ear (e.g., an electric-shaver), the noise level at the ear may be as much as 10 dB(A) greater than the 3 ft mea-

measurements. Figure 3 summarizes the noise measurements made by O&N and some of those reported in the literature. Each point represents a single measurement. Several measurements are given for a single appliance that operates in different modes. The solid circles represent noise levels generated by American appliances; foreign brands are represented by the squares. Problems arise in evaluating this data because the appliances were manufactured in different years by different companies, were scattered through the lines offered by the manufacturers, and may be providing different features. For example, a recently built refrigerator may be frost-free and may have special devices such as ice makers; therefore it may generate more noise than earlier refrigerators. Figure 4 presents octave band spectra for refrigerators that were manufactured through 1958 [8] and in 1965, 1967, and 1970 [7]. Noise generated by this sample of refrigerators demonstrates the problem of data comparison: the unit that was old in 1958 was the noisiest, while the 1970 unit was second noisiest. The quietest refrigerator is the 1965 model. However, there is considerable difference between the physical size of the units, and the newer models incorporate such features automatic defrost, ice-cube maker, water dispenser, and humidified compartment.

2.2.2 Noise abatement potential

The thirty appliances and eleven shop tools surveyed exhibited no apparent acoustical problems that could not be abated through the diligent application of noise control technology. Achieving a cost-effective solution that can be incorporated into the design of an appliance is more difficult but still possible. Standard noise control techniques are readily available; wrapping, damping, flexible connections, vibration isolation, better

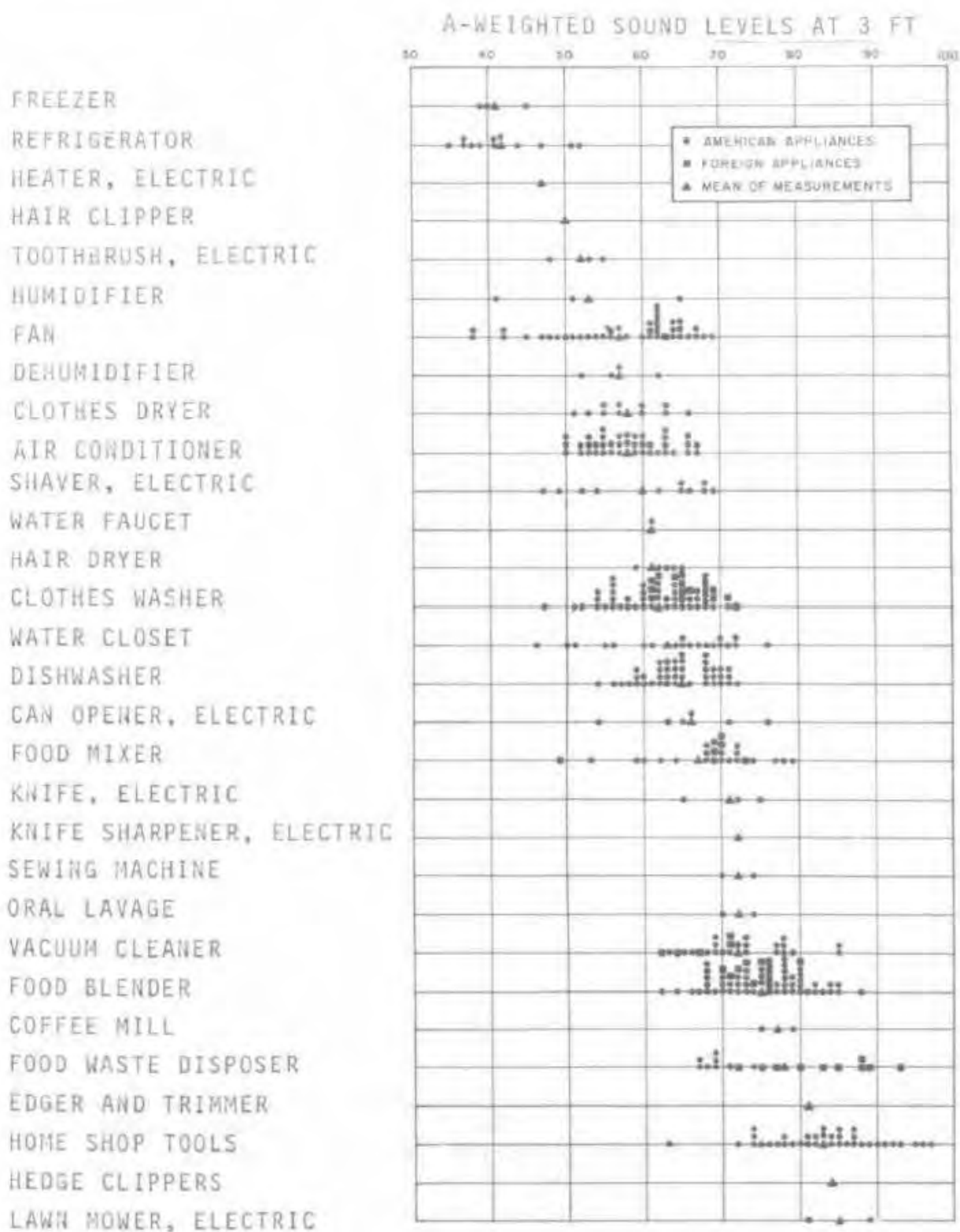


FIG. 3. A SUMMARY OF NOISE LEVELS FOR APPLIANCES MEASURED AT A DISTANCE OF 3 FT.

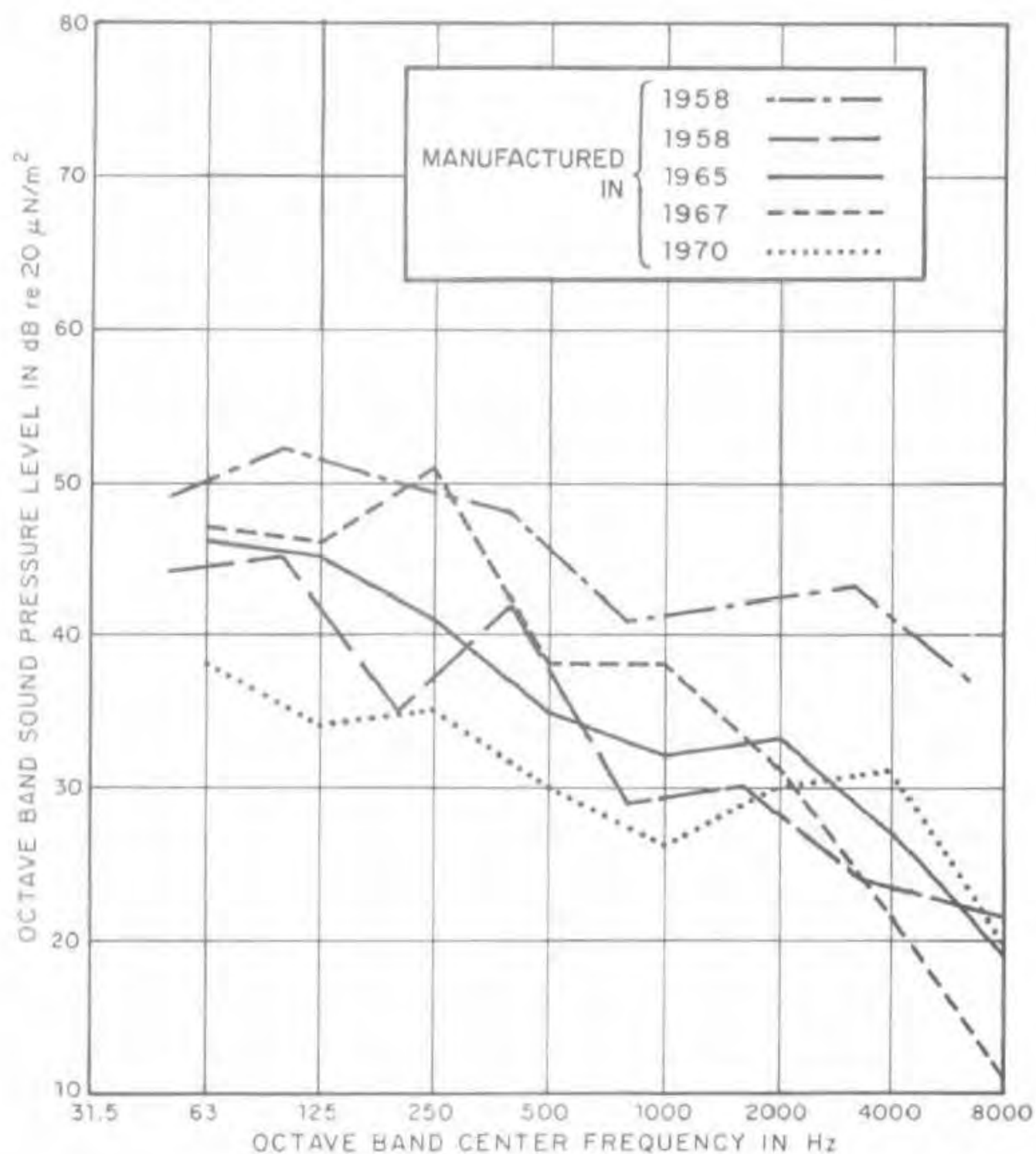


FIG. 4. SOUND PRESSURE LEVELS OF VARIOUS REFRIGERATORS (MEASURED AT 3 ft)

balance, and smoother mechanical connections. Since many appliances have similar mechanisms, noise control techniques used on one appliance can often be applied to another.

After reviewing the operating characteristics and mechanical properties of appliances, we ranked the noise sources in order of their contribution to the total noise generated by an appliance (see Table VI). Definitive measurements are not available to enable a quantitative breakdown of the contribution of individual components. However, in general, motors, fans, knives (or other cutting blades), and air flow are the most frequent sources of noise. Noise radiated from the casing or panels of the appliances and noise radiated from walls, floors, cabinets, sinks (set into vibration by solid structural connections) are also of major importance.

We review here in some detail the noise generating mechanisms of several appliances that have high enough noise levels and exposure time to be considered annoying. Included in this review are air conditioners, dishwashers, food waste disposers, vacuum cleaners, and toilets. Other appliances are discussed in Appendix A.

Room Air Conditioners

Figure 5 is a schematic view of a typical room air conditioner. Basically, warm air in the room or from outside is drawn through a dust filter, blown across cold evaporator coils and distributed back into the room. Fluid in the evaporator, heated by this action, flows to the condenser coils. Outside air is blown across these coils by the propeller fan. The fluid is then compressed and flows back to the evaporator.

TABLE VI. SOURCES OF APPLIANCE NOISE

Appliance	Source	Air Flow	Combustion Roar	Compressor	Fan	Gears	Knives (Cutting Blades)	Motors	Panels	Pump	Structureborne	Water Noise
Car. Opener, electric						1		1	2			
Clothes Dryer			1					1	2			
Clothes Washer								2	2	2		1
Coffee Mill												
Dehumidifier		1		3	1			1	2			
Dishwasher					3			3	2	2	2	1
Edger and Trimmer							1	2				
Fan		1			1			2				
Food Blender							1	1	2			
Food Mixer							1	1	2			
Food Waste Disposer							1	2			2	1
Freezer				1	1			1	2			
Hair Clipper						1		1				
Hair Dryer		1			1			2				
Heater, electric		1			1			1	2			
Hedge Clippers						2		1				
Home Shop Tools					1	1		1	1		2	
Humidifier		1			1			1				

TABLE VI (continued)

Appliance	Source	Air Flow	Combustion Roar	Compressor	Fan	Gears	Knives (Cutting Blades)	Motors	Panels	Pump	Structureborne	Water Noise
Knife, electric						1		1				
Knife Sharpener								1				
Lawn Mower						1		1	1			
Oral Lavage								1		1		
Refrigerator				1	1			1				
Room Air- Conditioner		1		2	2			2	3		3	
Sewing Machine								1				
Shaver, electric						1		1				
Toilet											2	1
Toothbrush, electric						1	1					
Vacuum Cleaner		1			1			1	2			
Water Faucet											2	1

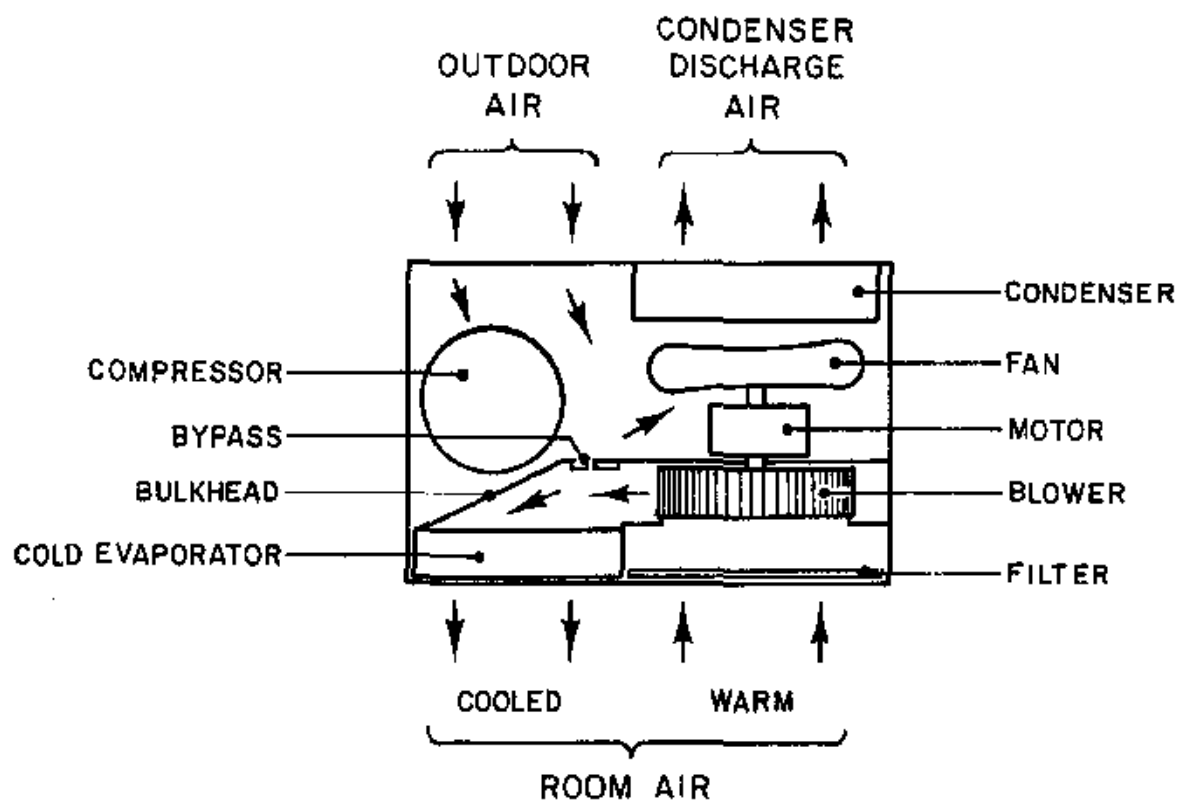


FIG. 5. SCHEMATIC VIEW OF A TYPICAL ROOM AIR CONDITIONER.

The major sources of noise in this process are the motor, the blower (evaporator fan), the propeller fan (condenser fan), the compressor, and the air flow across the evaporator coils. In addition, panels of the housing radiate noise, as does the structure upon which the air conditioning unit is mounted. The character of this noise is complex, consisting of pure tones, pulsating sounds, intermittent clicks, buzzes and rattles, all superimposed on broadband noise [8]. The tonal components and broadband noise represent the primary noises that require noise control treatment; for the most part, buzzes and rattles (often caused by loose parts), intermittent clicks (caused by spring activated thermostat controls and relays), and pulsating noises (generated by the capillary tube and evaporator valves) have been controlled in current models so that they do not dominate the total noise level.

Pure tones may be generated by (1) the motor at multiples of the rotation speed, (2) the compressor at multiples of the pumping fundamental frequency (the speed in revolutions per second times the number of pumping cycles per revolution), and (3) the propeller fan at blade-passage frequency (the speed in revolutions per second times the number of blades). Whether or not these pure tones appear in the spectrum heard indoors depends upon the structural connections between the components and the enclosure panels as well as on connections to supporting structures. In Fig. 6, noise levels measured on a particular unit with the fan on high speed, with and without the compressor, illustrate this concept; the increase in the one-third octave band centered at 63 Hz is due to a lack of sufficient vibration isolation of the compressor from its case and/or insufficient isolation of the casing from the wall supporting it.

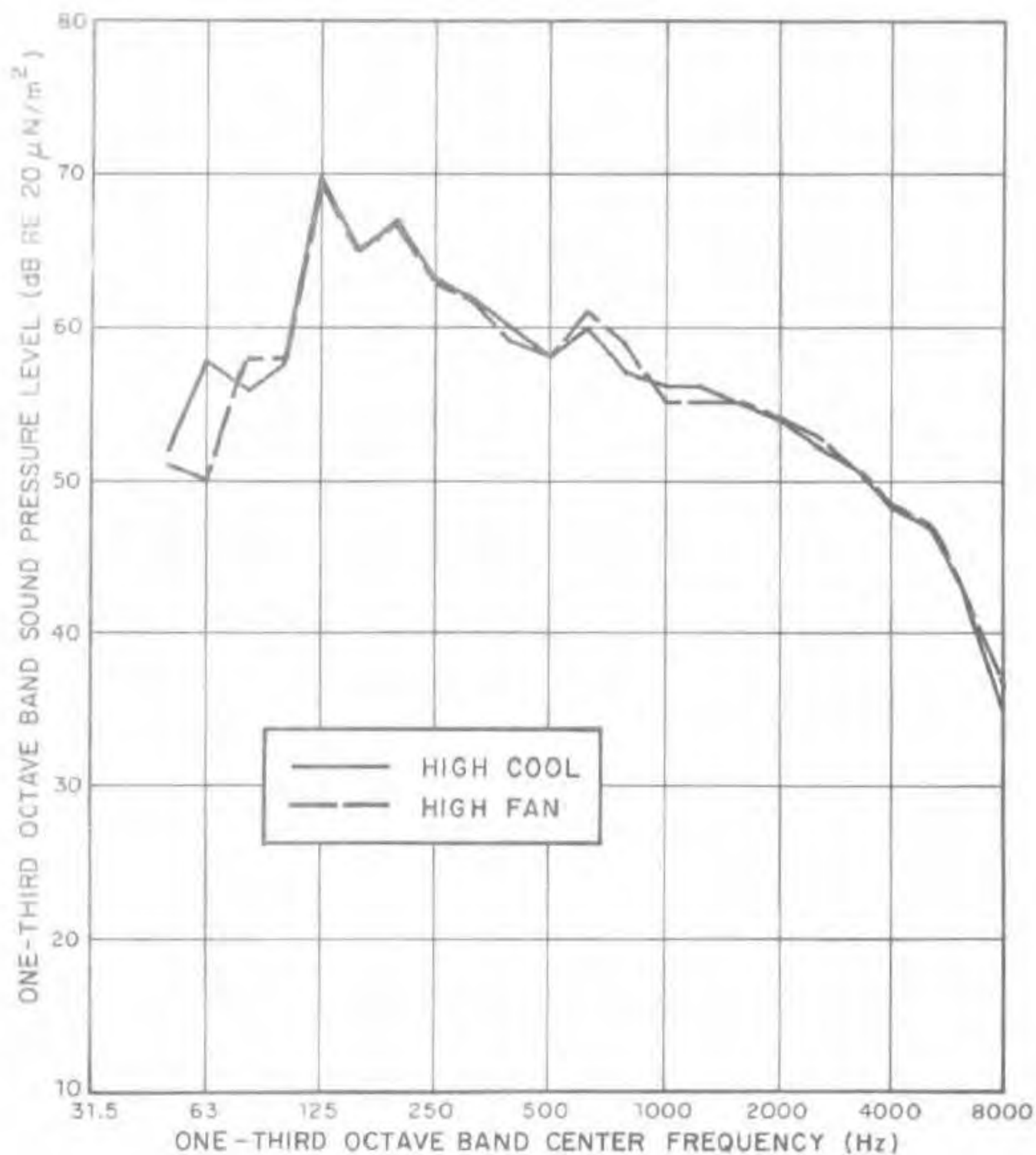


FIG. 6. SOUND PRESSURE LEVELS FROM AIR CONDITIONER ON HIGH COOL AND HIGH FAN SETTINGS (MEASURED AT 3 FT)

Broadband noise is generated by the blower, the flow of air through the evaporator coils, and the deflection of the air into the room. Often the blower can operate at several speeds; the slower the speed, the lower the noise level from both the blower and the air flow (see Fig. 7).

Noise control means that can be applied to motor and compressor noise include better vibration isolation of the motor and fans from the housing through use of rubber or neoprene mounts. Compressors, usually hermetically-sealed, can be mounted on springs internally, and on rubber or neoprene pads externally. A more thorough isolation of the motor, fans, and compressor from the casing and of the complete unit from its support could result in a noise reduction of about 5 dB in the low-frequency region controlled by tonal sounds from these components.

The broadband noise generated by the centrifugal blower and the air flow can be reduced by

- reducing the air velocity by using the low-speed fan (if maximum cool is not required);
- reducing the air velocity by increasing the area of the evaporator coils (perhaps increasing the total size of the unit);
- incorporating sound absorbing material, such as open-cell polyurethane foam, between the evaporator coils and the deflection grids and in the duct passage between the blower and the evaporator coils and the blower and the dust filter; and
- tightening the gasketing system to eliminate rattles.

Broadband noise can be reduced by 10 to 15 dB through effective use of these techniques. Coupled with more effective isolation

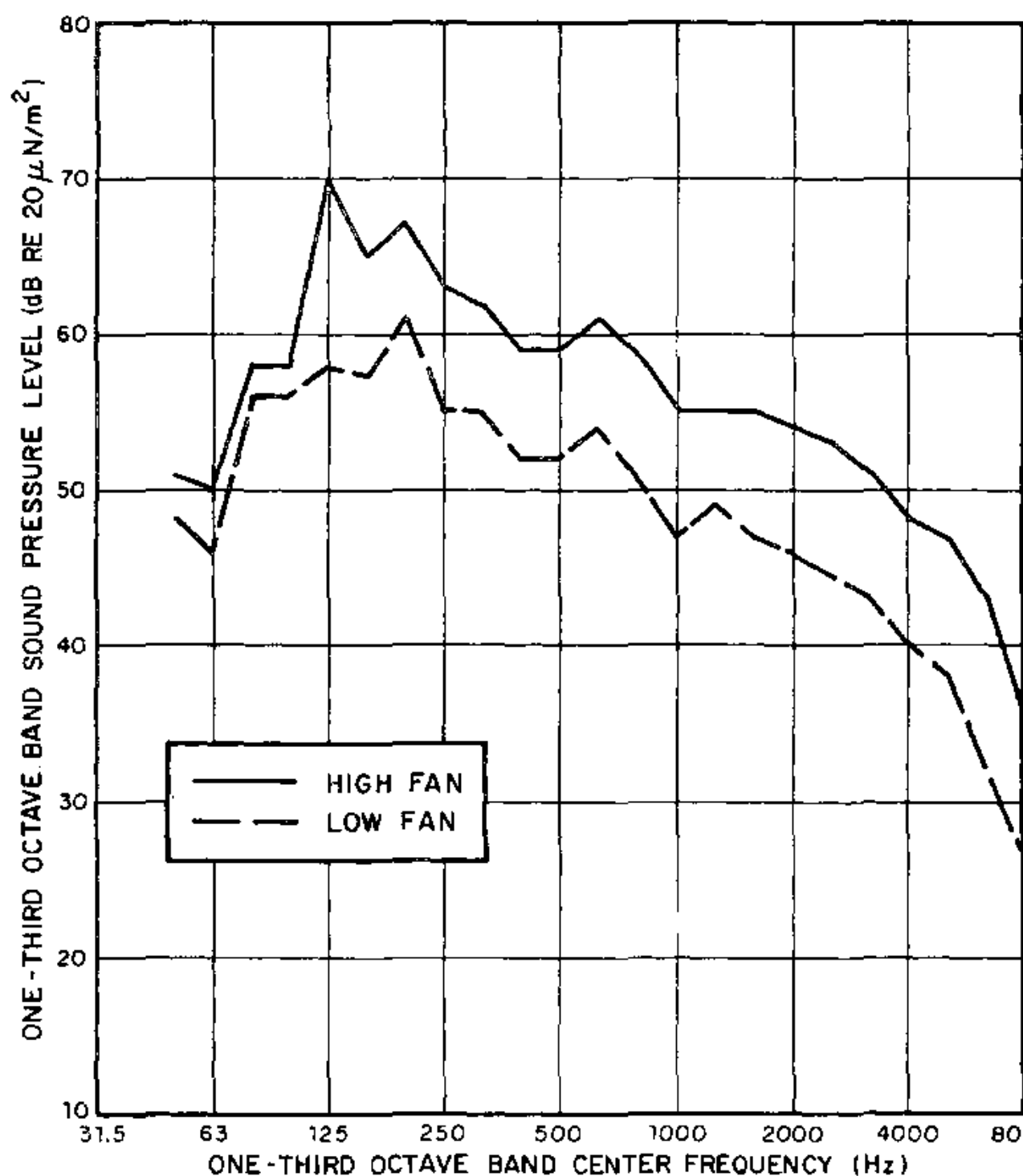


FIG. 7. SOUND PRESSURE LEVELS FROM AIR CONDITIONER ON TWO SETTINGS (MEASURED AT 3 ft)

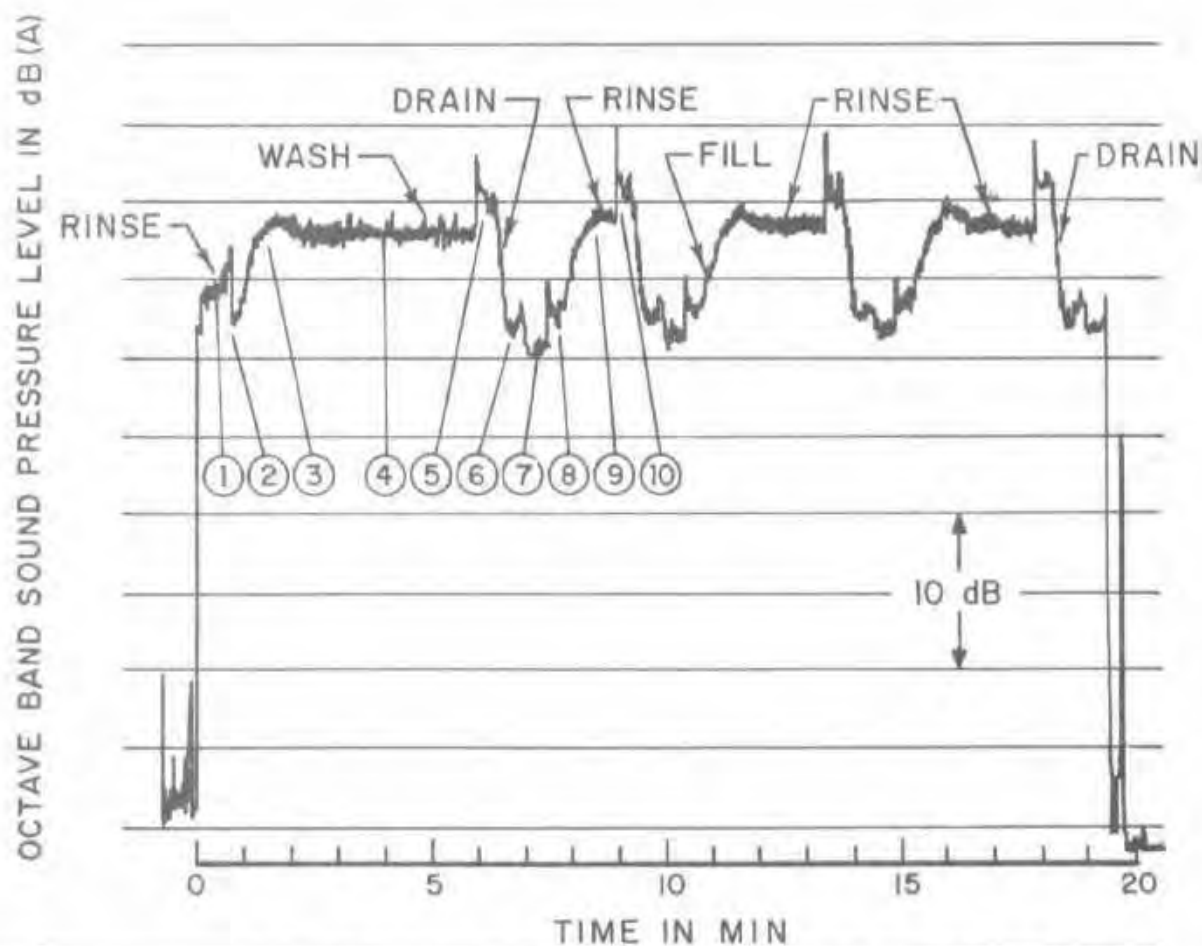
of the compressor, motor, and fans, a total noise reduction of 10 to 15 dB(A) is not unreasonable. Perhaps an appropriate design goal for high cool operation is 40 dB(A) at 3 ft.

Dishwashers

A dishwasher is essentially a tub equipped with a water spray system that is driven by a motor-pump assembly. Heating coils and a blower are provided to assist in the drying operation. A complete wash may consist of as many as thirteen cycles: rinse, fill, wash, drain, fill, rinse, drain, fill, rinse drain, fill, rinse, drain. Figure 8 plots the noise level in dB(A) as a function of operation [9]. In this example, the wash and rinse cycles are noisier than the drain and fill cycles by about 8 dB(A). Figure 9 presents octave band measurements made during the wash cycle on five different dishwashers. The data varies 5 to 20 dB between the quietest and noisiest dishwasher measured in 1971, depending on the frequency band of interest, representing about 10 dB(A) difference between the quietest and the noisiest. Although the data sample is small, this figure also illustrates, that some newer dishwashers are noisier than older ones.

The noise generating mechanisms in a dishwasher include the impingement of water against the sides and top of the tub, the motor, the pump, the excitation of panel casings, structural connections to water supply, water drain and cabinet, and the blower.

Broadband "water noise" is most important in the frequency range above 300 to 400 Hz; motor-induced noise, often pure tones at the motor rotation frequency and harmonics thereof, dominate the lower frequencies. The kick panel below the loading door on a dishwasher installed in a typical kitchen-cabinet also transmits noise from the motor enclosure into the room.



Freq. in Hz	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
31.5	58	55	65	64	64	53	51	55	64	65
63	58	57	62	60	61	53	51	54	62	61
125	62	61	64	60	60	54	58	60	62	61
250	59	60	69	67	70	58	58	59	68	69
500	61	62	66	64	66	60	59	63	66	66
1000	61	59	66	66	68	59	57	59	66	69
2000	60	55	62	61	63	57	54	56	62	63
4000	55	52	59	58	62	52	52	52	59	62
8000	50	49	55	54	58	46	44	49	55	58
Overall	69	68	74	73	75	67	66	67	74	75
A-weighted	66	64	70	69	72	64	62	64	70	72

FIG. 8. GRAPHIC LEVEL RECORDING AND OCTAVE BAND SOUND PRESSURE LEVELS OF A DISHWASHER.

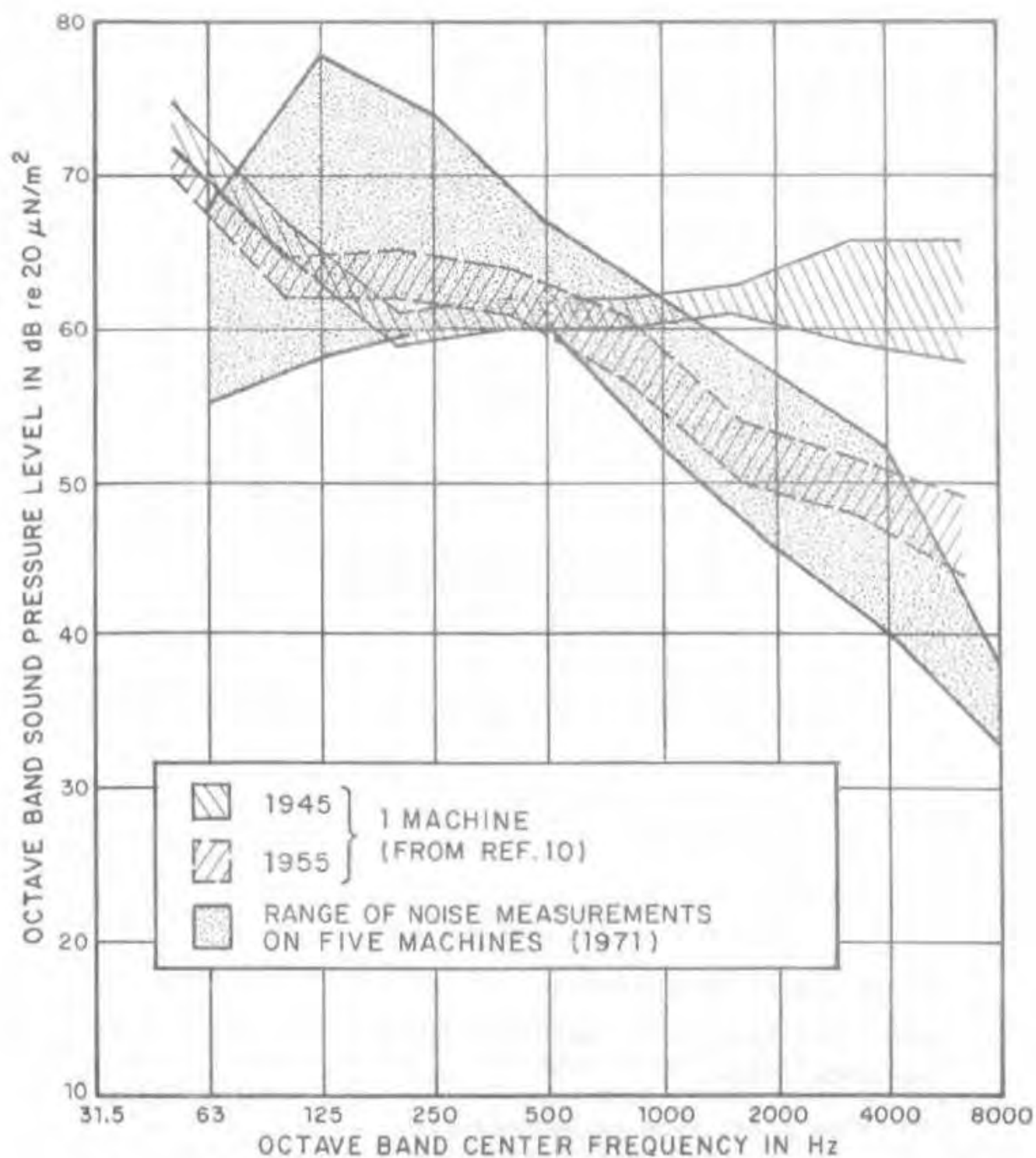


FIG. 9. SOUND PRESSURE LEVELS OF VARIOUS AUTOMATIC DISHWASHERS DURING WASH CYCLE (MEASURED AT 3 ft)

Through the use of experimental splash curtains, which prevent impingement of the water spray on the tub walls, water noise has been reduced by 6 to 8 dB(A) [11]. The motor-pump assembly is often isolated from the tub by rubber mounts; however, the effectiveness of these mounts can be reduced in the installation process by an insufficient clearance between the motor and the floor.

Often, the sides and top of a dishwasher are brought into contact with the cabinet. A clearance of 1/2 in. all around the machines, with neoprene isolation pads insuring the clearance, will reduce the noise radiated by the cabinet as well as the noise transmitted to other parts of the house. The use of rubber hoses for supply and drainage are an improvement over the copper tubing often provided. The incorporation of acoustic material in the motor-pump enclosure and a kick panel that is sealed (no air leaks) would also reduce the noise. It is anticipated that - if

- water noise were reduced (e.g., by installing splash curtains);
- effective vibration isolation of the motor-pump from the tub were ensured;
- effective vibration isolation of the dishwasher housing from the floor, cabinet walls and top were ensured;
- rubber hoses were used;
- acoustical absorption material were installed in the motor enclosure; and
- the kick panel were sealed air-tight -

the noise levels of a typical dishwasher could be reduced by some 10 to 15 dB(A), from a level in the mid sixties to one in the low

fifties. Because of its intermittent operation, a goal of 45 to 50 dB(A) at 3 ft is probably acceptable.

Food Waste Disposers

Continuous-feed and batch-feed disposers are chambers in which food waste is ground by a motor-driven wheel with cutting edges. Figure 10 presents one-third octave band sound pressure level data for four different disposers. Although the details of the spectra differ, each has a major peak at 125 Hz and several minor peaks at higher frequencies, all superimposed on broadband noise. The peak at 125 Hz is primarily motor noise. The minor peaks can be attributed to the blade-passage frequency of the grind wheel, multiples thereof, and resonances in the sink. The broadband noise is generated by the sloshing of water and waste against the housing of the chamber.

Noise is transmitted up through the mouth of the disposer. Batch-feed disposers, which require the sink cover to be in place before operation, have the potential for being quieter. Continuous-feed units sometimes have partial rubber closures at the mouth of the unit (primarily to prevent food waste from being expelled); for these closures to be effective in controlling noise, they must overlap to shut off the entire opening.

Basic noise control treatments that have been moderately successful include vibration isolation of the disposer from the sink and the enclosure of the chamber and motor with a double wall construction. It is estimated that the noise levels generated by disposers could be reduced by about 10 dB(A) with the following treatments:

- effective vibration isolation of the disposer from the sink;
- damping of the sink;

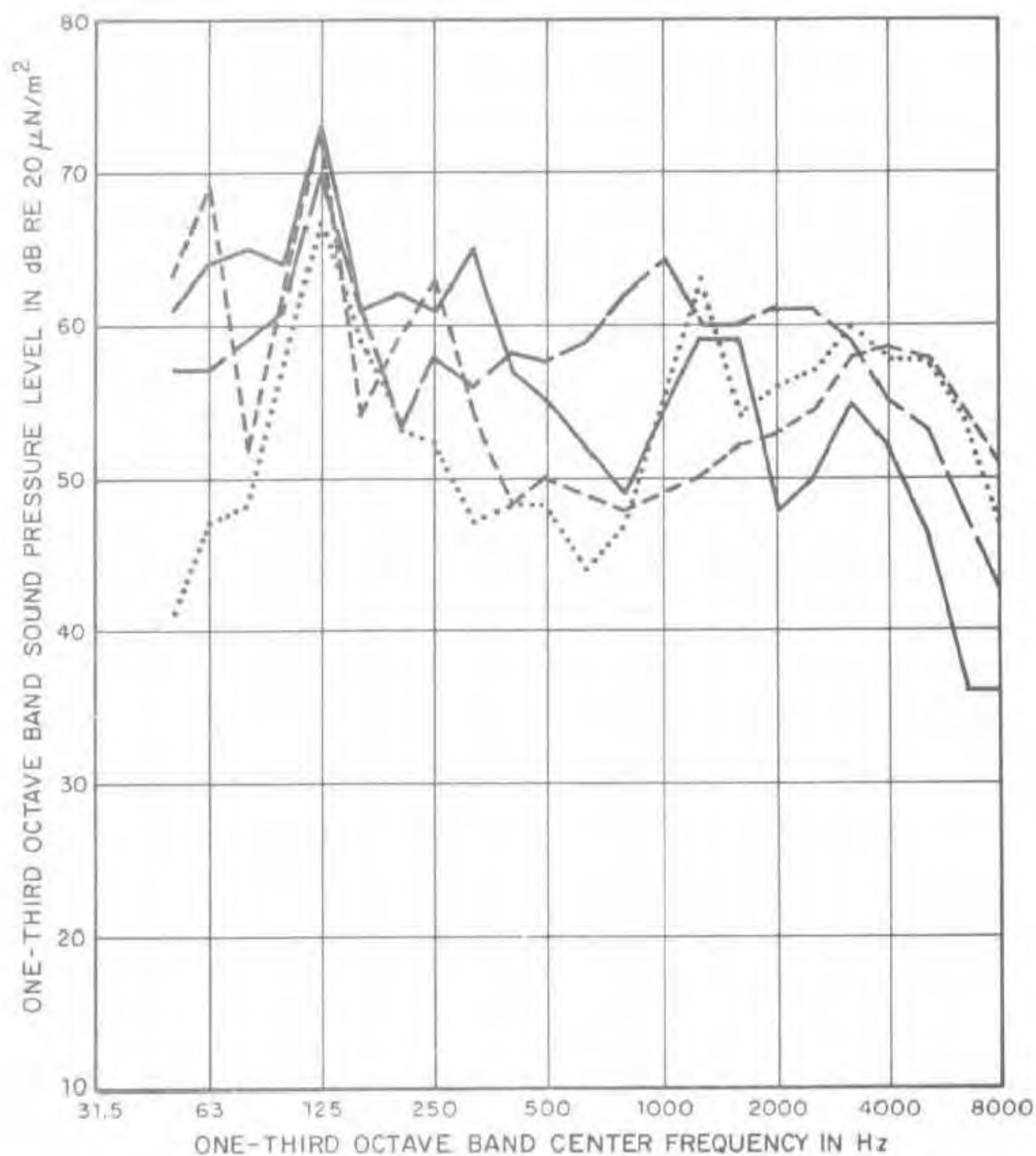


FIG. 10. SOUND PRESSURE LEVELS FROM FOUR FOOD-WASTE DISPOSERS (MEASURED AT 3 ft)

- flexible connections between the disposer and the drain pipe, which will also reduce the noise transmitted to other rooms and/or apartments;
- flexible electrical connection;
- enclosure of both the grinding chamber and motor, with appropriate ventilation; and
- effective closure of the mouth of the disposer.

Vacuum Cleaners

Canister vacuum cleaners consist of a tank (either horizontal or vertical) that provides suction, a connecting hose, and appropriate nozzles. Some recently manufactured canister units also have powered rotating brush attachments for cleaning carpets. Figure 11 presents sound pressure levels measured in one-third octave frequency bands for four canister units. As with other appliances, the peak at 125 Hz is motor-induced noise. The peaks in the 800 to 1600 Hz range are probably caused by the blade-passage frequency of the blower and/or resonances of the unit structure. Through the use of better blower design, more thorough vibration isolation of the motor and blower(s) from the structure, and damping and sealing of the canister structure, the noise generated by canister units could be reduced by 10 dB(A).

In addition to a motor-blower assembly, upright vacuum cleaners have a mechanism (either vibrating agitators or rolling brushes) that beats the carpet to bring dirt to the surface where it is sucked away. Figure 12 presents one-third octave band sound pressure level data for two upright vacuum cleaners — a large unit with a beating mechanism and a small one without a beater. For the larger unit, the low frequency noise is again

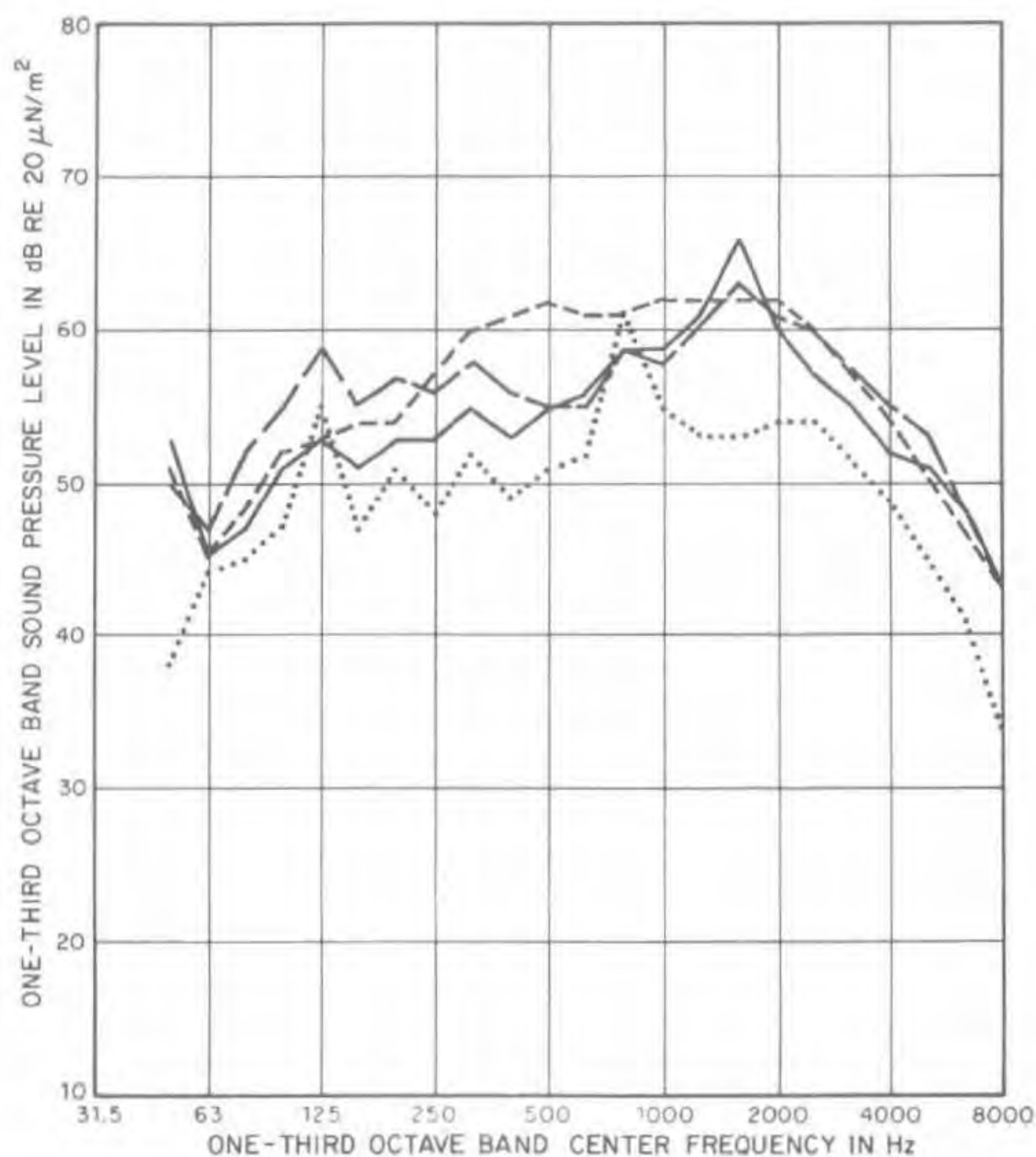


FIG. 11. SOUND PRESSURE LEVELS OF CANISTER VACUUM CLEANERS OPERATING ON 1000 PS TILG FLOOR (MEASURED AT 3 FT)

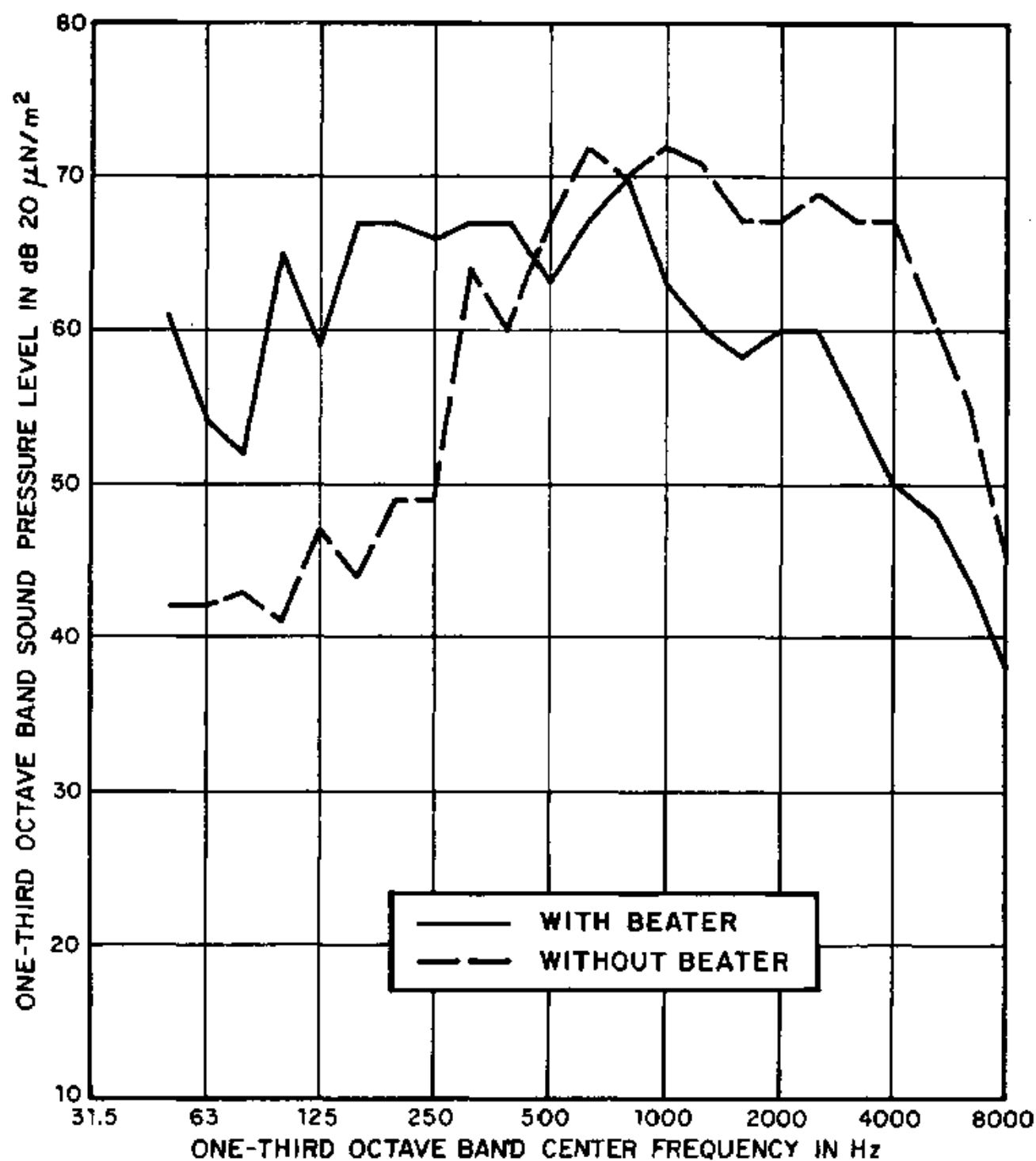


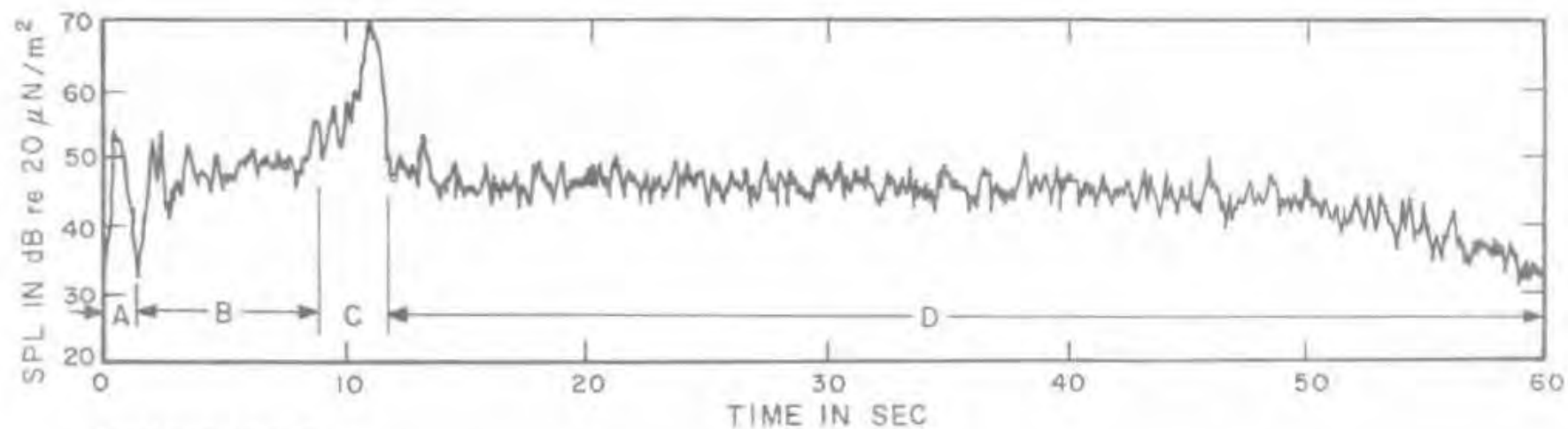
FIG. 12. SOUND PRESSURE LEVELS OF TWO UPRIGHT VACUUM CLEANERS (MEASURED AT 3 FT)

motor-induced. The peaks in the higher frequency range are caused by fan(s) and/or structural radiation. The difference between the two units in the low-frequency bands is due to the difference in capacity as well as to the lack of a beater on one model. Noise control for upright cleaners will be more difficult to achieve than for the canister units because of the location of the beater and the limitations on size. It is anticipated that a 5 dB(A) noise reduction could be achieved on the typical unit.

Water Closets

Water closets are either of the tank type or the valve type and are either floor-mounted or wall-mounted. Figure 13 illustrates the time history of the sound pressure level in the 250 Hz octave band for operation of a tank water closet [12]. Time Period A represents the valve opening and releasing water in the tank to flow into the bowl through an opening in the base of the bowl. The water produces a swirling action in the lower half of the bowl (Time Period B). The valve closes (Time Period C) and the tank and bowl are refilled (Time Period D).

Figure 14 illustrates the time history of the sound pressure level in the 250 Hz octave band for a flush valve water closet [12]. The valve opens (A); air and then water are forced out of the rim supply (B); the valve closes (C) and the bowl is refilled (D). A comparison of these two figures suggests that flush valve water closets generate somewhat higher initial noise levels during an operating cycle but that the noise does not persist as long as with tank water closets. Since the character of the sounds is different, it is not clear at this time which would be more desirable.



TIME PERIOD

A = VALVE OPENING

B = TANK EMPTYING

C = TANK CLOSET VALVE CLOSING

D = TANK AND BOWL FILL

FIG. 13. TIME HISTORY OF THE SOUND PRESSURE LEVEL IN THE 250 HZ OCTAVE BAND FOR A TANK WATER CLOSET.

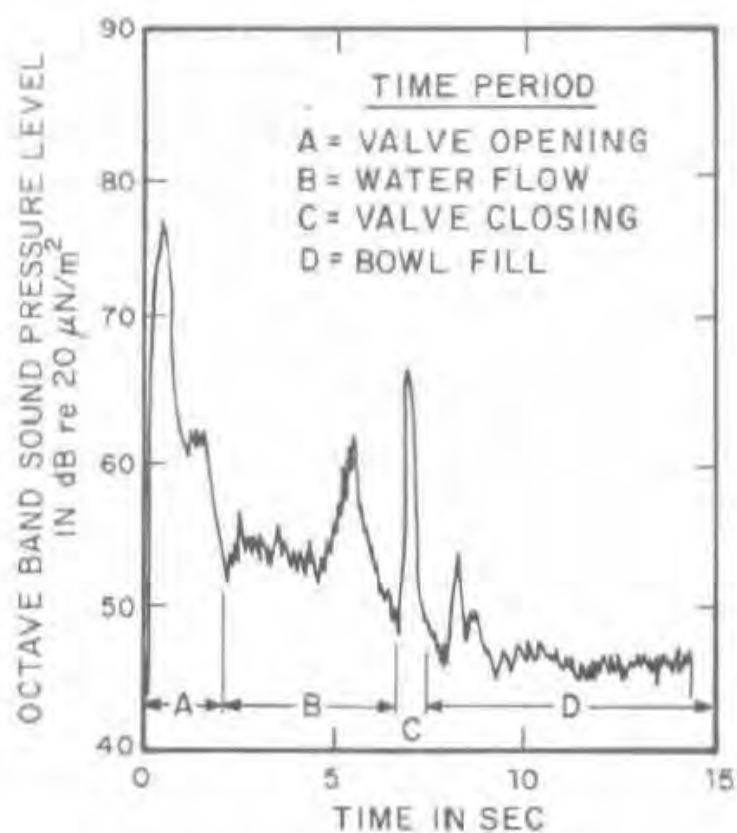


FIG. 14. TIME HISTORY OF SOUND PRESSURE LEVEL IN 250 HZ OCTAVE BAND FOR A FLUSH VALVE WATER CLOSET.

Figure 15 presents peak octave band data for a sampling of tank water closets and Fig. 16 for flush valve water closets. A comparison of these two figures shows that it is possible to have relatively noisy or quiet operation with either type of water closet provided. For tank water closets, water flow control and inlet water pressure are both important variables in the noise generated [12]. For flush valve closets, bowl design was found to be of major importance, with valve type (exposed flush vs recessed flush) and mounting (floor vs wall) of lesser importance. Resilient mounting of water closets and piping was found to be more important for some fixtures than for others - e.g., a range of several dB(A) to 15 dB(A) for valve-operated water closets.

2.3 Building Equipment

The proper operation of large buildings requires a number of different types of electrical and mechanical equipment. In this section, we review the noise levels generated by electrical and mechanical equipment, present noise levels for a typical multi-story building, and discuss the possibilities of noise control through architectural modification. Detailed descriptions of additional building equipment types are given in Appendix A.

2.3.1 Types of equipment

The majority of electrical and mechanical equipment in buildings is used to supply the building occupants with a suitable quantity of air at a comfortable temperature and moisture content. In addition, pumping and piping systems are used for water and fluid circulation, elevators and escalators are used for movement of personnel, and various conveyance systems are used for moving material.

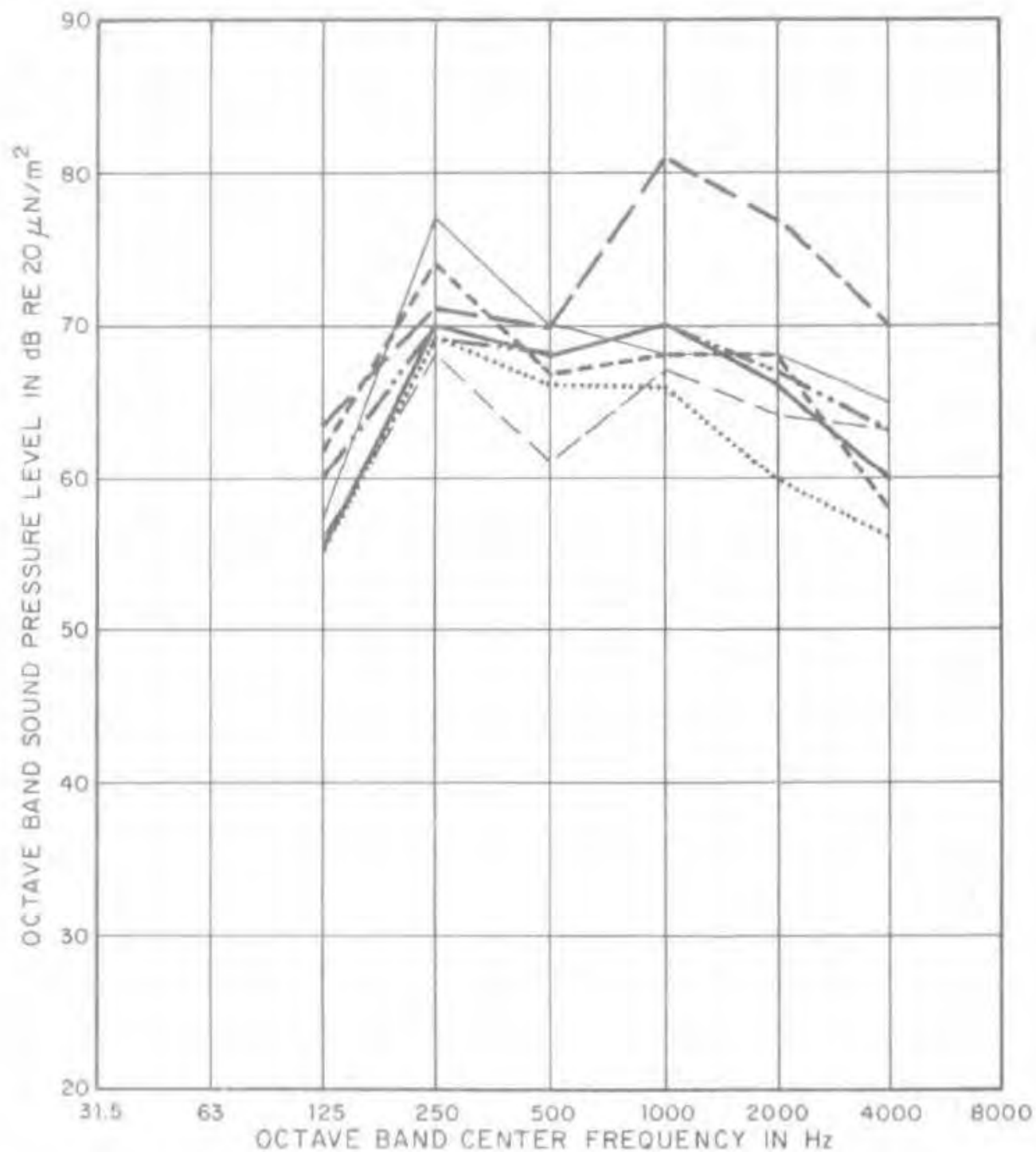


FIG. 15. RANGE OF PEAK OCTAVE BAND SOUND PRESSURE LEVELS IN ROOMS WITH TANK TYPE WATER CLOSETS (MEASURED AT 3 FT)

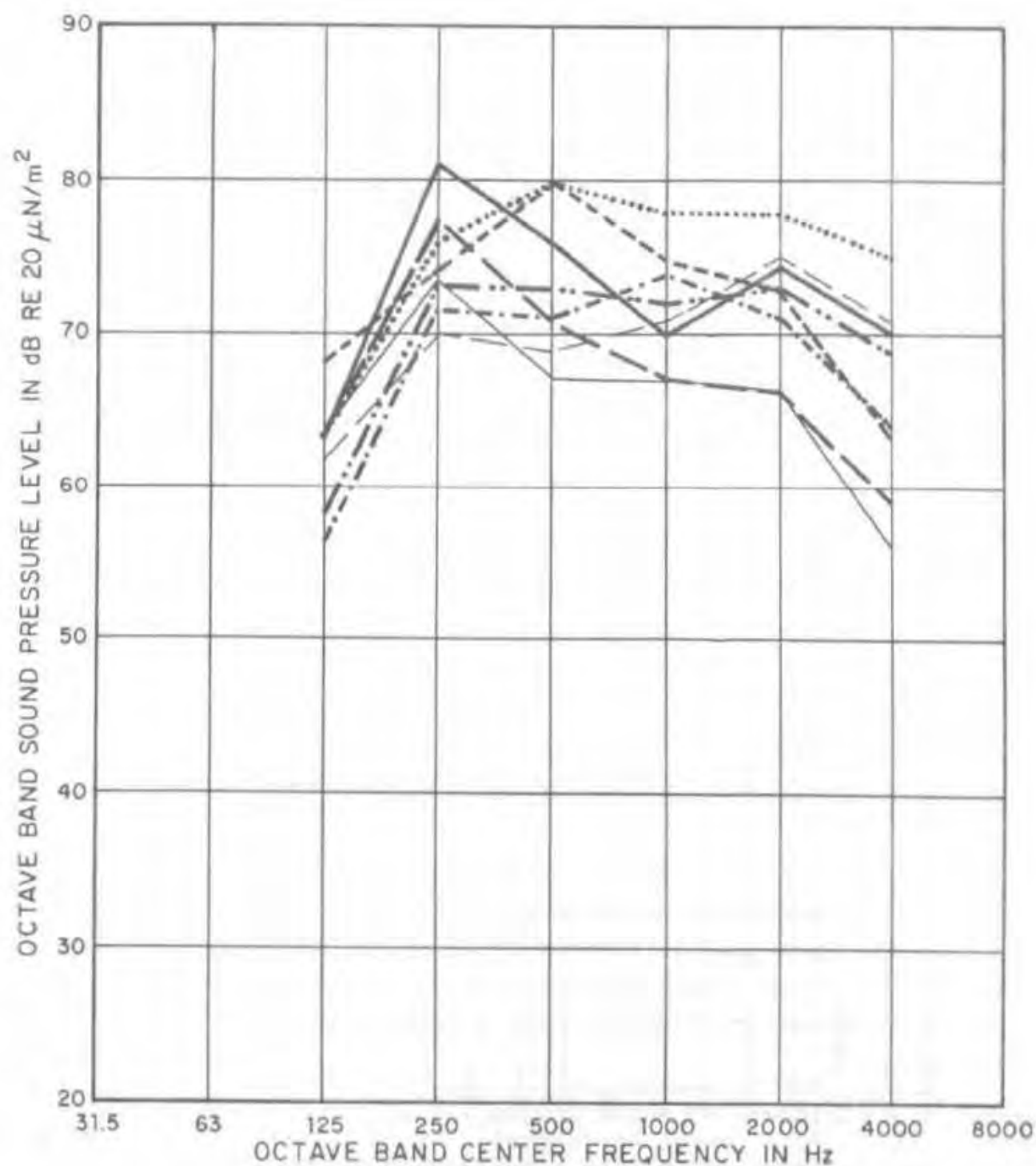


FIG. 16. RANGE OF PEAK OCTAVE BAND SOUND PRESSURE LEVELS IN ROOMS WITH FLUSH VALVE WATER CLOSETS (MEASURED AT 3 FT)

Figure 17 presents the typical range of sound levels in dB(A) at 3 ft for building equipment. Much of this equipment is hidden in mechanical equipment rooms, above ceilings, in walls, or behind cabinet type exterior enclosures. Table VII, which summarizes the exposure of occupants to the noise generated by building equipment, shows that occupants are *directly* exposed to the noise of only about eight different types of equipment. The noise generated by these units is thus of special interest since there are no intervening walls to provide attenuation. The noise generated by building equipment hidden from view can be sufficiently attenuated through the proper use of current architectural techniques. In practice, such techniques are not always implemented.

2.3.2 Noise levels within a typical multistory building

Although details of the frequency spectrum are of considerable importance in selecting noise control treatments, the model presented in this section is keyed, for simplification, to dB(A); it is not intended that this method be used for actual situations. Figure 18 presents a cross-section of a multistory building, locating a typical occupant with respect to building equipment. Figure 19 summarizes the noise exposure in dB(A) of an occupant to individual sources. The higher level in each case is representative of the sound level near the source — e.g., at 3 ft. The lower level is representative of the level to which the contribution from a particular source is reduced through proper implementation of noise control techniques. The treatments include:

E — enclosure of noise source

D — ductwork lined with acoustically absorbing material

W — wall

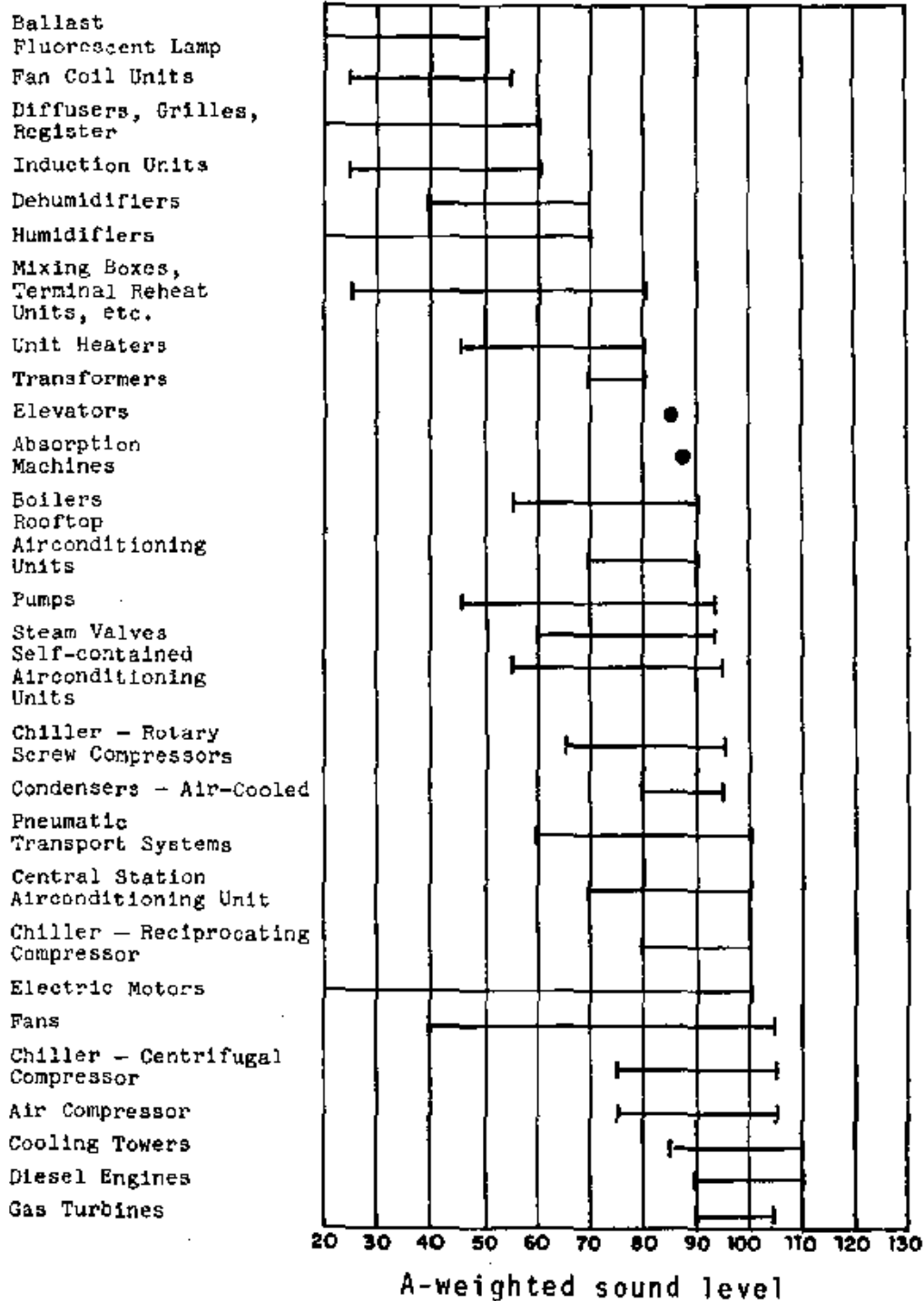


FIG. 17. RANGE OF SOUND LEVELS IN dB(A) TYPICAL FOR BUILDING EQUIPMENT AT 3 FT.

TABLE VII. EXPOSURE OF BUILDING OCCUPANTS TO THE
NOISE OF BUILDING EQUIPMENT

Building Equipment	Location	Type of Exposure		
		Direct	Indirect	
			Through Mechanical Distribution System	Through Walls, Floors, etc.
Air Conditioning	MER*		x	x
	Roof. Unit		x	x
	Wind. Unit	x		
Absorption Machines	MER			x
Air Compressor	MER			x
Ballasts	Room	x		
Boilers	MER			x
Boiler Feed System	MER			x
Chillers	MER			x
Condensers	Rooftop			x
Cooling Towers	Rooftop			x
Dehumidifiers	MER		x	x
Diesel Eng.	MER			x
Diffusers	Room	x		
Electric Motors	MER			x
Elevators	Varies	x	x	x
Escalators	Varies	x	x	x
Fans	MER		x	x
	Room	x		
Furnaces	MER			x
Gas Turbines	MER			x
Heat Pumps	MER			x
Humidifiers	MER		x	x
Mixing Boxes and Air Control Units	Varies	x	x	
Pneumatic Transporter System	Varies		x	x
Pumps	MER			x
Steam Valves	MER			x
Transformers	MER			x
Unit Vent and Unit Heat	Room	x		

*Mechanical Equipment Room

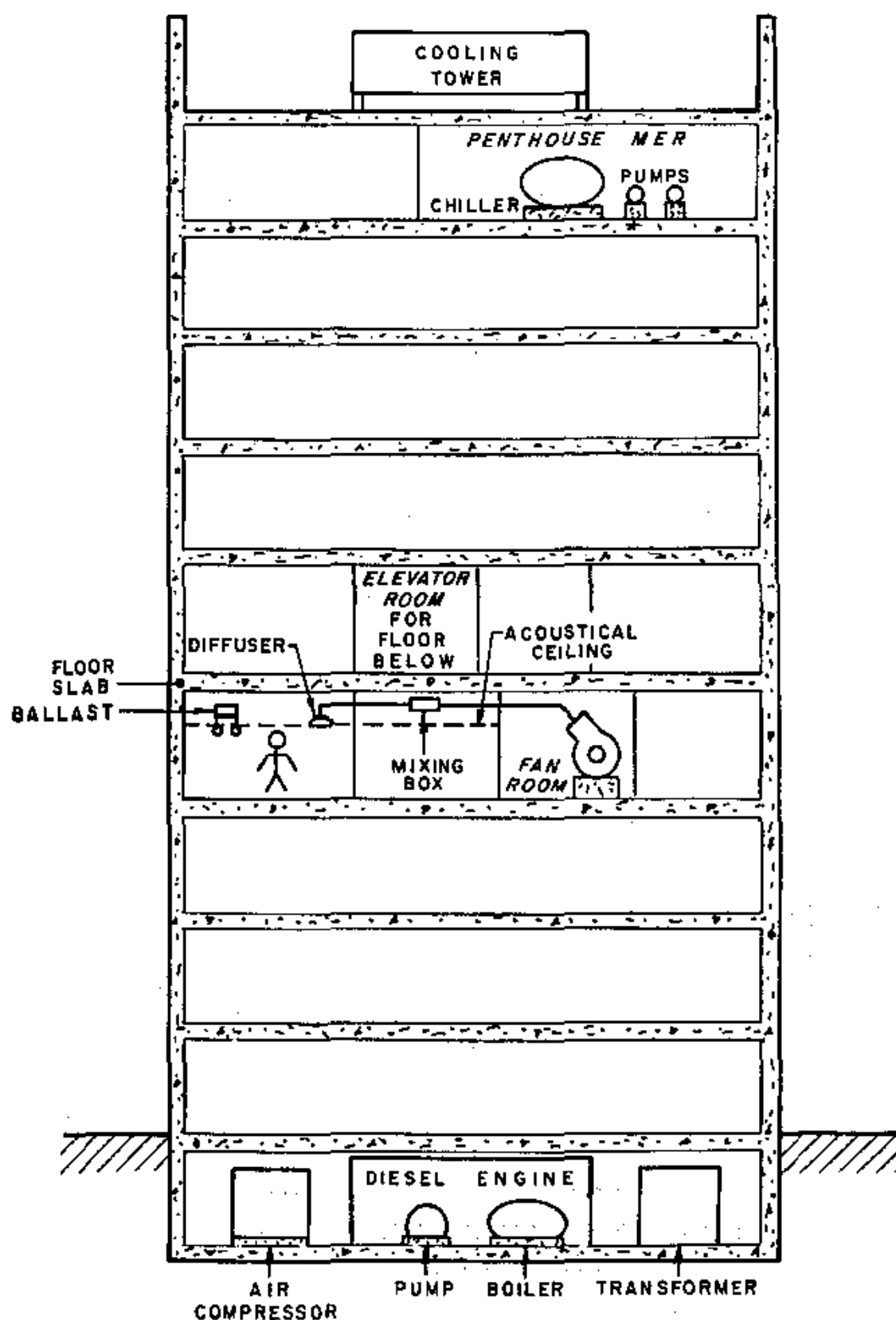
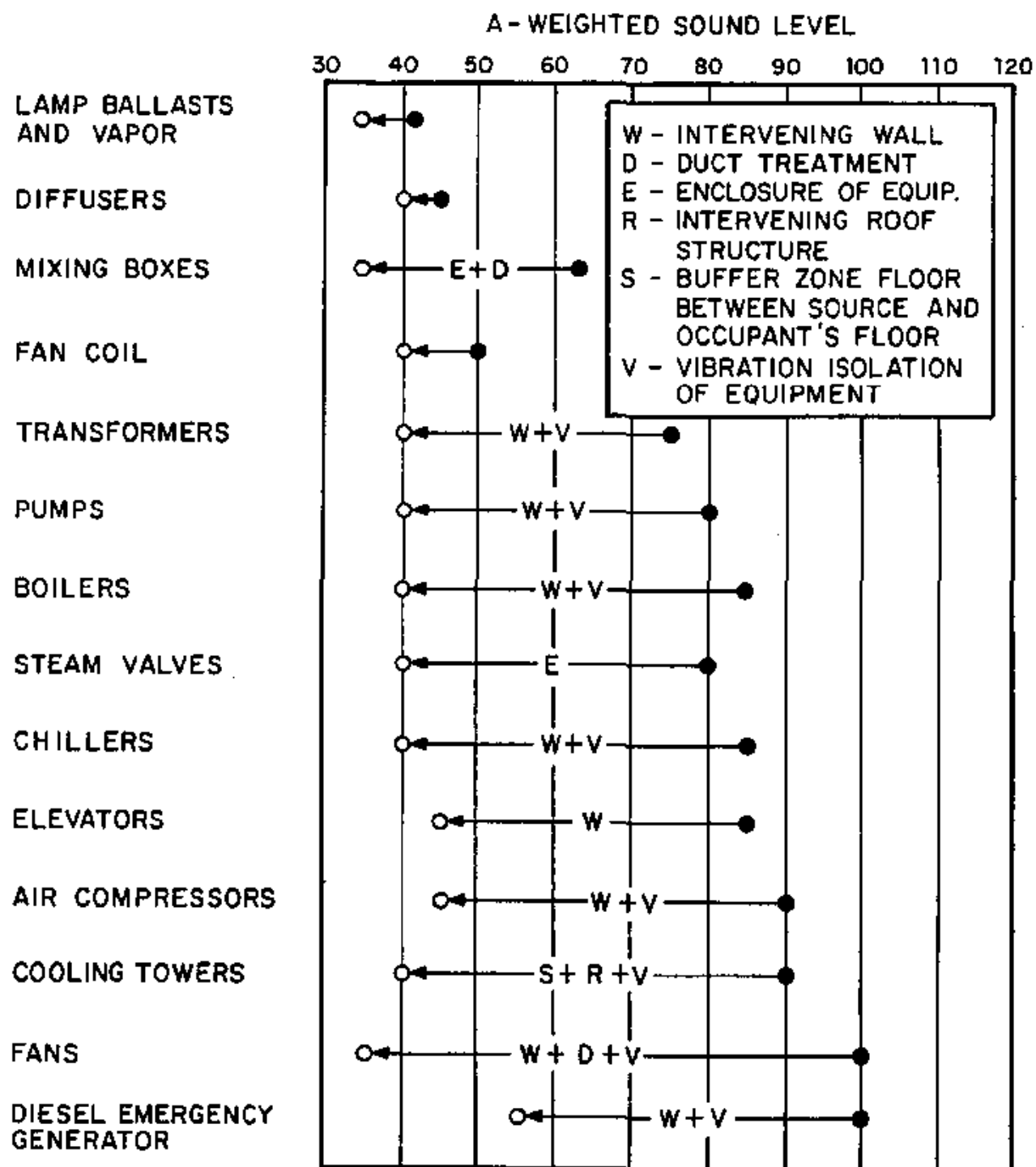


FIG. 18. CROSS-SECTION OF A TYPICAL MULTISTORY BUILDING SHOWING BUILDING EQUIPMENT.



● SOUND LEVEL AT 3 FT FROM SOURCE
 ○ SOUND LEVEL AT OCCUPANT'S POSITION

FIG. 19. RANGE OF BUILDING EQUIPMENT NOISE LEVELS TO WHICH PEOPLE ARE EXPOSED.

R - roof slab

S - intervening story - e.g., the penthouse mechanical equipment floor

V - vibration isolation.

Goals for acceptable noise levels vary with the activities to be held in a space. If one is interested in increasing the speech privacy within an office, then a higher noise level of an appropriate spectral shape would be appropriate. On the other hand, if one is performing certain types of tests or listening to critical sounds, a quieter environment is required. Through the use of current technology, it is possible to achieve virtually any noise goal, if the owner of the building is willing to bear the cost and space requirements of the treatment. Of course, by specifying quiet equipment, the owner may minimize these requirements.

3. IMPACT

3.1 Noise Level Criteria for Impact Evaluation

In this report, the impact of noise exposure upon people is evaluated primarily in terms of three direct effects and secondarily in terms of a number of indirect consequences. The three major effects are hearing-damage risk, speech interference, and sleep interference. The rationale for emphasizing these effects is twofold. First, they are among the most salient and tangible consequences of noise exposure and thus can be most readily interpreted in nontechnical terms. Evidence that they are widely understood by the public may be found in their frequent mention in noise complaints. Secondly, research on these three effects has been more extensive than on other noise effects; therefore, clearer predictions can be made with greater confidence.

Although the three primary effects are used to summarize the major impact of noise exposure, the indirect consequences of exposure also demand consideration. These effects include physiological stress, annoyance, startle, and task interference. They are termed "indirect" in that they are not produced exclusively by noise, nor are they simple functions of the physical magnitude of noise exposure. Further, relatively little systematic information about these effects is available; thus, specification of precise levels of noise exposure leading to particular levels of effect is a somewhat speculative matter. However, one may not assume that these secondary consequences are unimportant merely because they are difficult to quantify.

The following table presents the physical levels at which it is felt that each of the above-mentioned effects of noise exposure achieves (1) a moderate level of effect and (2) an appreciable level of effect. The decisions leading to these specifications are discussed below.

TABLE VIII. ESTIMATES OF MAGNITUDES OF NOISE EFFECTS
[IN dB(A)]

<u>Effect</u>	<u>Moderate Level</u>	<u>Appreciable Level</u>
Hearing Damage Risk	70	90
Speech Interference	45	60
Sleep Interference	40	70
Physiological Stress	*	90
Startle	*	110
Annoyance	40	60
Task Interference	55	75

3.1.1. Hearing-damage risk

The hearing-damage risk levels specified in Table VIII were selected on the basis of eight hours of daily exposure. Exposure durations of this order are chosen as representative of the amount of time usually spent in home and work environments. Since hearing-damage risk is cumulative over long periods of time [13], the recommendations are intended to account for prolonged noise exposure over a period of years.

The estimate of the level at which hearing-damage risk commences was determined on a rather stringent basis. The Walsh-Healey Public Contracts Act, as amended to include noise limits for hearing conservation, is based on a CHABA report [14], which permits permanent threshold shifts up to 10 dB at frequencies

*Effects at low levels are at best weak functions of the physical intensity of noise. They are determined far more strongly by factors such as the meaning associated with the acoustic signal, attitudes toward the source, rise time of the signal, unexpectedness of the signal, and so forth. It therefore makes little sense to specify discrete levels in these cases.

below 1000 Hz; up to 15 dB at 2000 Hz, and up to 20 dB at frequencies above 3000 Hz. Hearing losses of these magnitudes are considered inconsequential in the sense that they are ineligible for compensation under the terms of the legislation. Even these surprisingly lax limits are based on the questionable assumption of a sixteen-hour daily recovery period of little or no noise exposure [13]. Further, the CHABA report [14] is intended to afford this partial protection to only half of the population exposed to noise. Clearly, these criteria are neither applicable to individual circumstances nor capable of protecting many people from sizeable hearing losses.

Kryter's published redefinition of the hearing-damage risk criteria [15] maintains that no permanent threshold shift whatever is tolerable at frequencies below 2000 Hz and that no more than a 10 dB shift is tolerable at higher frequencies. Kryter also applies the protection afforded by his definition to 75% of the population rather than 50%. He states that the "threshold" of hearing-damage risk for eight hours of daily exposure is 67 dB(A). Cohen *et al* [13] operating under similar assumptions specify 75 dB(A) as the level at which hearing-damage risk commences. Miller [16] believes that a level of 70 dB(A) represents a level of noise exposure above which hearing-damage risk becomes nonnegligible. In Miller's terminology, habitual exposure to levels between 70 and 80 dB(A) represents yellow (i.e., cautionary) risk of hearing damage, exposure to levels between 80 and 90 dB(A) entails "orange" risk; while exposure to levels in excess of 90 dB(A) involves "red" (serious) risk.

The estimate of Table VIII for the onset of hearing-damage risk agrees with Miller's estimate. The estimate of the level at which appreciable risk of hearing damage occurs agrees both

with Miller's estimate and the provisions of the Walsh-Healey Act. The latter criteria, based on a report of the NAS-NRC Committee on Hearing, Bioacoustics, and Biomechanics [14], indicates that eight hours of daily exposure to levels in excess of 90 dB(A) constitutes a serious risk of hearing damage to one-half of the population.

3.1.2 Speech interference

The levels specified in Table VIII for speech interference are the most straightforward and readily defensible of all of the estimates. A criterion for adequate verbal communication in the home was taken to be comprehension of 98% of all sentences or an equivalent rate of comprehension of 85% of the words of a standard phonetically balanced (PB) list. In terms of nominal vocal effort [approximately 65 dB(A) at a distance of one meter], such a level of speech intelligibility would be sustained at a speaker-listener distance of approximately five meters in a noise background of 45 dB(A) [17]. Five meters was taken to be the maximal distance at which conversation in normal levels might reasonably be expected to be held in a quiet outdoor (nonreverberant) environment.* The level of appreciable effect specified in Table VIII was derived by assuming that noise-induced speech interference would be intolerable if conversation at nominal levels of vocal effort were precluded at speaker-listener distances greater than one meter. Such conditions prevail in noise environments in excess of 60 dB(A) [17].

*Greater speaker-listener distances would be possible indoors at the same levels of vocal effort and speech intelligibility, because sound pressure levels diminish more slowly than predicted by the inverse square law.

It should be pointed out that selection of the above criterion represents a belief that the 70% comprehension of PB words suggested by Webster [17] and Beranek [18] does not provide for a reasonable standard of communication in the home. Webster's criterion was established for "barely adequate communication" and is inappropriately applied to the home environment. The levels recommended in this report are thus 6 dB lower than Webster's.

3.1.3 Sleep interference

Two principal ways in which noise exposure can interfere with sleep are to delay the onset of sleep and to shift sleep "stages". Scores of studies are available on the sleep-delaying and stage-shift effects of noise exposure. Although there is frequently broad agreement among studies, detailed agreement is lacking. Discrepancies among outcomes of similar studies are attributable to incomparable control conditions, differences in experimental design, and the host of individual differences which beset sleep research.

For example, it is universally observed that the initial time required for subjects to fall asleep increases monotonically with exposure to increasing noise levels. Unfortunately, different studies produce estimates of the sleep-delaying effects of noise that are more than 35 dB apart. Thus, two studies report delays in onset of sleep from 20 to 90 minutes [19,20], corresponding to exposure to continuous noise at levels of 35 dB(A) and 50 dB(A), respectively. Other studies, [21-23] however, report that subjects can fall asleep in as little as twelve minutes despite exposure to noise levels of 70 dB(A).

Further, prolonged exposure to high noise levels can produce tinnitus (ringing in the ears), which has been claimed to delay

the onset of sleep [24]. In other words, aftereffects of noise, even in the absence of any noise exposure at bedtime, can impede sleep. It is also claimed in the literature that levels as low as 35 dB(A) can either induce a shift from a "deeper" to a "lighter" level of sleep or awaken certain people [25]. Pronounced differences in sensitivity to noise during sleep have been observed as a function of age as well.

An absolute criterion for noise exposure levels in sleeping quarters is obviously unjustifiable on the basis of extant research. A conservative criterion for noise exposure (from the point of view of minimizing sleep interference) might be based on the lowest levels at which sleep interference have been reported. According to the Wilson Report [26], levels of 40 dB(A) have been known to awaken approximately 25% of the sleeping population, while levels of 45 dB(A) appear to keep about 20% of the population from falling asleep immediately. These considerations have led to the adoption of 40 dB(A) as a criterion level for the onset of sleep interference effects. According to the Wilson Report data, a little more than half of the population may be awakened by noise exposure to levels of 70 dB(A), while a little less than half of the population will find some difficulty in falling asleep when exposed to such levels. These data led to adoption of 70 dB(A) as the level at which sleep interference effects become considerable.

3.1.4 Physiological stress

The amount of stress produced by low-level acoustic signals is primarily determined by their meaning. A footfall in one's bedroom at night, or a growling animal, or one's boss's voice can excite stress mechanisms by virtue of their implications rather

than their physical attributes. Since it is the learned and instinctive associations to sounds which are largely responsible for their ability to create stress, no level of minimal effect has been specified.

At high noise levels a somewhat stronger case may be made for specification of a criterion. Studies of physiological correlates of noise-related stress in animals suggest that noise levels in the vicinity of 90 dB(A) produce strong effects [27]. Pupillary dilation, increased pulse pressure and heart rate, and pulse volume changes have been observed in humans exposed to noise levels of approximately 70 dB(A) [28]. There can be little argument that at even higher levels noise stimulation induces stress in and of itself, rather than as an exclusive function of its meaning. Extremely intense noise fields can cause auditory and bodily pain. Such intense fields commonly are associated with strong vibrational components, which can also be harmful.

3.1.5 Startle

The arguments above about the relative roles of meaning and levels of acoustic signals in determining stress also apply to startle. For the same reasons, therefore, no minimal level of effect can be specified.

A major obstacle to establishing a firm criterion for the startling effects of high level noise is the phenomenon of habituation. In general, humans display a marked decrease in sensitivity to repeated exposure to startling sounds. Expectedness, regularity, familiarity, arousal level, and numerous other factors strongly mediate startle effects. Even at high absolute noise levels, startle is as much affected by signal-to-noise ratio considerations as it is by the level of the startling signal.

Thus, an exploding paper bag would almost certainly produce more startle in a library than in a boiler factory.

The level recommended in Table VIII is therefore chosen to represent a noise level sufficiently rarely heard and of a signal-to-noise ratio sufficiently great to make a significant startle reaction highly probable.

3.1.6 Annoyance

The levels recommended in Table VIII for gauging annoyance effects are intended to reflect the lowest level at which any of the other tabled effects can occur. In other words, one is expected to be annoyed by a noise sufficiently intense to produce sleep interruption, speech interference, etc.

It is, of course, also true that long-term exposure to very low level noises can be annoying. A dripping faucet or a chalk squeak can be exceptionally irritating. Once again, however, it is the meaning of the acoustic signal rather than its level *per se* which plays a major role in determining the magnitude of annoyance. Also, the spectral composition and temporal density of noise heavily influences its annoyance value. Unfortunately, temporal and spectral factors cannot be adequately expressed in dB(A).

3.1.7 Task interference

The literature on the effects of noise on human performance contains numerous conflicting and inconclusive reports. By and large, high-intensity, aperiodic, intermittent noise is reported to impede efficient work to a greater extent than low-intensity, steady-state noise [29]. Nonetheless, numerous studies find no effects of noise on performance, while a few studies find

paradoxical improvements in performance attributable to noise exposure [30]. Of course, improvements in performance when an environment is changed (presumably worsened) are often due to changes in the level of attention perceived by the subject and their attendant reaction. The nature of the task at hand and the duration of noise exposure also influence the extent of task interference.

It is our feeling that the most sensitive and complex tasks (of the nature of brain surgery, diamond cutting, etc.) might be sensitive to interference from noise at levels as low as 55 dB(A). Although most published studies which report task interference give levels in the vicinity of 90 to 110 dB(A), it is felt that certain tasks might prove susceptible to appreciable interference at approximately 75 dB(A).

3.2 Construction Noise

3.2.1 Extent of exposure

Our determination of the impact of construction noise on the American public is based on information obtained about the number of people exposed to such noise and the extent of their exposure. This information was gathered in four steps:

- We determined the number of construction sites of various types in various geographical regions.
- We determined the density of people in the geographical regions (two classes of people were considered: stationary population such as workers and residents and transient population such as drivers and pedestrians).
- We postulated a model of sound propagation around a typical construction site.

- We combined the information obtained in the first three steps with the site source level data presented in Sec. 2.1 to determine the number of people exposed to given levels of noise.

For the purpose of gathering and analyzing population and construction site statistics, we divided the U.S. into five regions. These regions are based on those defined by the U.S. Bureaus of the Budget [31] and of the Census [32]. A key to understanding the rationale used for establishing these regions is the concept of Standard Metropolitan Statistical Area (SMSA). An SMSA is a group of contiguous counties which contains at least one central city of 50,000 inhabitants or more, or "twin cities" with a combined population of 50,000 or more. There are 233 SMSAs containing 65% of the nation's population and about 10% of the land area. The population density in the nonmetropolitan areas is too low to create much construction noise exposure or to allow meaningful computation of the exposure that does exist. This study, therefore, restricts itself to construction occurring within the SMSAs (see Table IX).

Classification of Construction Sites

As explained in Sec. 2.1, four major categories of construction were studied:

- Residential buildings
- Nonresidential buildings
- Municipal roads
- Public works

Certain heavy construction and large civil works, such as dams and bridges, were omitted because this type of construction

TABLE IX. METROPOLITAN REGIONS CONSIDERED IN
CONSTRUCTION NOISE EXPOSURE ESTIMATE;
STATISTICS AS OF 1970*

	<u>Population</u> <u>(thousands)</u>	<u>Area</u> <u>(sq. mi.)</u>	<u>Population Density</u> <u>(people per sq. mi.)</u>
Large High-Density Central Cities** (12)	22,250	1,462	15,160
Large Low-Density Central Cities (14)	10,530	2,389	4,410
All Other SMSA Central Cities (186)	25,820	6,981	3,710
Urban Fringe	49,680	14,707	3,380
Met. Area Outside Urban Fringe	22,320	179,276	125

*Population figures are extrapolated to 1970 from 1969 Census figures according to recent growth rates.

**Large cities are those whose metropolitan area population exceeded 1,000,000 in 1960.

High-Density: Baltimore, Boston, Buffalo, Chicago, Cleveland, Detroit, New York, Philadelphia, Pittsburgh, San Francisco, St. Louis, Washington.

Low-Density: Atlanta, Cincinnati, Dallas, Denver, Houston, Kansas City, Los Angeles, Milwaukee, Minneapolis-St. Paul, Miami-Ft. Lauderdale, New Orleans, St. Petersburg-Tampa, San Diego, Seattle-Tacoma.

rarely takes place in heavily populated areas. The residential and nonresidential building categories were further subdivided into specific types of buildings to account for variations in the duration of construction and the mix of machinery at different kinds of sites.

The Number of Construction Sites

Data on the annual number of building sites on which construction was begun in 1970 was collected from the U.S. Business and Defense Services Administration [33] and from unpublished compilations made by the Bureau of the Census. Data for large central cities and for the nation as a whole were directly available; sites were ascribed to "other central cities", "urban fringe", and "nonurbanized metropolitan area" on the basis of population distribution. The number of residential and nonresidential building sites in the five metropolitan-area regions is shown in the first two columns of Table X, as well as the average cost of construction for each case. A more detailed breakdown by type of building is given in Appendix B.

Data on total municipal road construction [34] was apportioned among the various metropolitan regions by assuming a constant ratio of miles of road constructed to miles of road in place. The number of miles of such work performed in 1969 is shown in the third column of Table X.

Unlike the case with buildings and roads, data on construction and maintenance of public works such as sewers and water mains is not collected on a national basis. The extent of this construction, therefore, has been estimated first by determining the ratio of sewer construction to street construction for several cities in the Boston area and then by using this ratio to

TABLE X. ANNUAL CONSTRUCTION ACTIVITY - 1970*

Metropolitan Regions	Residential Buildings (no. of sites)	Nonresidential Buildings (no. of sites)	Municipal Streets (miles)	Public Works (miles)
Large high-density central cities	8,708	1,952	273	398
Large low-density central cities	21,578	4,903	2,350	3,140
Other central cities	102,559	12,021	6,000	8,700
Urban fringe	262,800	30,915	11,800	16,865
Met. area outside urban fringe	<u>118,779</u>	<u>13,758</u>	<u>21,700</u>	<u>31,550</u>
Total	514,424	62,549	41,923	60,653

* All figures are in thousands.

estimate the miles of sewer construction nationwide for 1970. These figures are contained in the fourth column of Table X. A more detailed description of this computation is contained in Appendix B.

Construction Phases

Construction of buildings and other works is carried out in discrete stages, each of which has its own characteristic mix of equipment. Because of the items of equipment on a site change as construction progresses, the noise output from the site also changes with time. As explained in Sec. 2.1, we have characterized the noise output from each site according to construction phase:

- Clearing and demolition
- Excavation
- Placement of foundations
- Erection of frame, floors, roof, and skin
- Finishing and cleanup.

These phase descriptions are used for road and sewer construction, even though the actual operations are different from those for buildings, so as to allow a consistent analysis of the various types of sites. (See Sec. 2.1 for a more complete description.) A list of the equipment commonly found in each phase is given in Table A-1.

Number of Individuals Exposed

We obtained the number of people exposed to various levels of noise from construction sites by combining information on

population density, the number of sites active per year, and the sound propagation model described below.

We revised the population figures in Table IX, which represent the residential distribution of the U.S. population, to reflect the net transfer [35] of people from suburbs to central city during the average working day, the period when most construction noise is produced. These revised density figures are given in Table XI in terms of people per square mile and people per one-eighth mile of street (assuming the entire metropolitan area to be divided into city blocks one-eighth of a mile long).

TABLE XI. GEOGRAPHICAL DISTRIBUTION OF
WORKING-DAY POPULATIONS

	<u>People per square mile</u>	<u>People per 1/8 mile of street (approximate)</u>
Large high-density central cities	16,650	120
Large low-density central cities	4,860	40
All other central cities	4,070	32
Urban fringe	3,100	24
Met. area outside urban fringe	114	--

Note that the number of people per city block in the metropolitan area outside the urban fringe is negligible and therefore is disregarded in the following discussions.

In addition to the working-day population density estimate given in Table XI, we must also account for the number of passers-by who are exposed to construction noise. Since there are no data on typical driver and pedestrian distributions, a definitive estimate of this type of exposure is not possible. We have, however, made an order-of-magnitude estimate on the basis of some survey work performed by the Boston Traffic Department (1970). Although incomplete, these surveys report seemingly reasonable numbers, which are therefore offered in Table XII as preliminary estimates.

TABLE XII. NUMBER OF PEOPLE PER DAY
PASSING A CONSTRUCTION SITE

	<u>Drivers and Passengers</u>	<u>Pedestrians</u>
Large high-density central cities	3000	1000
Large low-density central cities	3000	1000
Other central cities	1500	500
Urban fringe	500	100

Table XIII presents the total number of building construction sites active in 1970 (see Table X) for all metropolitan regions. In the case of roads and sewers, the definition of a "construction site" is somewhat obscure, since such projects extend linearly for some distance with construction usually occurring one section at a time. The area of influence of construction on one section is about one-eighth of a mile. We therefore consider each eighth-mile of street and sewer construction as an independent site.

TABLE XIII. LEVEL OF ANNUAL CONSTRUCTION ACTIVITY

<u>Type of Site</u>	<u>Number of Sites (National Total)</u>
Residential Building	514,424
Nonresidential	62,549
Municipal Streets	336,000
Public Works	485,000

The level of exposure to noise from a construction site depends on one's distance from the site and the nature of his immediate environment. In city streets, it has been found experimentally that sound intensity decreases as the inverse square of the distance from the source [36]. In logarithmic units, this amounts to a 6 dB reduction per distance doubled. This model has been adopted for open-air propagation, which is significant in the case of pedestrians. In addition, a factor of 20 dB(A) attenuation has been included for people who are inside buildings with closed windows and 15 dB(A) for people inside cars with closed windows [37]. Construction noise is assumed to propagate along the street adjacent to the site, but to be heavily attenuated in the direction transverse to the street; in effect, only the people along the street adjacent to the site are affected by the noise. A further assumption is that the sound is reduced 10 dB(A) when one crosses a street intersection [36].

Using these parameters, we illustrate in Fig. 20 a representative geometry for a building construction site and contours of attenuation for observers. Details of the computations involved in constructing this diagram are given in Appendix B. Assuming a uniform distribution of observers along the sides of

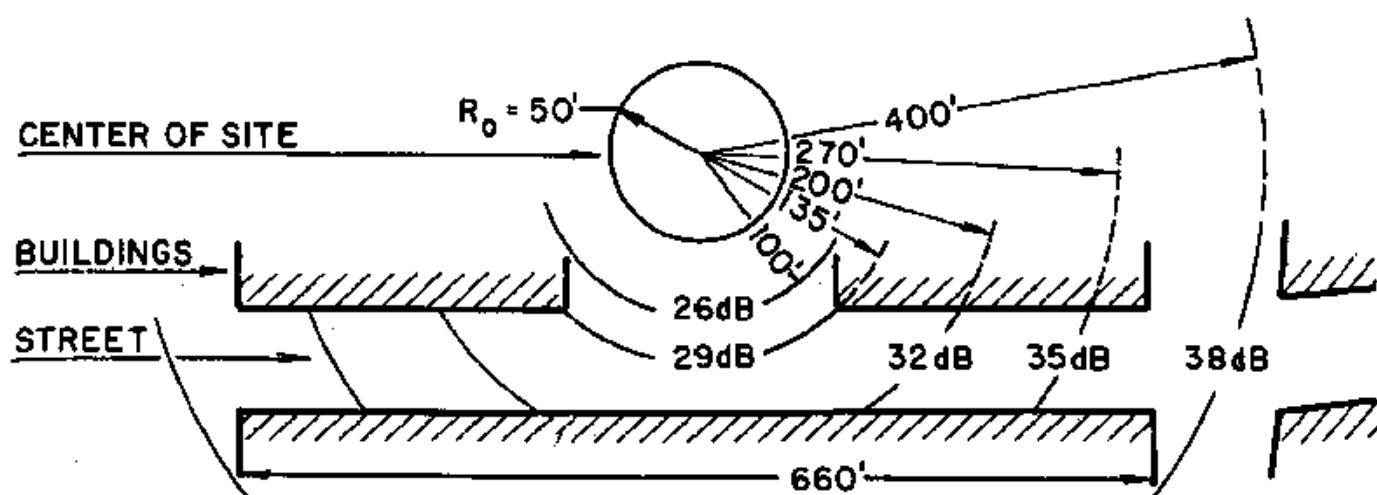


FIG. 20. CONSTRUCTION SITE GEOMETRY AND ATTENUATION CONTOURS FOR A STATIONARY POPULATION WITHIN BUILDINGS. (SEE APPENDIX B FOR METHOD OF COMPUTATION.)

the street, we can determine the fraction of people within each set of attenuation contours. These proportions, which are shown in Table XIV below, apply only to observers in buildings with closed windows adjacent to the street on which building construction is taking place; drivers and pedestrians move relative to the site, crossing contours as they go.

TABLE XIV. DISTRIBUTION OF STATIONARY OBSERVERS
RELATIVE TO ATTENUATION CONTOURS

<u>Attenuation Interval</u>	<u>Percent of Observers</u>
26 - 29 dB	15%
29 - 32 dB	35%
32 - 35 dB	32%
35 - 40 dB	18%

All observers more than 40 dB away from the site have been disregarded, as they are assumed to be unaffected by the noise. The actual number of people within each pair of attenuation contours can be obtained by multiplying the percentages in Table XIV by the number of people per 1/8 mile of city street for the appropriate metropolitan area (as given in Table XI).

In the case of street and sewer construction, operation is typically distributed along the length of the street and cannot be modeled as a point source. Accordingly, all the people in the eighth-mile of city street adjoining the site are assumed to be exposed to the same noise level. This level is taken to be the source level of the site diminished 20 dB to account for attenuation within buildings with closed windows.

The noise exposure of pedestrians and drivers cannot be computed by the above model, since, as noted above, their distance from the site varies with time. In these cases, we consider the peak exposure experienced by the transient observer. For pedestrians, this exposure is 6 dB less than the site source level referenced to 50 ft; for drivers, it is 20 dB less.

Noise Exposure Estimates

The above figures on observer densities, number of sites, and attenuation have been combined with the data on average and peak site source levels presented in Sec. 2.1 to determine the number of people exposed to particular levels of noise. Table XV shows the national noise exposure of the stationary population due to residential building, nonresidential building, municipal street, and public works construction. The noise levels are broken down into the five phases of construction described above.

To compute exposure of drivers and pedestrians, one multiplies the number of people per day passing each site by the number of sites. This gives the number of passersby exposed per day of site operation. Multiplying this number by the average number of days each site is operated gives the total annual number of instances in which an individual passes a construction site and is thus exposed to noise. For this computation, we use the number of sites from Table X and the number of passersby from Table XII. The duration of construction on the average site is not available from survey data but the following figures are considered typical:

- Residential buildings (single-family only) - 27 days
- Nonresidential buildings and multifamily dwellings - 170 days
- Streets and Public Works - 7 days.

TABLE XV. AVERAGE AND PEAK EXPOSURE LEVELS TO CONSTRUCTION NOISE

<u>Number of People</u>	<u>Average Levels</u>					<u>Peak Levels</u>				
	<u>Construction Phase</u>					<u>Construction Phase</u>				
	I	II	III	IV	V	I	II	III	IV	V
RESIDENTIAL BUILDING CONSTRUCTION										
1,725,000	56.5	54.5	54.5	47.5	54.5	63.5	70.5	57.5	57.5	70.5
4,025,000	53.5	51.5	51.5	44.5	51.5	60.5	67.5	54.5	54.5	67.5
3,680,000	50.5	48.5	48.5	41.5	48.5	57.5	64.5	51.5	51.5	64.5
<u>2,070,000</u>	47.5	45.5	45.5	38.5	45.5	54.5	61.5	48.5	48.5	61.5
11,500,000										
NONRESIDENTIAL BUILDING CONSTRUCTION										
225,000	56.0	57.5	50.5	51.0	56.5	63.5	70.5	60.5	60.5	70.5
525,000	53.0	54.5	47.5	48.0	53.5	60.5	67.5	57.5	57.5	67.5
480,000	50.0	51.5	44.5	45.0	50.5	57.5	64.5	54.5	54.5	64.5
<u>270,000</u>	47.0	48.5	41.5	42.0	47.5	54.5	61.5	51.5	51.5	61.5
1,500,000										
MUNICIPAL STREET AND PUBLIC WORKS CONSTRUCTION										
14,500,000*	63.0	65.0	68.0	58.0	64.0	71.0	78.0	71.0	69.0	71.0
FEDERAL AND STATE HIGHWAY CONSTRUCTION										
7,000,000*	63.0	65.0	68.0	58.0	64.0	71.0	78.0	71.0	69.0	71.0

*Assuming homogeneous exposure of all people indoors with windows shut.

The estimated number of occasions per year in which a driver or pedestrian passes a site is shown in Table XVI below. These figures do not represent the number of people who pass construction sites, since one person may pass many sites, or one site many times. If one divides the grand total of Table XVI, 24.7 billion passings, by the total national metropolitan population of 137 million, it is seen that the average inhabitant of metropolitan areas passes a construction site approximately 180 times per year.

3.2.2. Impact assessment

Determining the impact of construction noise on people is a multistage process. The procedures by which estimates of levels and durations of noise exposures were derived are discussed in the preceding section (3.2.1). Development of the criteria by which the severity of noise effects are judged is discussed in Sec. 3.1. In this section, we explicitly combine the exposure data with the criteria; Appendix B contains a number of important comments on the inferences which may be prudently drawn from the findings reported here.

Table XV of Sec. 3.2.1 and Table XVII of this section provide an overview of the exposure data as they pertain to impact assessment. The tables contain information about the number of people who receive primary and secondary exposure to construction site noise and the levels of noise to which they are exposed *in their listening environments*. Estimates of the duration of noise exposures are also presented in the tables. The following discussion is organized according to strength of impact.

TABLE XVI. ESTIMATED ANNUAL PASSINGS OF CONSTRUCTION SITES -
ALL METROPOLITAN REGIONS* (MILLIONS OF OCCURRENCES)

	<u>Residential Buildings</u>	<u>Nonresidential Buildings</u>	<u>Municipal Streets and Public Works</u>	<u>Total</u>
Drivers and Passengers	8,300	8,160	1,980	18,440
Pedestrians	2,760	2,700	882	<u>6,342</u>
			Grand Total	24,782

*A "passing" is defined as one person passing one site by car or foot.

Speech Interference

Perhaps the single most obvious effect of exposure to construction site noise is speech interference. Even cursory examination of Table XV reveals that in almost all phases of construction, noise levels associated with construction activity are capable of degrading speech communication. In many instances -- specifically, those in which construction noise produces levels approaching or exceeding 60 dB(A) in the listening environment -- degradation of speech communication is severe. When one considers that the "average" levels of Table XVII are energy averages, it is clear that peak levels of construction noise, although infrequent, can preclude speech communication completely.

It is apparent from Table XVII that for those people who live or work in the vicinity of construction sites (i.e., those who receive primary exposure to construction noise), the duration of speech interference effects can be considerable. It seems safe to state that approximately 3¹/₂ million people suffer a total of several hundred hours of speech interference yearly as a result of exposure to construction site noise in the United States. Approximately 20 million of these people must communicate in noise environments which seriously degrade speech intelligibility and/or demand significantly increased vocal effort.

In contrast to those who must endure such speech interference on a relatively long term basis, there are many more people who suffer the same effects on a briefer time scale. These people are the passersby who are exposed to construction site noise for a matter of minutes daily. Although the actual number of different individuals who pass by construction sites on foot or in vehicles is difficult to estimate, there are probably on the order of 25 billion such brief encounters yearly. The prin-

TABLE XVII. ORDER OF MAGNITUDE ESTIMATES OF YEARLY DURATION OF
CONSTRUCTION NOISE EXPOSURE

<u>Source</u>	<u>Number of People</u>	<u>Hours of Exposure by Construction Phase</u>				
		I	II	III	IV	V
Primary (Stationary) Exposure to Domestic Construction Noise	11,500,000	24	24	40	80	40
Primary (Stationary) Exposure to All Other Building Construction	1,500,000	80	320	320	480	160
Primary (Stationary) Exposure to All Other Construction in SMSA Areas	14,500,000	8	8	16	16	8
Municipal Public Works		12	12	24	24	12
Federal and State Highway	<u>7,000,000</u>	250	250	500	500	250
Subtotal						
Secondary (Passerby) Exposure of Pedestrians to Construction in All SMSA Areas	6,342,000,000*	Five minutes' exposure to levels approximately 30 dB higher than those of Table XV				
Secondary (Passerby) Exposure of Drivers and Passengers to All Construction in SMSA Areas	<u>18,440,000,000*</u>	Thirty seconds' exposure to levels approximately 15 dB higher than those of Table XV				
Subtotal						

*These figures represent the number of annual occurrences of exposure, defined as the product of the number of people exposed and the frequency of their exposure.

cial effect of such transient exposure to construction noise is probably interruption of conversation.

Applying state-of-the-art noise reduction techniques to the major sources of construction noise could provide a meaningful reduction of both the severity of speech interference and the number of people exposed to speech interference effects. Quieting all construction equipment by 10 dB(A) would lower peak construction noise levels by an equivalent amount and average levels by a somewhat lesser amount (due to overlapping temporal patterns of use). Nonetheless, speech interference effects increase sharply in the range between 40 and 60 dB(A), so that a noise reduction of about 10 dB(A) could be highly beneficial. Interestingly enough, the advantages of reducing construction noise an additional 10 dB(A) might not be as great. Although 20 dB(A) reduction of construction noise would clearly result in even less speech interference than would a 10 dB(A) reduction, at the resulting levels construction noise might well be submerged in background noise a good part of the time. Additional reductions [beyond the first 10 dB(A)] might be necessary for the benefit of those who operate the equipment, however.

Sleep Interference

To the extent that construction activity and sleep do not commonly occur during the same hours, construction noise does not interfere with sleep. However, daytime sleeping needs of the very young, the sick, and people working irregular or night hours, and emergency and other nighttime construction work must be taken into account. The total number of adults so affected by construction is estimated to be about 3 million. Judging from the ratio of people exposed to construction noise to the total population of the country, approximately 15% of the children four years of

age or younger, or about 2.5 million, might also be exposed to sleep interference from construction noise.

The 5.5 million people attempting to sleep during exposure to construction noise are likely to encounter substantial interference. Even at relatively great distances from construction sites, levels in the vicinity of 50 dB(A) are encountered. Such levels are capable of significantly lengthening the time required to fall asleep and of awakening roughly 40% of sleeping persons.

Nonetheless, the usefulness of reducing average construction noise levels by 10 dB(A) (possible through state-of-the-art noise reduction procedures) appears marginal. The number of people whose sleep is disturbed by construction noise is relatively small, and the shallow slope of the function relating the number of people awakened to noise levels argues that construction noise would have to be reduced by much more than 10 dB(A) to effect a significant reduction of sleep interference.

Hearing-Damage Risk

The risk of hearing damage from construction noise for those not directly concerned with construction activity does not seem very great. In most cases the distance between the construction site and people exposed to its noise and the transmission loss of the buildings or vehicles are sufficiently great to minimize the probability of hearing damage. It is possible that peak noise levels from construction sites might present some risk to those who are frequently in close proximity to the site. The greater number of such people (presumably pedestrians), however, are subject only to short exposure durations.

If state-of-the-art noise reduction techniques were applied to the major sources of construction noise, exposure levels would

probably be sufficiently reduced to render hearing damage a remote risk. In short, construction noise does not pose a major hearing-damage risk for the public.

Other Indirect Effects

Without doubt, a major consequence of exposure to construction noise for many people is annoyance. Both those who are exposed to construction noise on a regular, long-term basis as well as those who are exposed to it on a transient basis are annoyed by their exposure. Annoyance is particularly great if the noise intrusion from the construction site is perceived as unnecessary or inappropriate. People who must endure weeks or months of construction noise exposure may exhibit some form of habituation to the noise, but despite the commonly expressed attitude toward noise of "you get used to it", it is doubtful that construction noise ever loses all of its annoyance value.

In relative terms, annoyance from construction noise probably represents less of a problem than annoyance produced by aircraft or traffic noise. Nonetheless, both individual complaint behavior and community action could conceivably result from the annoyance of exposure to construction noise.

One measure formulated to provide some degree of quantification for annoyance due to noise exposure is the Noise Pollution Level [2]. Table I contains NPL's encountered in the immediate vicinity of construction sites. Unfortunately, interpretation of NPL's is not a straightforward procedure. Relative interpretations of two or more noise situations are readily enough made through use of the NPL index. Few grounds exist, however, for absolute interpretations. It has been suggested that long-term exposure to noise levels characterized by an NPL value of 72

(computed from A-level measurements) is "acceptable" [2]. By this criterion, noise levels in the immediate vicinity of construction sites are clearly "unacceptable" on a long-term basis. However, the bulk of exposure to construction noise of such high levels is of a transitory nature. Residents or transients exposed to construction noise would be exposed to levels about 30 dB lower. Although it would be tempting to assert that such exposure (to NPL's in the range of 60-70) would be marginally acceptable, only meager evidence could be marshalled to support such a claim.

It is distinctly possible for exposure to construction noise to result in task interference. It seems plausible that among the approximately 20 million people exposed on a long-term basis to the highest levels of construction noise (Table XV), some might be engaged in exacting manual or mental work which could be sensitive to interference. Such tasks might include medical operations library use, scholarly activities, and the like. Unfortunately, one cannot quantify the amount of task interference produced by construction noise by applying the usual procedures of estimation and assumption.

Similar comments apply to the potential startle and physiological stress produced by exposure to construction noise. Although startle does not seem to be a very common consequence of exposure to construction noise, it is nevertheless possible for startle to result from unexpectedly or intermittently high-level noise. The size of the standard deviations of distributions of construction noise levels discussed in Sec. 3.2.1 makes the occurrence of unusually high noise levels reasonably probable events.

As for the stressful consequences of exposure to construction noise, we can offer only informed conjecture. Noise-induced

physiological stress is known to be cumulative, and exposure to construction noise is only one determinant. Perhaps some of the people who are faced with exposure to construction noise at work every day for months must also face noisy home environments. For such people, exposure to construction noise could constitute a major source of stress.

Tables XVIII and XIX summarize the impact of construction noise on people. A composite quantity intended to reflect both the extent and duration of exposure to specific noise sources was developed to permit concise summation. The quantity is defined as the product of the estimated number of people exposed to noise from a particular source and the estimated duration of individual exposure to the same source. The statistic expressing the quantity is called (for lack of a better term) the "person-hour".

Extreme caution must be used in interpreting figures expressed in terms of person-hours. First, figures so expressed are intended only as order-of-magnitude estimates rather than as precise quantities. Second, inferences about the equivalence of number of people and duration of exposure in assessing psychological or physiological impact are completely unjustified. No compensatory model of number of people exposed and exposure duration is intended. Third, comparison of person-hour figures for exposure to noise from one source with person-hour figures for exposure to noise of another source is without theoretical foundation. Thus, comparisons of impact among different sources expressed in common terms of person-hours should be performed in a fashion similar to "addition" of apples and oranges. In other words, inferences about severity of impact may be drawn only within person-hour estimates of similar origin.

TABLE XVIII. ORDER-OF-MAGNITUDE ESTIMATES OF CONSTRUCTION
NOISE EXPOSURE IN MILLIONS OF PERSON-HOURS PER WEEK

<u>Source</u>	<u>Millions of Person-Hours Per Week</u>
Primary (Stationary) Exposure to Domestic Construction Noise	46
Primary (Stationary) Exposure to All Other Building Construction	39
Primary (Stationary) Exposure to All Other Construction in SMSA Areas	<u>16</u>
Subtotal	101
Secondary (Passerby) Exposure to Pedestrians to All Construction in SMSA Areas	10
Secondary (Passerby) Exposure of Drivers and Passengers to All Construction in SMSA Areas	0.3

TABLE XIX. ORDER-OF-MAGNITUDE ESTIMATES OF IMPACT OF PRIMARY AND
SECONDARY EXPOSURE TO CONSTRUCTION NOISE EXPRESSED IN
MILLIONS OF PERSON-HOURS PER WEEK

<u>Noise Source</u>	<u>Speech Interference*</u>		<u>Sleep Interference*</u>		<u>Hearing Damage Risk</u>	
	<u>Moderate</u>	<u>Severe</u>	<u>Slight</u>	<u>Moderate</u>	<u>Slight</u>	<u>Moderate</u>
	(45-60)	(>60)	(35-50)	(50-70)	(70-80)	(80-90)
Primary (Station-ary) Exposure to Domestic Construction Noise	44			2	0	
Primary (Station-ary) Exposure to All Other Building Construction	38			2	0	
Primary (Station-ary) Exposure to All Other Construction in SMSA Areas	14			1	0	
Secondary (Pass-erby) Exposure of Pedestrians to Construction in All SMSA Areas		10	0			10
Secondary (Pass-erby) Exposure of Drivers and Pas-sengers to all Construction in SMSA Areas		0.3	0			0.3

*Entries in these columns may not be interpreted directly as person-hours of direct speech or sleep interference (see text).

With these restrictions firmly in mind, the reader is referred to Tables XVIII and XIX for a concise summary of the impact of construction noise on people. Table XVIII expresses the impact of construction noise in terms of millions of person-hours per week. (It may be useful to bear in mind that a week in the United States contains approximately 35 billion person-hours.) Table XIX relates the impact of construction noise directly to the principal criteria of Sec. 3.1 in terms of person-hours per week. Entries for speech interference and sleep interference effects reflect the number of person-hours of potential impact, which may be interpreted as upper bounds.

3.3 Appliances

3.3.1 Extent of exposure

This section is concerned primarily with power tools and household appliances whose volume cannot be controlled by the user. Therefore, volume-controllable equipment such as televisions, radios, and stereos are not included, nor are gasoline-engine powered outdoor equipment and audible signaling mechanisms (bells, alarms, etc.). It should be noted, however, that non-controllable noise-producing devices often raise the background level of noise to such a degree that volume-controllable sound has to be increased in level to be heard and, hence, is more apt to affect neighbors. An estimate of the number of noncontrollable noise-producing devices being used in the United States in 1971 is given in Table XX.

To determine the extent of exposure to home appliance and tool noise, we gathered three kinds of data: The distribution of appliances and tools over family units, the time that the devices are typically in use, and the exposure of people who are

TABLE XX. NONCONTROLLABLE HOUSEHOLD NOISE SOURCES (1971) [31]

	<u>Number (thousands)</u>	<u>Percent of Homes</u>
Wired Households	62,800	100
Complete Plumbing	58,000	93
Major Appliances		
Refrigerator	62,600	99.8
Clothes Washer	57,600	91.9
Vacuum Cleaner	56,900	90.7
Clothes Dryer	25,300	40.3
Freezer	20,000	30.0
Air Conditioner	18,000	29.6
Dishwasher	14,900	23.7
Food Disposer	14,100	22.9
Trash Disposer	(introduced in 1970)	
Other Appliances		
Food Mixer	51,200	81.7
Can Opener	27,100	43.2
Sewing Machine	31,300	50.0
Food Blender	19,900	31.7
Electric Shaver	25,000	40.0
Slicing Knife	25,000	40.0
Floor Polisher	10,000	16.0
Power Tools		
Saw, Drill, etc.	12,500	20.0
Outdoor Equipment		
Electric Mower	2,000*	3.2
Edger	1,000	1.6
Trimmer	4,000	6.4
Building Equipment (residential)		
Fan	50,000	80.0
Humidifier	4,600	7.4
Dehumidifier	4,200	6.7

*There are approximately 37 million powered mowers in use.

in the home. In collecting this information, we found that the variables, particularly with regard to personal behavior, covered a very large range. We therefore created a simplified model to show the extent of household noise.

Data were obtained from a variety of sources. Statistical information was collected from government sources, such as the Bureau of the Census. Of particular help was information provided by Cornell University's College of Human Ecology on domestic living patterns. Industry information was obtained from various trade and business publications. Individual company material was used in instances where the material was applicable to the whole industry and was available to the public. Various organizations representing consumers and home economists were contacted. We also conducted our own survey of appliance use in 20 households.

Appliances, Tools, and Building Equipment

The dimensions used by industry to analyze household appliance purchase and use patterns usually include home ownership, age of the head of the family, size of family, and family income. Since these dimensions are interrelated, we chose only one — family income level — for our analysis. We treat the time that appliances are used as a function of the age of the homemaker and of the number of school and pre-school children in the family. Figure 21 shows the trend toward greater use of home appliances and power tools. Figure 22 gives the distribution of some common appliances as a function of income level.

Noise-producing devices used in and around the home are usually classified as

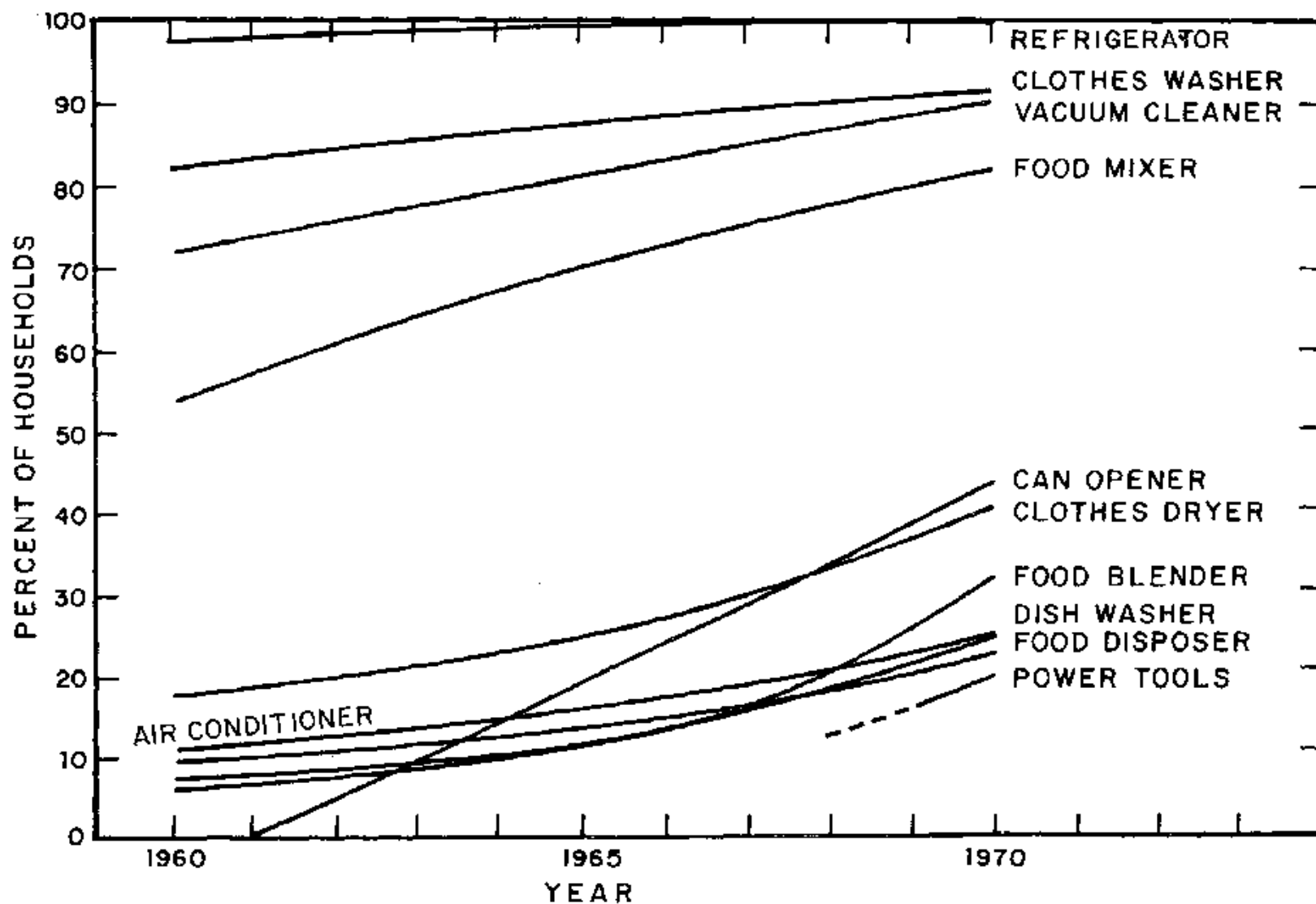


FIG. 21. PERCENT OF HOUSEHOLDS WITH SELECTED NOISE-PRODUCING APPLIANCES AND TOOLS.

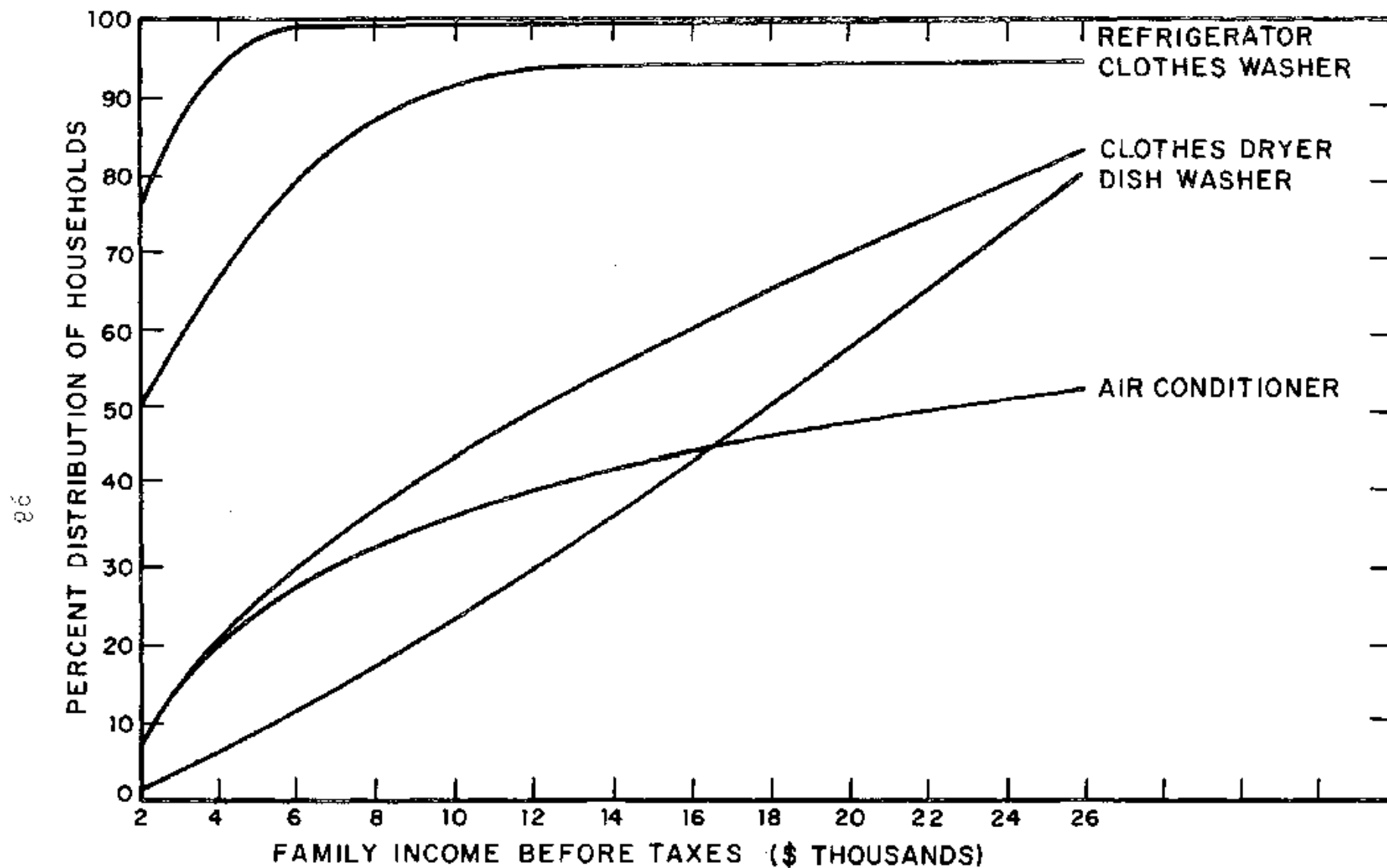


FIG. 22. ESTIMATED PERCENT-DISTRIBUTION OF MAJOR APPLIANCES BY INCOME LEVEL.

- Major Appliances (including clothes washers, clothes dryers, refrigerators and freezers, air conditioners, dishwashers, vacuum cleaners, disposers, dehumidifiers, and compactors)
- Other Household Appliances
- Power Tools
- Outdoor Equipment
- Building Equipment

Other convenient classifications are based on time mode of operation (continuous or intermittent) and method of operation (manual or automatic).

Analysis of the noise-producing building equipment used in homes is complicated by interaction of the equipment with the structure of the house, by do-it-yourself modifications of equipment, and by differences in the adequacy of equipment maintenance. Size of housing is also a factor in noise level. Smaller housing units are apt to be noisier because of reverberant buildup of sound levels. Larger housing units on the other hand, frequently reflecting a higher standard of living, tend to have more appliances and more frequent exposure but lower noise levels for any particular appliance owing to the larger space and to the room separation from the various sources. Multiple-family housing units are subject to higher levels of noise from the building equipment.

In heating systems either the heating source or distribution system or both are common sources of noise; however, the number of factors involved is too great to allow a precise analysis of the extent of heating noise. Electric heating, which is essentially noiseless, is currently being used by 4.4 million customers.

(It should be noted, however, that electric heating customers are likely to be high users of electric appliances. Furthermore, humidity control, ventilating, and/or air cleaning, which are often used in conjunction with electric heating, require air circulation; therefore, fan noise is present where these additional functions are performed.) The more common heating systems generate burner noise, fan/duct noise (in hot-air systems), and pipe, valve, and pump noise (in hot water and steam systems).

Twenty-one percent of all households have one or more room air conditioners. Location of these air conditioners is distributed approximately [38]:

Living Room	35%	Kitchen	7%
Master Bedroom	27%	Playroom	4%
Other Bedroom	5%	Other	22%

All dehumidifiers and many humidifiers are substantial noise sources. Frequently, dehumidifiers are located in the basement and therefore direct exposure to the noise is small. Dehumidifiers are used in 6.7% of homes; humidifiers in 7.4% [38].

Living patterns, equipment installations, etc. are variables that make it difficult to estimate the extent of plumbing noise. The typical range of toilet flushes is 10 to 50 per day. Complete plumbing (hot and cold water, bath or shower, toilet) is found in 82% of all rental units and in 93% of all owner-occupied units in the United States.

The number of fans being used in this country far exceeds the total number of households. Many fans are part of other appliances, but many are used for immediate air circulation (i.e., cooling fans, kitchen fans, etc.).

Use of Domestic Appliances and Tools

The extent to which appliances are used is an important factor in assessing the total noise exposure. Statistical information is scarce, but we have found the following sources useful:

- BBN survey (in-depth study of noise levels and appliance use in 20 homes).
- New York State College of Human Ecology, Cornell University (both published and unpublished data gathered as part of a 1296-household survey of Syracuse, New York).
- Department of Agriculture information based on studies of home activities (a long-term interest, which is now being continued under the Agriculture Research Service Division of the Department of Agriculture).
- Potomac Electric Power Company (an informal survey conducted by their Home Services Department).
- Manufacturer's industry information.

Although many factors affect the range of appliance use, there is a tendency for people in the family-raising years to have increased incomes, own their homes, and possess more appliances. The time a homemaker spends in household activities is a strong function of age, number of children, and the presence of pre-school children, as shown in Table XXI. Table XXII presents the information on which we base our estimate of typical use of appliances; Table XXIII gives our estimate of appliance use in two typical households; appliance operating times are estimated from Table XXII. Using the values of appliance use (total minutes per week) and of average noise levels given in Table XXIII, we present in Fig. 23 a schematic illustration of the noise levels of the two typical households.

TABLE XXI. AVERAGE HOURS PER DAY SPENT ON HOUSEHOLD WORK BY
1296 HOMEMAKERS, ACCORDING TO NUMBER OF CHILDREN AND AGE OF
YOUNGEST CHILD, SYRACUSE, NEW YORK AREA, 1967-68 [39]

	Hours
All homemakers	7.3
<u>Number of children</u>	
0	4.8
1	6.8
2	7.8
3	7.7
4	8.2
5 or 6	8.5
7 to 9	9.2
<u>Age of youngest child</u>	
Under 1 year	9.3
1 year	8.3
2 to 5 years	7.7
6 to 11 years	7.1
12 to 17 years	6.0

Level of Exposure

We have selected two criteria to show different measures of exposure. A *potential exposure* represents the number of people likely to be exposed to an appliance and depends solely on an average distribution of the population and the percentage of households that possess the particular appliance. A *primary exposure* is estimated by the normal mode of operation, the location

TABLE XXII. APPLIANCE USAGE SOURCE DATA (TIMES PER DAY UNLESS INDICATED)

Appliance		Cornell University Data, 1296 Homes* (N.Y. State College of Human Ecology)										Potomac Electric Co., Home Services Dept. (informal estimate for home with 2-3 children)	BBN estimate of use for family with 3 children
		Percent of homes with appliance	Percent used var- ious day (of 1296)	Number of days in one week which appliance was used.									
				0	1	2	3	4	5	6	7		
Clothes washer†			62	135	104	167	197	163	163	178	189	2	1.5
Clothes dryer			43										1
Dishwasher		30		931	4	5	13	33	25	14	272	2	1.5
Food disposer		24	22	1002	1	5	2	5	3	10	268	6-7	6
Vacuum cleaner		97	48	111	211	275	260	164	76	80	119	3/wk	3/wk
Room air conditioner		17											
Trash disposer													
Food mixer }		98	28	277	226	286	207	153	80	28	39	1-2/wk	2/wk
Food blender }												3/wk	3/wk
Can opener												2	2
Sewing machine													1/wk
Slicing knife													1/wk
Floor polisher		48	3	1161	107	17	6	1	0	0	4		1/mo
Electric shaver													1
Power tools (saw, etc.)													2/mo
Mower		72											1/wk
†	No. of Loads	Loads	0	1	2	3	4	5	6	7	8	Ave.	
	on One Day	Homes	502	210	263	159	82	44	18	6	4	1.50	

*Sample selected to give equal numbers of homes with different number of children; therefore, sample shows homes with more persons than national average.

TABLE XXIII. USE OF NONCONTROLLABLE NOISE-PRODUCING APPLIANCES AND
TOOLS IN TYPICAL HOUSEHOLDS

		Household No. 1*			Household No. 2†			
		Average dB(A) ¹	Times Used Per Week ²	Minutes Per Use ³	Total Minutes Per Week	Times Used Per Week	Minutes Per Use	Total Minutes Per Week
Major Appliances								
	Clothes washer	64	10.5	30	315	7	30	210
	Vacuum cleaner	70	3	30	90	2	25	50
	Clothes dryer	57	7	30	210			
	Room air conditioner	58	(full-time - seasonal)					
	Dishwasher	65	10.5	45	472			
	Food disposer	70	6	0.2	1			
104	Household Appliances							
	Food mixer	69	2	5	10	3	5	15
	Can opener	69	14	0.2	2			
	Sewing machine	72	1	15	15	0.5	15	15
	Food blender	76	3	1	3			
	Electric shaver	64	7	2	14			
	Slicing knife	71	1	1	1			
	Floor polisher		1	10	10			
	Trash disposer		14	1	14			
	Power Tools							
	Saw, drill, etc.	83	0.5	20	10			
	Mower		1	30	30			
	Edger	81	0.75	5	4			
	Trimmer	81	0.25	15	4			

*2 Adults, 3 children (1 pre-school age), family income \$16,000.

†2 Adults, family income \$8,000.

¹Measurements taken 3 ft from source during BBN household survey.

²Based on data from BBN survey, Cornell Univ. survey of Syracuse, N.Y., and Potomac Electric Power Company information.

³Based on average cycle times of current model appliances.

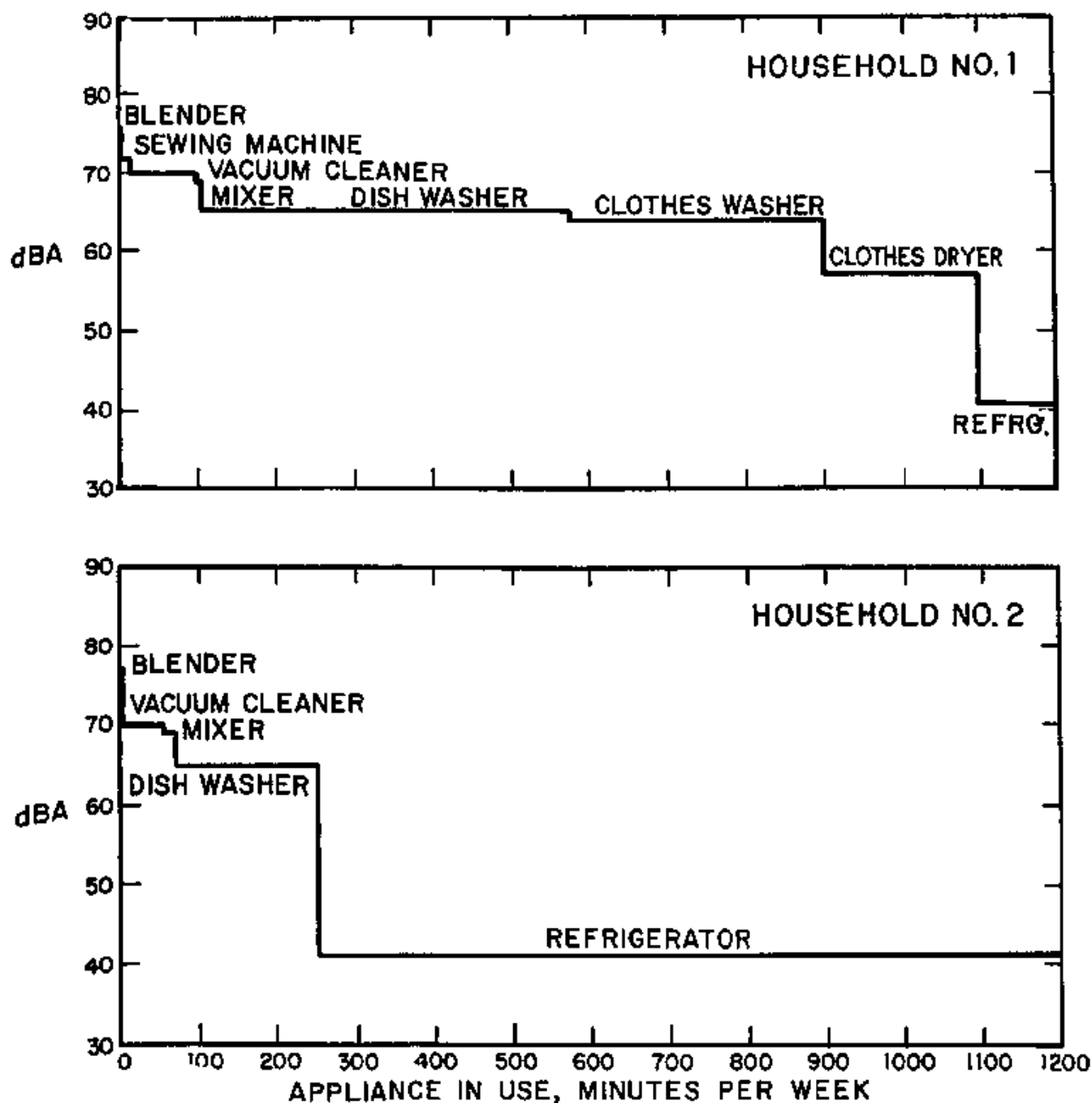


FIG. 23. NOISE PROFILES FROM APPLIANCE FOR TYPICAL HOUSEHOLDS PER WEEK (AT 3 ft)

No. 1: AVERAGE-INCOME FAMILY WITH CHILDREN

No. 2: LOWER-THAN-AVERAGE-INCOME FAMILY WITHOUT CHILDREN

of the appliance, and the number of operators and observers likely to be exposed to noise when the appliance is operating. Table XXIV gives these two kinds of exposure for each appliance; Table XXV relates exposure to income level.

3.3.2 Impact assessment

The estimates of the extensiveness of distribution, duration of exposure, and noise levels of a variety of building equipment and home appliances are discussed here with a view toward assessing the impact of noise from these sources on people in the home environment. To approximate the environment in which noises are heard, we had to adjust the noise levels from the standardized values used in previous sections (i.e., levels recorded at a measurement position 3 ft from the source). Thus, 10 dB was added to the noise levels of hand-held appliances, such as electric shavers, to obtain a fair representation of noise levels at the user's ear. Similarly, 2 dB was subtracted from levels for exposure to noise in a highly reverberant field, such as a kitchen or bathroom; 3 dB from standardized measurements to account for noise exposure in less reverberant spaces, such as carpeted (living room) or open areas; 10 dB from the standard values to compensate for exposure in adjacent rooms connected by open doors; and 20 dB to represent the transmission loss of a typical frame house to noise from external sources (such as powered yard tools). Levels for about thirty typical home appliance and building noise sources adjusted in this manner appear in Table XXVI.

Table XXVII classifies the noise sources discussed in the previous section of this report into four categories: (1) Quiet Major Equipment and Appliances, characterized by operating levels lower than 60 dB(A); (2) Quiet Equipment and Small Appliances,

TABLE XXIV. NUMBER OF INDIVIDUALS EXPOSED TO
INDICATED APPLIANCES (MILLIONS - 1970) [39]

	Potential Exposure	Primary Exposure
Major Appliances		
Refrigerator	199	70
Clothes washer	183	65
Vacuum cleaner	181	66
Clothes dryer	80	28
Freezer	63	23
Air conditioner	60	21
Dishwasher	47	17
Food disposer	46	17
Trash disposer	-	-
Household Appliances		
Food mixer	163	59
Can opener	86	31
Sewing machine	100	36
Food blender	63	23
Electric shaver	80	25
Slicing knife	80	30
Floor polisher	32	40
Power Tools		
Saw, drill, etc.	40	13
Outdoor Equipment		
Electric Mower	6	2
Edger	3	1
Trimmer	12	4
Building Equipment (residential)		
Fan	160	90
Humidifier	15	5
Dehumidifier	13	1

TABLE XXV. ESTIMATED NUMBER OF INDIVIDUALS EXPOSED TO
DOMESTIC APPLIANCE NOISE (MILLIONS - 1965)*

Family Income (\$ thousands)	Typical Appliance Possession	Total House- holds	Potential Secondary Exposure	Potential Primary Exposure			Total Persons Primary Exposed
				"Home- makers"	Children Under 6 yrs.	Night Workers	
Under 5	Mostly only essential	12.6	41	12.6	2.9	0.6	9.9
5 - 10 }	Wide variety of appliances	21.2	71	21.2	6.0	1.0	18.8
10 - 15 }		16.8	55	16.8	5.0	0.8	14.4
15 and over	Often most appliances	12.0	39	12.0	3.8	0.6	10.5
Total		62.8	200	62.8	17.7	3.0	83.5

108

*Calculated from average distributions and income information in Ref. 36.

TABLE XXVI. SOUND PRESSURE LEVELS OF HOME APPLIANCES AND BUILDING EQUIPMENT ADJUSTED FOR LOCATION OF EXPOSURE [IN dB(A)]

<u>Noise Source</u>	<u>Level of Operator Exposure</u>	<u>Level of Exposure to People in Other Rooms</u>
Group I: Quiet Major Equipment and Appliances		
Refrigerator	40	32
Freezer	41	33
Electric Heater	44	37
Humidifier	50	43
Floor Fan	51	44
Dehumidifier	52	45
Window Fan	54	47
Clothes Dryer	55	48
Air Conditioner	55	48
Group II: Quiet Equipment and Small Appliances		
Hair Clipper	60	40
Clothes Washer	60	52
Stove Hood Exhaust Fan	61	53
Electric Toothbrush	62	42
Water Closet	62	54
Dishwasher	64	56
Electric Can Opener	64	56
Food Mixer	65	57
Hair Dryer	66	51
Faucet	66	51
Vacuum Cleaner	67	60
Electric Knife	68	60
Group III: Noisy Small Appliances		
Electric Knife Sharpener	70	62
Sewing Machine	70	62
Oral Lavage	72	62
Food Blender	73	65
Electric Shaver	75	52
Electric Lawn Mower	75	55
Food Disposal (Grinder)	76	68
Group IV: Noisy Electric Tools		
Electric Edger and Trimmer	81	61
Hedge Clippers	84	64
Home Shop Tools	85	75

TABLE XXVII. ORDER-OF-MAGNITUDE ESTIMATES OF THE EXTENT AND DURATION OF
EXPOSURE TO BUILDING EQUIPMENT AND HOME APPLIANCES

	<u>NOISE SOURCE</u>	<u>PRIMARY EXPOSURE*</u>	<u>DURATION[†]</u>	<u>SECONDARY EXPOSURE*</u>	<u>DURATION[†]</u>
Group I: Quiet Major Equipment and Appliances					
	Refrigerator	70	25	200	10
	Fans	90	10	178	5
	Air Conditioner	21	3	80	1
	Humidifier	5	3	15	5
	Clothes Dryer	28	0.5	80	1
	Freezer	23	0.25	20	0.50
Group II: Quiet Equipment and Small Appliances					
	Plumbing (Faucets, Toilets)	200	2	200	5
	Vacuum Cleaner	66	1.5	191	1.0
	Dishwasher	17	5	47	8
	Clothes Washer	65	.5	193	1
	Electric Food Mixer	59	0.15	163	0.10
	Electric Can Opener	31	0.03	86	0.02
	Electric Knife	80	0.02	80	0.01
Group III: Noisy Small Appliances					
	Sewing Machine	36	0.25	100	0.10
	Electric Shaver	25	0.25	80	0.10
	Food Blender	23	0.02	63	0.02
	Food Disposer	17	0.10	46	0.05
	Electric Lawn Mower	2.0	0.50	4	0.25
Group IV: Noisy Electric Tools					
	Home Shop Tools	13	0.10	40	0.10
	Electric Yard Care Tools	5	0.10	10	0.10

*In millions of persons

[†]In hours per week

characterized by noise levels between 60 and 70 dB(A); (3) Noisy Small Appliances, characterized by noise levels between 70 and 80 dB(A); and (4) Noisy Electric Tools, characterized by noise levels in excess of 80 dB(A).

Group I: Quiet Major Equipment and Appliances

Group I contains the noise sources to which people are exposed for the greatest lengths of time in the home environment. Most building climate-control equipment, food-refrigeration appliances, and clothes dryers fall into this category. In view of the widespread distribution of equipment in Group I, it is indeed fortunate that this equipment is among the least noisy in the home.

In general, due to the low levels of noise produced by equipment and appliances in Group I, effects of exposure are either negligible or mild. Noise sources in Group I present no appreciable risk of hearing damage under conventional operating conditions. Under certain conditions, however, these noise sources can affect sleep. Of the noisier sources in Group I, only fans and air conditioners are likely to be present in sleeping quarters at night. These devices are characterized by nearly steady-state spectra because of their continuous operation. Differences in levels among operating cycles are small, so that peak noise levels are usually within a few dB of average levels. As such, these devices may delay the onset of sleep, but are unlikely to awaken many people. They may, in fact, facilitate sleep for those directly exposed to their noise, since they function as sources of masking noise which can suppress interference from other sources.

The major effect of exposure to noise from Group I equipment is speech interference. Conversations in the immediate vicinity of the noisier sources of Group I would have to be conducted in somewhat higher than normal levels, or at slightly shorter than normal speaking distances.

The annoyance value of exposure to noise from Group I appliances is also minimal. The steady-state nature of their amplitude and frequently spectra are highly conducive to rapid habituation. Only rarely does one become sufficiently aware of refrigerator noise, for example, to become annoyed by it. Indeed, it is the noise sources of Group I which define the background noise environment of many homes.

Exposure to Group I noise sources has little or no bearing on startle and stress. Very few people are startled by the noise of their air conditioners or feel menaced by the implications of their refrigerator's whirring.

Considering the mild nature of most of the effects of exposure to noise from Group I sources, noise reduction is not an urgent need. Many appliances in Group I already operate at or near the level of background noise in the home, so that submerging them further into the background noise environment would serve little purpose. Those few noise sources in Group I which do produce noise levels appreciably above background levels could probably profit greatly from approximately 10 dB(A) of quieting. Such noise reduction, well within the capabilities of existing technology, would alleviate the undesirable effects of noise exposure from this group of appliances.

Group II: Quiet Equipment and Small Appliances

Most of the noise sources of Group II are found in many American homes, although not all of the sources are as common as the major equipment and appliances of Group I. Noise levels in Group II are sufficiently elevated to render certain appreciable effects, particularly speech interference and annoyance. Fortunately, the typical pattern of exposure is an infrequent, brief encounter.

Of the three major effects by which noise impact is gauged in this report, noise sources in Group II produce only speech interference in significant measure. Hearing-damage risk is negligible, both for operators and for others who may experience secondary exposure. Since most of the appliances in this group require an operator, sleep interference is not a serious consequence of primary exposure. Secondary exposure probably affects daytime sleeping to some slight extent. Secondary exposure to plumbing noise in multi-unit residences could conceivably awaken as many as 35% of sleepers, although habituation probably reduces the percentage dramatically.

Operators of the appliances in Group II would find speech communication during operation quite difficult; conversations would have to be conducted with significantly greater than normal vocal effort or at very short ranges, and the intelligibility of fixed level speech (such as radio or television) would become marginal. The obvious mitigating circumstances, however, is the brevity of noise exposure typical of this group of appliances. In practical terms, the most likely consequence of exposure to this sort of short duration appliance noise is a temporary interruption of conversation.

Annoyance is the most significant of the indirect consequences of exposure to noise from Group II appliances. While the operator may be summarily annoyed by the brief speech interference effects, people experiencing secondary exposure may be equally, if not more, annoyed. The annoyance of these people (such as neighbors in multi-unit residences or other family members in different rooms) is conditioned in part by the intrusive nature of the exposure and in part by feelings of lack of control of the noise source. Feelings of helplessness, exasperation, or frustration are themselves unpleasant and can produce further annoyance. Should secondary exposure become unduly or unreasonably common, physiological stress from emotional arousal might develop.

Primary exposure to the noise of these appliances is not likely to result in much task interference. This is true simply because it is the undemanding and highly practiced task at hand that is generating the noise. Exposure to appliance noise for people other than the operator could interfere with certain highly sensitive tasks. Generally, however, considering the usual brevity of exposure, such task interference would be the exception rather than the rule.

A 10 dB(A) reduction of noise levels produced by appliances of Group II would be a useful and worthwhile endeavor. Many of the effects of secondary exposure would become negligible, while the speech interference effects for the operator would be considerably reduced. It is clear from Table XXVII that the single most common source of noise exposure in the home is plumbing. Better design of plumbing fixtures would have a gradual but significant effect in making multifamily residences less noisy. Sales resistance to less noisy products (including the much-discussed "quiet vacuum cleaner") may be expected to diminish as the public becomes more noise conscious.

Group III: Noisy Small Appliances

The distribution and exposure patterns of noise sources in Group III continue the trend observed in Group II. Group III appliances are found in fewer homes than the appliances of the preceding group. Exposure to their noise is for equally brief periods at long intervals. Both of these factors tend to moderate the impact of the relatively high-level noise developed by these appliances.

Hearing-damage risk can no longer be dismissed as of minor importance for this group of noise sources. While it is true that average exposure is measured in fractions of hours per week, it is very likely that certain elements of the population are exposed to one or another of Group III source for prolonged periods of time. Home seamstresses, for example, could easily be exposed to several hours of sewing machine noise daily. Yard care specialists might be exposed to equivalent amounts of lawn mower noise. Although even these exposure durations would not constitute an imminent hazard to hearing (in the sense that they would be unlikely to lead to sizeable permanent threshold shifts for many years), they would nevertheless hasten eventual hearing damage in the context of cumulative exposure from many sources. In Miller's [16] terminology, noise sources in Group III would be rated "yellow" (cautionary) with respect to hearing-damage risk.

Speech interference is severe. Operators receiving primary exposure to noise sources of Group III would not attempt conversation during the brief periods in which the appliances are used, although communication by shouting would still be possible. Secondary exposure to the noise of Group III sources would also interfere somewhat with verbal communication. The principal

form of interference, however, would be degradation of speech intelligibility rather than more severe disruptions of conversation.

Since appliances of Group III require operators, sleep interference effects of primary exposure to their noise are negligible. Sleep interference effects of secondary exposure to this set of appliance noises also tend to be low, both because the noise exposure often occurs during hours during which sleep is uncommon and because the very brief periods of exposure occur only infrequently. Of course, the tendency for more mothers to be employed outside the home during the day constrains their use of appliances to evening hours, when the attendant noise levels may interfere with family social activities and the sleep of young children.

Annoyance is once again the chief indirect effect of exposure to noise from Group III sources. The operator himself may find the noise signature of the appliance unpleasant, particularly if it contains pure tone components or a highly variable temporal distribution of levels. Secondary exposure to these noises is also likely to be annoying, particularly if the people exposed to the noise feel that they are deriving none of the benefits of the appliance's use.

Task interference, startle, and stress reactions are all plausible consequences of exposure to this sort of noise. As usual, however, difficulties in assessing the unexpectedness of the intruding signal or the nature of background activity make precise prediction of the magnitude of these effects impractical.

Reduction of noise produced by appliances of Group III could substantially reduce the levels of hearing-damage risk and speech interference. The operator's annoyance with the noise signature of an appliance could also be affected by noise reduc-

tion, but special attention would have to be paid to the spectral characteristics of the appliance. All of the effects of secondary exposure to noise from this appliance group would be significantly lessened by a 10 dB(A) reduction of noise output levels.

Group IV: Noisy Electric Tools

Group IV contains the appliances which produce the highest levels of noise exposure in the home environment. Considering the potentially serious effects of exposure to such levels, it is fortunate that the distribution of sources is quite restricted. As may be seen from Table XXVII, only about 250,000 electric yard care tools have been sold, and only about 12 million electric shop tools are in use. Further, the use of such tools is probably concentrated in nonurban areas where secondary exposure effects are not as widespread as they might be in multi-unit residences.

Hearing-damage risk can be great if exposure to the noise levels of Group IV sources is habitual or prolonged. Hobbyists who engage in regular use of power tools are likely to receive considerably more than the average six minutes per week exposure noted in Table XXVII. Many such tools (saws, drills, routers, etc.) are operated within a few feet of the user's ear, making hearing-damage risk even more probable. In Miller's (1971) terminology, such tools can produce "orange" or even "red" hearing damage risk if exposure is prolonged. It is doubtful that any major risk of hearing damage is encountered in secondary exposure, owing to the much lower levels experienced.

Speech interference effects of exposure to noise of Group IV sources can be of sufficient magnitude to preclude verbal communication in any form other than shouting directly into the

and. Even the spoken interference effects of secondary exposure can be great enough to require conversation to be conducted at high levels of vocal effort or at very short distances. As was pointed out earlier, however, relatively few people are affected by such secondary exposure, and those who are affected are exposed for very brief intervals.

Sleep interference effects of exposure to Group IV sources would be quite serious were the hours of use of Group IV appliances to coincide with hours of attempted sleep. Primary exposure, of course, is not a problem here, but even secondary exposure can reach levels in the vicinity of 60 to 70 dB(A). Data from the Wilson report [26] may be interpreted as predicting that such levels will awaken one-half of all sleepers and about one-third of all people would find it difficult to fall asleep. Use of electric yard care tools at night is unlikely, but home shop tools are often used at night.

To the extent that noise exposure to such high levels is perceived as avoidable or unnecessary, annoyance effects are probably quite pronounced. A neighbor's noise, particularly at such high levels, is rarely welcome. The high noise levels produced by these tools may also interfere with the very tasks the operators are attempting to accomplish. If noise levels are sufficiently high to mask warning signals or other unexpected acoustic signs of danger, the safety of the operator and his efficiency may be compromised. Stress produced through prolonged exposure to noise levels characteristic of Group IV tools may be appreciable, particularly if exposure is involuntary.

Considering the seriousness of the effects of exposure to noise of appliances in Group IV, application of noise reduction techniques is urgently needed. Reduction of noise levels by as

little as 10 dB(A) would have immediate benefits in reducing the hearing-damage risk to the operator and reduction of the speech interference and annoyance-related effects for those receiving secondary exposure.

Summary of Effects of Appliance Noise on People

Tables XXVI and XXVII summarize the impact of appliance noise on people in concise terms. Table XXVII contains an account of the extent and duration of noise exposure from all four appliance groups in terms of millions of person-hours per week. The reader is reminded of the cautions expressed in the summary of Sec. 3.2.1 for the interpretations of figures expressed in person-hours. Table XXVIII relates person-hours of exposure directly to the major criteria of Sec. 3.1.

3.4 Projections of Construction and Appliance Noise to the Year 2000

Projecting conditions to the year 2000 involves a number of uncertainties. One of these is the exponential rate at which technology is evolving and affecting society. As pointed out by Sir Arthur Clark*, life in the year 2001 will be as different from the present as the present is from 1890. Who - in 1890 - could have realized the impact that electricity and the automobile would have both on life style and on the environment? Technological innovation, however, is not the only factor to be considered. One simply cannot account for future changes in social attitudes. Although a few far-sighted technologists may have predicted in 1940 the capability to transport passengers at

*Lecture to the Arlington Library Association, Arlington, Mass. (Sept. 1970).

TABLE XXVIII. ORDER-OF-MAGNITUDE ESTIMATES OF EXPOSURE TO HOME APPLIANCE AND BUILDING EQUIPMENT NOISE EXPRESSED IN MILLIONS OF PERSON-HOURS PER WEEK

Noise Source	Speech Interference*		Sleep Interference*		Hearing Damage Risk	
	Moderate (45-60)	Severe (>60)	Slight (35-50)	Moderate (50-70)	Slight (70-80)	Moderate (80-90)
Group I: Quiet Major Equipment and Appliances						
Fans	1200		0		0	
Air Conditioner	242		121		0	
Clothes Dryer	94		10		0	
Humidifier	10		15		0	
Freezer	0		0		0	
Refrigerator	0		0		0	
Group II: Quiet Equipment and Small Appliances						
Plumbing (Faucets, Toilets)		535	267		0	
Dishwasher		461	4		0	
Vacuum Cleaner		280	0.5		0	
Electric Food Mixer		222	1		0	
Clothes Washer		215	0.5		0	
Electric Can Opener		117	0.2		0	
Electric Knife		1	0.1		0	
Group III: Noisy Small Appliances						
Sewing Machine		19		0.5	9	
Electric Shaver		6		1	5	
Food Blender		2		0.2	0.5	
Electric Lawn Mower		1		1	0.3	
Food Disposer		0.5		0.5	0.5	
Group IV: Noisy Electric Tools						
Home Shop Tools		5		2		1
Electric Yard Care Tools		1.5		.1		0.4

*These figures are not directly interpretable in terms of person-hours of lost sleep or speech interference (see text).

supersonic speeds, it is doubtful that they could have predicted that such a technologically feasible system would be abandoned largely because it was expected to make too much noise.

Although any long-term predictions are fraught with such difficulties, one can still make educated guesses with a reasonable level of confidence. Rather than merely extrapolate existing conditions to the indefinite future, we try to be somewhat quantitative by projecting the impact of construction and appliance noise on the basis of existing forecasts of population, family size, gross national product, and trends toward urbanization. Construction activities will continue to follow such growth patterns, although the character of construction may change significantly with greater use of prefabricated materials and the introduction of new kinds of equipment. Similarly, ownership of appliances has been found to be a function of family income level, and we use their relationship to project the growth of appliance use in the generally more affluent households predicted for the year 2000. Also, rather than trying to account for conflicting trends and changing attitudes, we project the extent of exposure with the assumption of no change in noise level for a given equipment or appliance type and consider only major trends that can be easily identified.

We use the following data, taken from the U.S. Census Bureau, for projecting the increase in exposure to construction and appliance noise:

	<u>1970</u>	<u>2000</u>	<u>Ratio</u>
GNP (billions of 1958 dollars)	720	2240	3.2
Total Population (millions)	200	293	1.45
Total Number of Households (millions)	63	104	1.65
People per Household	3.17	2.8	0.9

3.4.1 Construction activity

Given the predicted increase in population and in financial resources, one can expect fairly extensive building activity. However, the urban areas have limited space available for new building; thus, the trend is for areas outside those now identified as central cities to become urbanized. Figure 24 illustrates this trend for single-family, multi-family, and nonresidential construction activities. With available land becoming more and more scarce within the central city, the building of single-family and multi-family dwellings will continue to decrease sharply. In 2000, we can expect to find approximately one-third the number of residential construction sites as were active in 1970. Nonresidential building is expected to increase. In areas outside the central cities, both residential and nonresidential construction should increase significantly. Nonresidential building activity is expected to increase by over 50% as the present suburbs become urbanized. With this general trend in mind, we use the data given above to project the expected increase in exposure to noise from construction activities.

Nonresidential

We assume that the level of nonresidential construction activity in any given year is proportional to the real Gross National Product (GNP) for that year. To find the nonresidential construction activity for any particular year, the ratio of the GNP for that year to the 1970 GNP is multiplied by the number of nonresidential sites built in 1970 (Table X). The resulting total construction figures are apportioned between "central cities" and "other metropolitan areas" in the same proportions as occurred in 1970. Despite the expected decrease in total con-

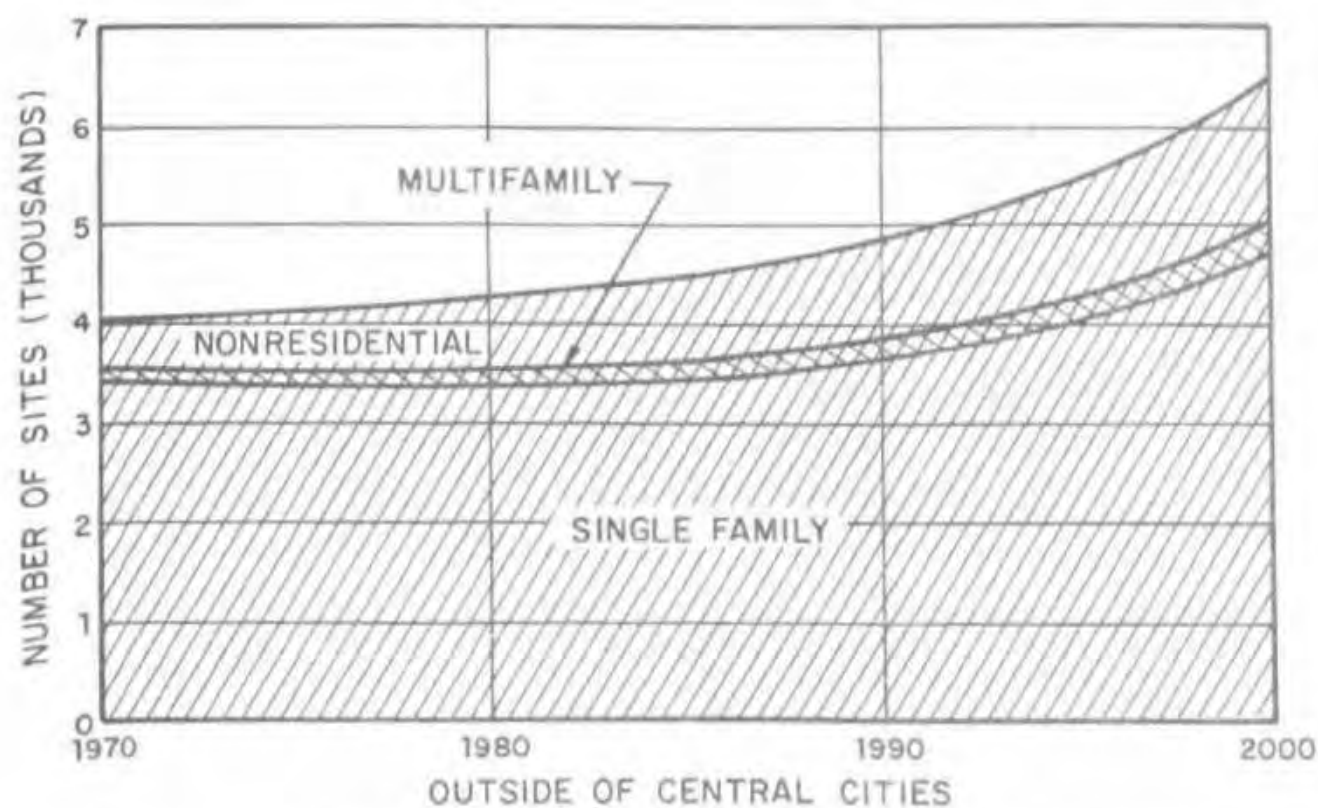
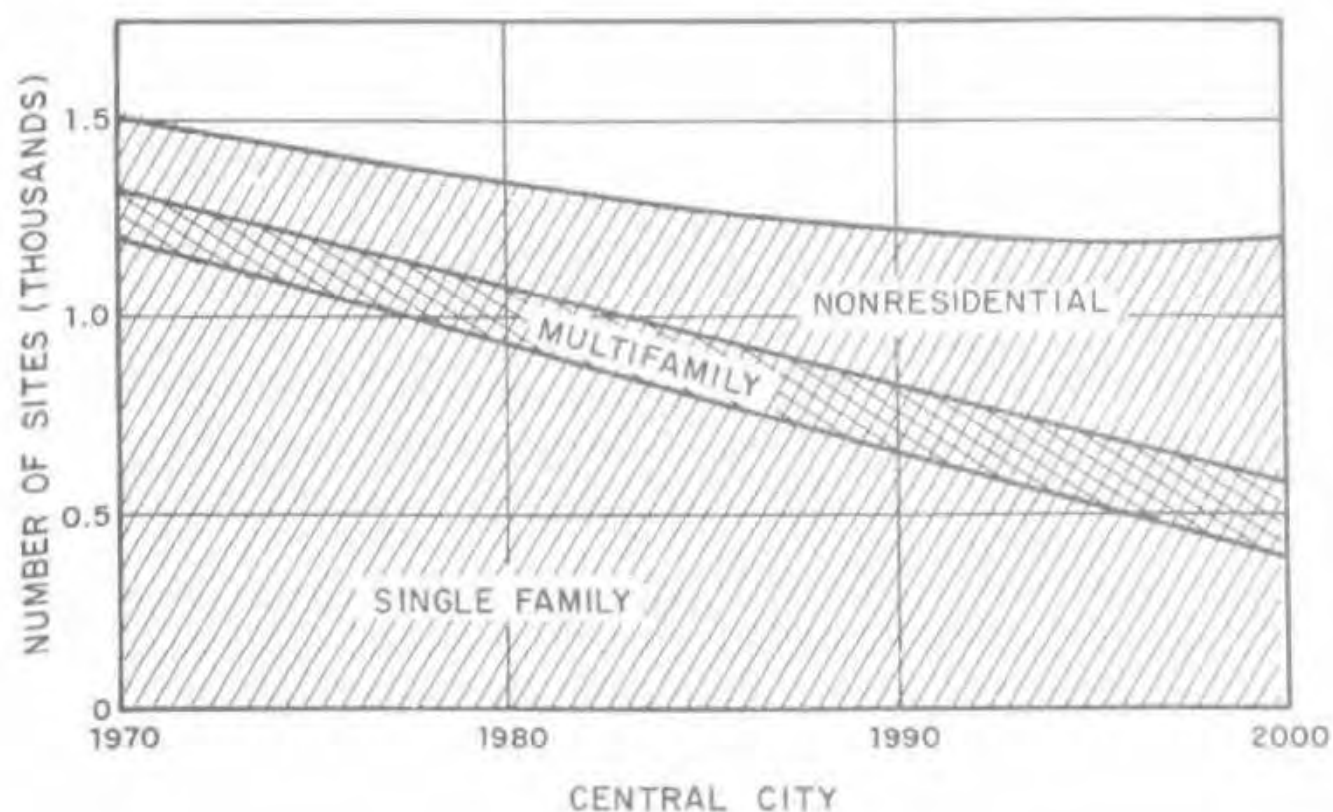


FIG. 24. NUMBER OF BUILDING CONSTRUCTION SITES PROJECTED TO THE YEAR 2000.

struction site within the central city, nonresidential sites are expected to increase.

Residential

We assume that the population and population density of central cities will remain at their present levels until the year 2000, and that most residential construction in central cities will be for the purpose of replacing decayed units rather than for housing new population. The number of construction sites will decrease due to the established trend toward an increasing population of multi-family dwellings over single-family dwellings. (Two- to four-family houses, which represent a negligible fraction of total construction, are here included in the total for single-family housing.)

For metropolitan areas other than suburbs, the number of units constructed in any one year is assumed to be proportional to the population increase in the previous ten years. To estimate this increase, we project the total metropolitan population by multiplying the projected total national population by the estimated proportion of the population living in metropolitan areas. All the increase in metropolitan areas population for a particular year is ascribed to noncentral city areas.

Roads

A simple but plausible indication of road construction activity, is the population level. Clearly additional people will require additional roads, the capability of rapid transit being small at present. However, the urban areas have limited space for new roads, and urban residents are expressing increasing opposition to new road construction on grounds of aesthetics,

pollution, and the community dismemberment concomitant with the installation of limited access highways. Thus, it would seem unlikely that road construction will rise as fast as other measures such as the GNP. We therefore project the future level by multiplying the present level of activity by the ratio of the projected population divided by the current population.

The number of people affected by construction sites is computed in the manner described in Sec. 3.2.1. Population densities for all metropolitan areas are assumed to be constant with time - 4500 people/sq mi for central cities and 2400 people/sq mi for other metropolitan areas. At any one site, people are apportioned to specific transmission loss intervals according to the method shown in Fig. 20. The resulting exposure to construction noise is given in Fig. 25 in person-hours. In this figure, multi-family residential construction has been included with nonresidential construction, since these types of building activities are quite similar. Note that the number of people exposed to noise from single-family dwelling construction declines steadily with time. This trend is more than compensated for by the rapid increase in nonresidential and multi-family sites - for which the duration of construction is typically six times greater than the duration for single-family houses. Thus, the number of person-hours of exposure is expected to increase by about 50% in the next 30 years.

3.4.2 Appliance use

We assume that the probability of future appliance ownership as a function of income level will remain the same and that appliance costs will remain approximately the same in current dollars. With these assumptions in mind, we base our approximation of appliance use on projected population, family income,

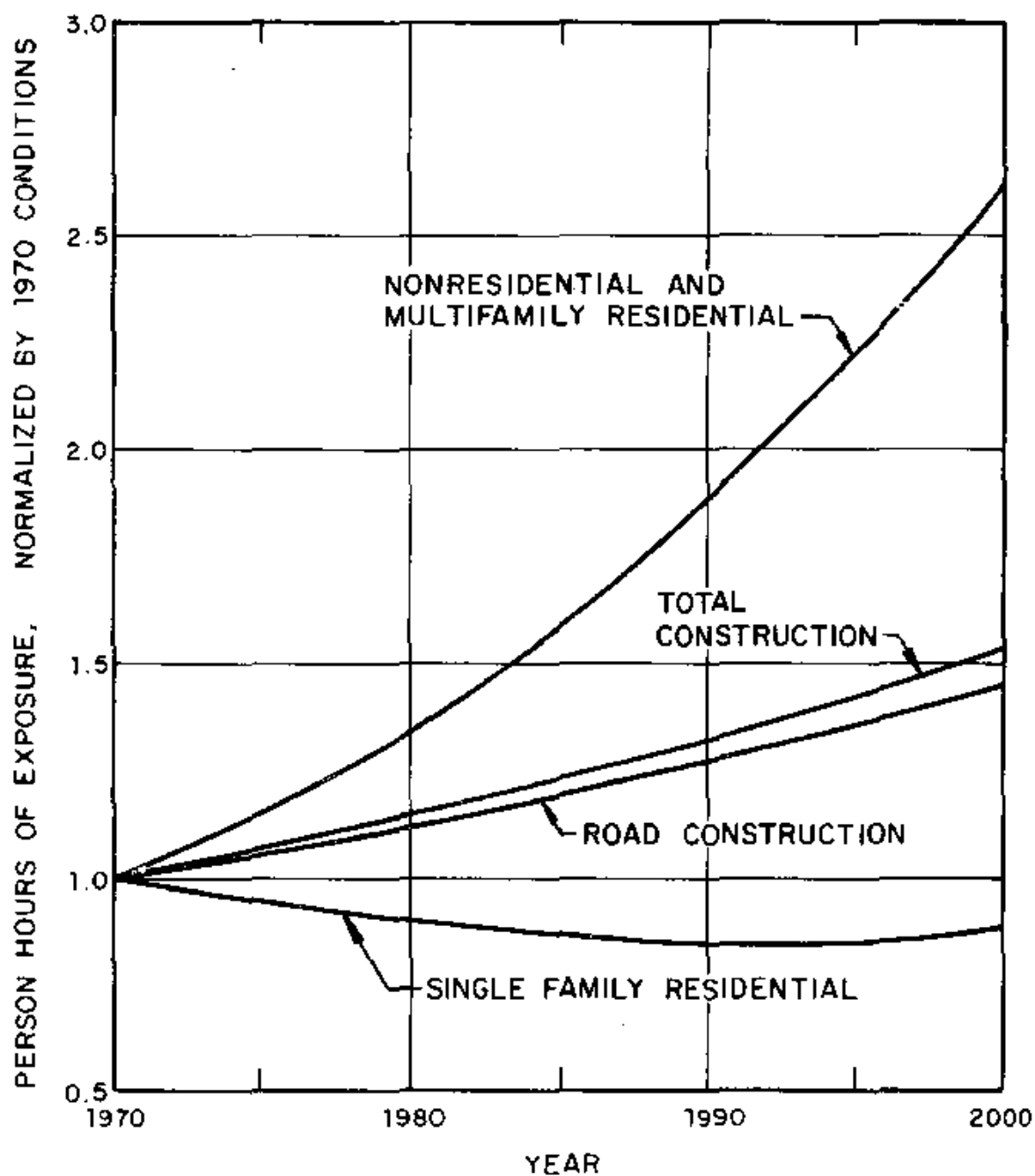


FIG. 25. PROJECTED CHANGE IN EXPOSURE TO CONSTRUCTION NOISE, ASSUMING NO CHANGE IN NOISE LEVELS.

and income distribution. This estimation is likely conservative as some appliances are continuing to increase their acceptance in all income levels, although their growth of acceptance is low at the higher income levels where some appliances have nearly saturated the market. For those appliances for which insufficient information is available on appliance possession at the various income levels to make the projection described above, we estimate future possession from current marketing information on percentage of replacement sales and on market penetration.

In projecting future impact, we estimate that the appliance usage will remain approximately at current levels. Supporting this assumption is the little deviation shown in average time spent by homemakers over the last forty years.

Figure 26 illustrates the increase in exposure to appliance noise by plotting hearing-damage risk and speech and sleep interference in person-hours of exposure. As explained in Sec. 3.1, these three effects are among the most salient and tangible consequences of noise exposure and thus can be most readily interpreted in nontechnical terms. As can be seen on Fig. 26, we project that number of person hours during which people will be exposed to the risk of hearing damage will more than double in the next thirty years, as will the number of person-hours during which normal conversation will be difficult and people will be either awakened or prevented from falling asleep.

As explained previously, we have not taken into account certain trends, discussed in Sec. 4, which are having some effect on the noise levels produced by construction equipment and appliances. However, one should note, when reviewing these projections, that industries are becoming sensitive to a growing concern about noise pollution among the general population. For

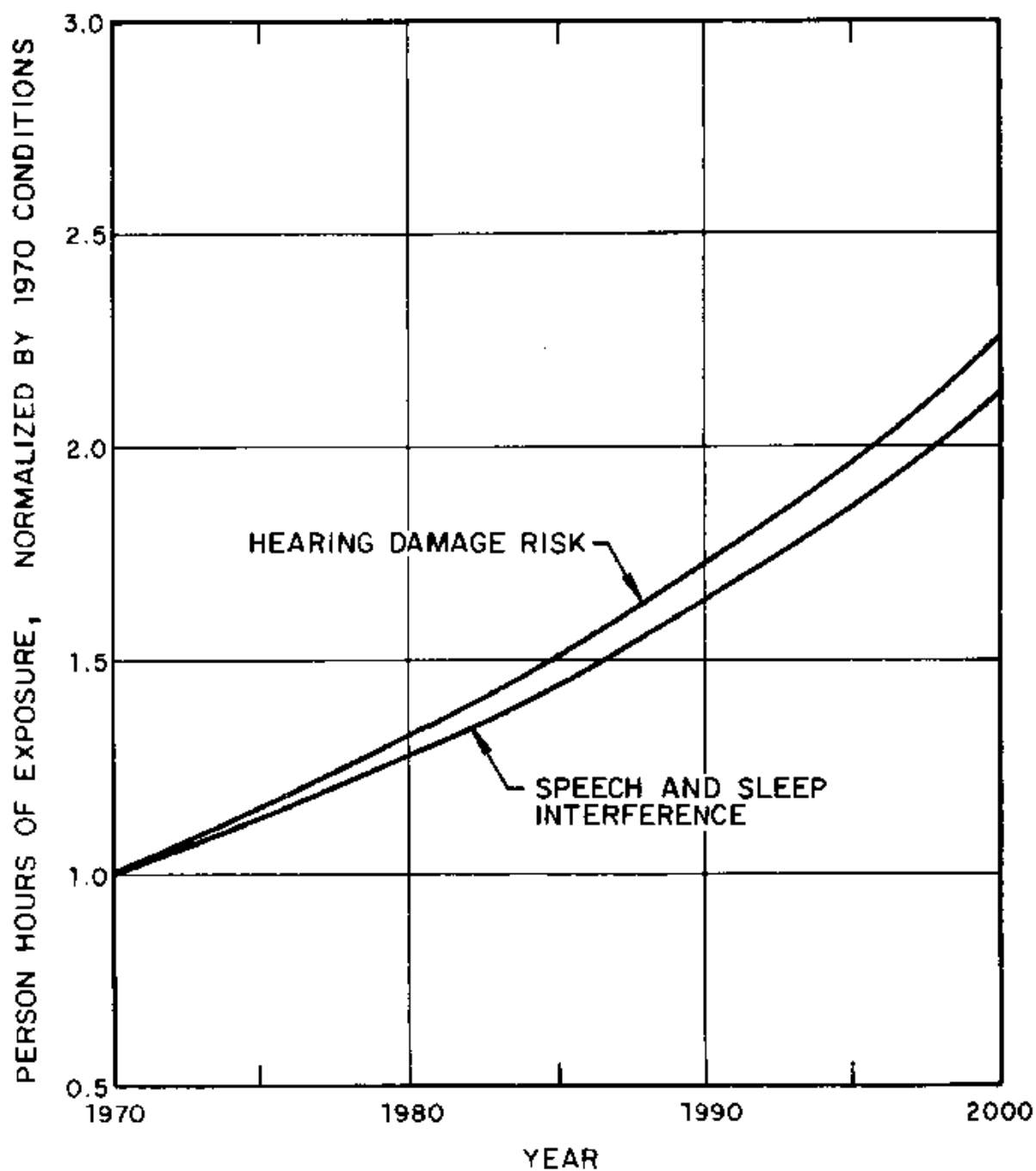


FIG. 26. PROJECTED CHANGE IN EXPOSURE TO APPLIANCE NOISE, ASSUMING NO CHANGE IN NOISE LEVELS.

example, construction equipment has become noisier as it has become more powerful; yet, one manufacturer has developed and is marketing a quiet air compressor. Conversely, refrigerators and air conditioners have become noisier as manufacturers have strived to meet market-place demands for extra features and smaller size. Thus, rather than try to account for an infinite number of variables, we have assumed no change in noise levels for both construction equipment and appliances. We feel that this method has resulted in reasonable near-term projections, if no noise control action is taken.

4. INDUSTRY EFFORTS

4.1 Introduction

Efforts by industry to quiet products are usually motivated by two factors: market place demand and government regulation. The consumer can exert pressure on industry by electing to buy or not to buy or by selecting a competitive brand that produces less annoying noise levels. This kind of "consumer regulation" can be very effective -- particularly with regard to appliances -- in that manufacturers are quick to respond to consumer tastes. However, consumer pressure can also subvert efforts a manufacturer may wish to make; for example, housewives often associate the noise produced by a vacuum cleaner with its ability to clean -- the noisier the machine, the more satisfied a homemaker may be with its performance. In any event, the purchaser can apply direct pressure to the industry.

Public pressure, on the other hand, is usually very ineffective. The only recourse for people who do not own the noise sources to which they are exposed is to register a complaint. Such complaints have no effect whatsoever unless enough exposed people organize and concentrate their efforts on a particular source. This kind of community response may eventually result in government regulation.

Our analysis of industry efforts to quiet construction equipment, appliances, and building equipment was organized as follows:

- We constructed a matrix of common products and significant manufacturers.

- We rank-ordered products as to approximate magnitude of noise impact or need for quieting.
- We rank-ordered manufacturers as to their importance in the product area.
- We examined the resulting manufacturer/product "intersections" with a view toward organizing a number of interviews that would cover important products and leading firms and still be within the time and effort constraints of the study.
- We developed an extensive interview format both to guide the interview and to provide a standardized method of reporting. (Full use of this format was not possible within the constraints of this study; it could be useful, however, in the event that industry efforts are to be examined in more detail.)
- Under guidance of the format developed, we collected subjective data and objective observations; this information forms the basis for representative generalizations cited in this report.

As expected, the industry is concerned about releasing data which might disclose proprietary ideas or expose a competitively sensitive area of operations. Accordingly, identity of sources is carefully safeguarded herein. This need for corporate security has limited our collection of statistically meaningful data; the trends observed, however, are clear and, in themselves, undoubtedly represent the noise control environment in industry.

4.2 Construction Industry Efforts

We view the construction industry as consisting of two major sectors: equipment manufacturing and equipment operation (i.e., building construction). The functions of these two sectors of the industry are so different as to warrant separate discussion.

4.2.1 Equipment operation

Section 3.2 describes this sector of the construction industry in detail, identifying types and phases of site activity and describing the areas in which noise abatement can be achieved.

The industry has, in fact, done almost nothing to quiet site operations. Its attitude may be attributed in part to the fact that quiet equipment has not yet been made available on a cost-effective basis; however, a limited capability does exist for quieting a site by relocating or rescheduling equipment. This sector has not exercised its influence as a "consumer" to bring pressure to bear on the equipment manufacturers, nor has it responded to public complaints. Hence, regulatory measures may be the only solution to the problem of construction site noise, and such regulations are imminent.

4.2.2 Equipment manufacturers

There are approximately 2000 manufacturers* of construction equipment in the U.S. In total, these companies offer about 200 different products. For the purposes of assessing the state of noise control in this sector of the construction industry, we

*Defined by counting separately certain divisions of larger firms which have a highly identifiable product line.

categorized 48 general types of products that are potentially significant noise sources. We group these product types into three orders of classification: (1) class of noise problem anticipated, (2) relation of equipment to function at the site, and (3) specific equipment names.

I. Engines and power trains

A. Excavating equipment

1. backhoes
2. clamshells
3. dozers
4. draglines
5. loaders
6. rippers
7. (power) shovels

B. Highway equipment

1. compacters
2. graders
3. pavers
4. pipe layers
5. pulverizer/mixers
6. rollers
7. rotary borers and drills
8. scrapers
9. street sweepers
10. trenchers and backfillers

C. Equipment to handle finished materials

1. cranes
2. fork (and similar) lifts
3. travel lifts

D. Mobile units

1. tractors, crawler
2. tractors, wheel
3. trucks

E. Power supplies

1. compressors
2. electric-power generators

- II. Interaction between equipment and materials (may include engines and power trains)
 - A. Equipment to handle bulk materials
 - 1. bins (and hoppers)
 - 2. concrete mixers
 - 3. conveyors
 - B. Large impact tools
 - 1. drop hammers
 - 2. pile drivers
 - C. Medium impact tools
 - 1. jack hammers
 - 2. rock (vibrating) drills
 - D. Small impact tools (power)
 - 1. impact hammers
 - 2. impact wrenches
 - 3. riveters
 - 4. stud drivers
 - E. Rotary tools
 - 1. bench drills
 - 2. grinders
 - 3. hand drills
 - 4. hand saws
 - 5. table saws
- III. Miscellaneous (may include sources characteristic of I and II above)
 - A. Pumps
 - 1. concrete pumps
 - 2. stripping pumps
 - 3. well-point pumps
 - B. Other
 - 1. burners and heaters
 - 2. sand blasters
 - 3. screeds
 - 4. concrete vibrators

Two assumptions underlie the terminology selected:

(1) equipment in transit under its own power is a truck or tractor, even though when working it may be a dozer or a crane, and (2) classification by function at the site is arbitrary since many types of equipment have several uses.

Manufacturers of construction equipment can be classified according to size/type of equipment produced as

- large companies producing large volumes of essentially similar, large items of machinery;
- medium-size companies producing "customized" production runs of more limited numbers, usually of smaller machinery; and
- manufacturers of power hand tools and pneumatic equipment.

Our interview program was organized to cover the two major acoustic source types (prime-movers and power trains) and the forty-eight types of products and three classes of companies identified above. We concentrated our efforts on significant leaders in the industry and companies producing a wide variety of products that have high levels of noise output:

- Of the ten manufacturers intensively interviewed, about eighty product analyses resulted.
- Eight of the firms produced equipment in which the prime-mover or power train is a significant source of noise; two companies produced only power hand tools.

- Three companies were high-production manufacturers; seven manufactured customized equipment.
- Three-quarters of all the products were subjected to specific analysis, covering all significant noise sources except impact tools and pumps.
- The ten firms represent a significant part of the industry: Of the two thousand firms nominally in the industry, about twenty comprise the industry "core". Eight of the ten interviewed are part of this core.

Our overview of the equipment manufacturing industry showed that:

1. Large companies closely resemble the Detroit assembly-line manufacturing concept. They tend to have large engineering staffs and are quite advanced in their efforts toward developing quieter products. They are aware of the competitive advantage of quieting equipment but are also sensitive to price competition from smaller companies and foreign manufacturers.

2. Medium-size companies producing "customized" items tend to feel more keenly the competitive pressures of the market place. Competition comes not only from domestic and foreign companies but also from other types of equipment that can perform the same operation. Engineering staffs tend to be small and product-oriented, interested only in improvements that incorporate new technology (e.g., hydraulic vs mechanical drive). Little effort has been made toward quieting products, with pressures of current and planned noise control legislation being passed on to their suppliers. They generally have no plans or see no need for developing greater noise control technology.

3. Manufacturers of hand power tools and pneumatic equipment fall into two categories: Large multiproduct companies which tend to mount considerable R&D efforts and smaller companies which are not so innovative but which do follow trends developed by the larger companies. Noise control has been pursued rather vigorously by these larger companies as part of their product improvement programs, but effective quieting of hand tools is difficult because of such practical constraints as size and weight.

Our in-depth interviews revealed that in the past the industry's concern with noise problems has been directed primarily to protection of the equipment operator. The impetus for this concern came largely from noise codes imposed by foreign countries, where some U.S. equipment has had to be "reworked" by foreign distributors. Three of the eight "large equipment" companies interviewed had previously quieted equipment to enter European markets. Switzerland and Belgium, for example, specify permissible noise levels for such machinery; in addition, foreign manufacturers make quieter machines and set a competitive pace in foreign markets. American manufacturers seem to have met this competition by custom-designing equipment for export. There is an implication here, of course, that many American machines marketed abroad have been quieter than counterparts that were marketed domestically; however, this implication has not been verified by this study.

Half the companies interviewed are currently undertaking programs to quiet their products for the domestic market for the first time. Many of the present programs have been started this past year and are aimed primarily at protecting operators, so as to conform to impending legislation/regulation regarding occupational health and safety. Only one of the companies indicated

that purchasers complain about protection for operators on their own initiative, and only one case emerged where a union had lodged a formal complaint. Six of the eight companies described pressures on behalf of operators that originated with existing or proposed governmental action.

Many manufacturers feel that the efforts they are now making on behalf of equipment operators will pay off in meeting future noise limits designed to protect the public. Perhaps, one of the most promising future approaches has been taken by one of the manufacturers of large equipment, who has charged design teams with the responsibility of integrating noise control into the overall design of his next generation of products and has set up review boards to evaluate new designs from all standpoints, including noise.

Four of the eight companies specifically mentioned the recently enacted Chicago noise ordinance as contributing to their specific future objectives. The industry generally anticipates EPA-administered federal control; the visits of our interviewers reinforced this feeling. Two companies believe that pressures for quieting will increase with time -- apparently as a result of an increasing public awareness of noise as an environmental pollutant.

Although the industry has become increasingly aware of the pressures for noise control and has already made some efforts in this area, manufacturers must cope with economic pressures that argue against noise abatement. Some companies feel that the intensity of competition sets the limits on what price the market will bear. One of the industry's leaders was concerned that purchasers will continue using old equipment if prices rise significantly. Other industry leaders point out that foreign-made machines (some of them already quieted) will enter

the American market if prices rise appreciably. One company predicted that a small rise in the price of truck-mounted concrete mixers would lead to the introduction of alternative methods for handling concrete delivery and production.

Companies who feel that the demand for their products is great enough plan to pass quieting costs onto the consumer, although such threats as foreign competition and alternative methods put limits on this process. The question here is how fast the industry dares to move. One limit on rapid movement is price competition. One company may be able to beat its competitors to the market with a quiet machine, but it does not dare raise prices substantially in the face of competition. Different companies approach this problem differently. Most express the intention to meet or exceed the competition, but they feel that any great competitive advantage they gain through an all-out effort to quiet their products would be short-lived. One company sees its competition as being extremely severe, and fears that it may not be prepared for the next round of quieting, while another company has actively launched a program designed to produce quieter machines than its competitors at lower costs than the competitor will incur.

This company and some others expressed the concern that often accompanies any industry leadership; i.e., a company may invest large sums in quieting which will thus increase the cost of products, while another company that refuses to quiet products keeps its prices low and may successfully challenge noise regulation in the courts.

While all companies regard cost as an immediate — and perhaps as the ultimate — constraint, two other constraints become paramount if and as costs diminish: time and technology. Three companies, each in a different fashion, represented that costs can be traded for development time; i.e., more time for development would reduce the cost of competition, allowing quieting techniques to be integrated into planned engineering efforts and to be an integral part of the seasonal progression of models. The very company that is setting out to achieve the most quieting for the least cost is the one that feels that technology will eventually supercede cost as the principal factor that limits quieter equipment.

At another firm, the technical limitations are spelled out in terms of: (1) loss of equipment power through increased muffling; (2) increase in the difficulties and cost of maintenance; (3) fire hazards through using insulating materials that can become oil-soaked; (4) unsafe operation by suppressing or distorting the noise "signals" upon which operators depend for safety; and (5) ineffective operation, by disturbing these same "signals", thus hindering the ability of the operator to tell how effectively he is operating.

The industry also voiced concern over the feasibility of noise abatement where equipment and materials being worked interact to become prominent sources of noise; e.g., concrete mixers (where the structure may be the noise radiator); jack hammers (where the tool and its driving media may be the offender); riveters (where the structure of the building may be the primary source); and pile drivers (where both the structure and the media may be significant sources). This "interaction" type noise source may be very difficult to quiet.

However, no firm interviewed condemned noise limits out-of-hand, nor did they deny their inevitability. Six of the eight companies expressed the opinion that unless they quieted their products, their markets would disappear. Feelings varied from acceptance of inevitable reality to enthusiastic approval of the trend.

During the course of this study, members of the BBN team were actively engaged in the regulatory efforts of three cities and one state - Boston, Chicago, San Francisco, and Illinois. This work provided an insight into the mechanism of regulatory control from outside the construction industry. In addition, discussions were held with the Construction Industry Manufacturer's Association (CIMA) to obtain information about controls within the industry.

There are potentially four levels of regulatory bodies outside the industry: federal, state, city/town, and specialized local departments (city departments of health, air pollution control, zoning/building, etc.). The regulatory power exercised by these bodies is generally graduated into four steps: general standards (setting goals), enabling powers (granting power to a lower body), specific regulations (against which are judged infractions), and procedures (for measuring performance).

The target of the regulatory powers is either basic equipment performance (i.e., noise of new equipment as sold by manufacturer) or equipment operation (e.g., total noise emitted from a site). Regulations are usually aimed toward protecting (1) health (as in the hearing-protection section of the Federal Public Contracts Act) and (2) environmental quality (as in the construction site operating limits proposed for the city of Boston).

No fixed pattern has yet emerged which interrelates the regulatory bodies, nature of powers, targets, or degree of protection. Current activity at all levels, however, has alerted the industry that controls are imminent. One significant set of controls already in existence limits the noise from new construction equipment sold in Chicago; dual controls are being proposed in Boston, to limit site operation noise and to restrict noise from new equipment. Enabling legislation exists (as in the General Laws of the General Court of Massachusetts), and enabling powers have been passed on through city ordinance (again as in Boston). Even though the Federal Public Contracts Act does not apply to local construction, its philosophy is impressed on the industry, and its effect is increasingly noted in the carryover of standards into new federal occupational health and safety legislation.

In summary, the regulatory bodies outside the construction industry have begun to exercise some influence in the area of noise abatement.

CIMA and the national standards-setting bodies of ASTM/SAE are both actively addressing the problems of measuring equipment noise and recommending quieting standards. The equipment manufacturing industry would like to coordinate its activities with those of its closely related standards-setting bodies (see Appendix B for discussion of a paper prepared by CIMA). Self-regulation via industry-initiated standards is presumably somewhat hindered by federal anti-trust provisions.

As yet, no broad controls have been established. It is assumed that the example set by the City of Chicago equipment noise ordinance will stimulate other similar action, eventually resulting in a proliferation of standards put forth at the local

level. As an alternative, the industry would welcome one comprehensive overriding standard. However, some anxiety was expressed as to the reasonableness of future legislation, specifically that sufficient time would not be allowed to conform to such a standard. Typical new product lead-times are on the order of five years. Industry believes it could meet noise goals without excessive cost to the consumer, if given enough time.

In general, it appears that industry is aware that it will be forced to comply with ever-tightening noise standards. While this fact seems to worry everyone to some extent, most manufacturers are confident that they will meet the limits set by current and anticipated legislation/regulations/standards. In fact, all but one of the companies interviewed stated their noise control goals in terms of such limits, frequently specifying either the levels stated in the Walsh-Healey Public Contracts Act for operators or those set forth by the Chicago ordinance for public exposure.

Early abatement efforts made by the manufacturers have been highly successful; thus, the industry is somewhat optimistic about its ability to cope with pressures for noise control. However, it is important to note that the industry has begun with the most obvious and the easiest tasks it must accomplish. Future tasks are apt to be far more difficult and costly; therefore, future struggles to comply with more stringent standards could possibly influence company attitudes, making them less receptive to regulation.

4.3 Building Equipment and Appliance Industry Efforts

Throughout this study we have viewed the home appliance industry as consisting of two major sectors: owner-controlled appliances and major building equipment (such as heating and plumbing systems in multifamily dwellings). We continue this division, since (even though certain large companies produce both types of equipment) the nature of the marketing and of the pressures for noise control are quite different.

4.3.1 Building equipment

The quieting of building equipment involves the contributions and decisions of an interdependent chain that consists of owner, regulatory body, architect, engineer (both mechanical and structural), equipment, and manufacturer. For purposes of analyzing industry programs, three sectors of this network are significant: (1) the equipment manufacturing sector; (2) the design sector, and (3) the control sector.

Overall, quieting of the equipment in a building thus becomes a compromise between the elements of the chain on matters of design, budget and technical performance.

Manufacturing Sector

Manufacturers of building environmental control and services equipment are currently aware of the significance of quieting their products; they realize that they have a role to play in quieting at the source. The manufacturer does not have complete control over the quieting of the finished system; here, he is dependent on the architect and the mechanical/structural engineers as to location, local architectural treatment, and surrounding structural design.

Given this ambiguity, manufacturers in the past have been uncertain as to what to quiet, how much to quiet, and even how to measure progress in quieting. In a recent review of a wide variety of currently available equipment from a variety of manufacturers, several types of equipment showed spreads as large as 10 dB within the type. However, no line of equipment from a single manufacturer was characteristically noisy or quiet.

Currently, manufacturers are trying to solve problems of rating their equipment. This effort is being channeled largely through the trade associations and the technical societies. The fundamental aim of this effort is to furnish the architect and engineer with ratings that they can utilize in designing their equipment layouts and in specifying their equipment.

In the compressor industry this step has been substantially achieved. The result is that competitive criteria have become clearer and that the major technical barrier to quieting is common to the industry as a whole. (It is the blade-rate scream from the impeller.) It is apparent that if a manufacturer could make a technical breakthrough in this area, he would achieve a strong competitive advantage. There is some question, however, as to whether any single manufacturer can afford the development costs that such a breakthrough would entail.

When rating methods have been developed and when, as a result, the technical problems become better defined, manufacturers of building equipment will face three basic alternatives in reducing the noise from their products that reaches the building's occupant: (1) redesign of the equipment, (2) enclosure of the noise source by the manufacturer and (3) passing the problem along to the building designer.

Design Sector

The mechanical engineer is starting to add acoustic performance of equipment to the list of building specifications. These specifications are passed back to equipment manufacturers.

The mechanical and structural engineer interface with the equipment manufacturer in the area of containment of noise vs quieting at the source. Trade-off between the two approaches must be considered on both sides. Enclosures, if chosen often become a manufacturer's problem because of the need to bring proper controls and services through the enclosure.

The same two factors face each other regarding size of equipment. The design sector wants compact equipment in order to increase usable space as well as be able to move through doors, while the manufacturer tends toward larger equipment to favor quieting.

The architect meets the manufacturer at another interface that concerns equipment location, local architectural treatment and selection of structural system. Acoustically remote spaces are often not possible to be allotted to house equipment in view of the high cost of building space and the attendant desire to maximize revenue-bearing space. Architectural taste for openness in design and novel structural systems can often make the isolation of equipment spaces more expensive.

The designer faces a unique combination of equipment for every structure he designs. These combinations create unique problems of design. They also create unique patterns of emission. Thus in one building, the designer may be able to afford a fairly noisy piece of equipment because it will operate by itself or because it will operate in relative isolation. In another

building he may require a very quiet piece of equipment to perform the same function because it may be operating alongside other noisy machinery or in a location that makes the building users vulnerable.

Control Sector

Controls regarding building equipment acoustic performance emanate from four sources: (1) trade associations within the building equipment industry; (2) specialized technical societies also within that industry; (3) generalized professional technical societies (such as ASME, IEEE, etc.) serving all U.S. equipment industries; and (4) regulatory bodies (Federal, state and local).

The role of the trade associations is to set standards for rating the performance of equipment and to evolve guidelines for proper application of the equipment. Among the most active in dealing with noise control are:

- . Air Conditioning and Refrigeration Institute
- . Air Moving and Conditioning Association
- . Air Diffusion Council
- . Compressed Air and Gas Institute
- . American Gear Manufacturers Association
- . National Fluid Power Association
- . Hydraulic Institute
- . National Electrical Manufacturers Association

In contrast, the technical societies both within the building equipment industry and outside, serving all industries, are dedicated to developing measurement procedures and standardizing the

techniques for making measurements and reporting results. Most active in the measurement area are:

- American Society of Heating and Refrigerating and Air Conditioning Engineers
- Institute of Electrical and Electronics Engineers
- American Society of Mechanical Engineers
- American National Standards Institute
- American Society for Testing Materials

Government agencies exercise control in three ways: (1) as regulatory agencies concerned with occupational health; (2) again as regulatory bodies concerned with community noise; and (3) as significant purchasers of equipment for use in public buildings or publically financed projects. The occupational health and noise control aspects of the Walsh-Healey Public Contracts Act has served as a pace-setter for establishing targets for the building equipment industry, although the federal act itself generally has little direct applicability to most of equipment currently sold.

As state and local governments extend their protection against occupational health hazards, they are tending to adopt the Walsh-Healey criteria. These enactments tend to put pressure on manufacturers and designers alike. The most active current issue arises from the establishment of a stringent specification (80 dB(A) at three feet) by the General Services Administration for machine noise in federal buildings.

Manufacturers are having difficulty meeting the G.S.A. standards through quieting at source, but G.S.A. replies that containment will solve the problem. In one instance, however,

a substantial federal building project has not been able to attract qualified equipment bidders. Minimum property standards for FHA-assisted dwelling units have been in effect for a number of years. Some latitude regarding enforcement appears to be permitted to the directors of regional offices.

In total, the criteria for acoustic performance of building equipment are still in a state of evolution. More detailed discussion of standards is contained elsewhere in this report. Measurement procedures are still under development, and the current acoustic performance of standard equipment is still not fully understood within the various sectors of the industry. A system for rating equipment by category is seriously needed to give the control sector, designer and manufacturer a common language. The divergence of the city codes that do exist (15 dB spread) needs to be eliminated to reduce customizing requirements on the equipment manufacturers.

Summary of Pressures For/Against Quieting

a. For

- Quieting deemed a "necessity", no longer a "luxury"; tenants now in second or third generation of air conditioned buildings, and attitude toward quiet has matured to this point of view.
- Architectural desire for openness of design, new lightweight structural systems and economy of nonrevenue bearing space places premium on quieting of source.
- Mechanical engineers increasingly aware of need for quieting, hence now specifying acoustical performance.
- Occupational health and safety pressures spreading, following example set by Walsh-Healey Act.

- Codes at city level to enhance community quiet.
- Quieting generally becoming cost-beneficial in eyes of building owners.

b. Against

- Technical barriers make next step too expensive for single manufacturer to attempt by himself.
- Lightweight and small equipment desired to fit into small allocated spaces and remain tolerant of light foundations.
- Specific quieting goals are not clearly set, and codes and regulations are confusing and contradictory.

c. Trade-off Must be Examined

- Containment via enclosure vs quieting source - which is more cost effective?

4.3.2 Home appliances

There are approximately 70 to 80 important manufacturers* of home appliances in the U.S. These companies offer 30 to 40 different products that are potentially significant noise sources. For the purposes of assessing the state of noise control within this industry, we rank-ordered specific appliances according to their relative importance with regard to noise abatement in and around the home.

- air conditioners,
- dishwashers,
- water closets,

*Defined by observing company names and appliance categories in various well-established consumer journals.

- other major appliances (clothes washers, dryers, refrigerators), and
- appliances whose noise output is interpreted as a measure of its efficiency (vacuum cleaners, blenders).

The industry is characterized by four major company/product mix categories:

- large, multidivisional companies producing a broad range of products;
- medium-size companies formerly specializing in a well-known product but now branching out to take advantage of a good name in the consumer market;
- small and medium-size firms who maintain a certain leadership character through continued specialization; and
- companies manufacturing "private label" appliances to be sold by others, usually by large retailers who contract for and control the product policies of a large volume of home appliances.

Our interview program was organized to cover leading manufacturers of a range of equipment as well as retailers and industry associations. We interviewed eleven manufacturers (or manufacturing divisions of large companies), two major retailers, and two industry associations. Twenty-nine products and ninety-six product/manufacturers were covered by this survey.

Our overview of the industry's attitude toward noise control shows it to be so direct a function of market place pressure that noise control technology often exceeds application. Appliance manufacturers tend to maintain sophisticated R&D and product engineering staffs that are capable of delivering more noise reduction than market strategy can justify. In fact, some companies have tried - unsuccessfully - to market quiet products, such as air conditioners, vacuum cleaners, blenders, and hair dryers; others have developed a number of quiet prototypes that were not put into production.

Consumer research shows low noise levels are not highly valued by most customers. Several companies keep systematic track of customer correspondence, while the industry itself maintains a Major Appliance Consumer Action Panel (MACAP) that acts as a clearinghouse for complaints. These records, all of which concern major appliances, show relatively little complaint about noise. For example, only 5% of the letters to MACAP in the first eight months of 1971 were about noise.

The objectives for quieting household appliances seem to vary with the market pressures on particular products. With this observation in mind, we organize our discussion of noise control efforts around the "problem" appliances identified above.

Air Conditioners

There is probably more market pressure to quiet air conditioners than to quiet any other household appliance. Since air conditioners emit noise both indoors and out, they frequently affect not only the purchaser and his family, but also neighbors and passersby. Both kinds of emissions generate pressures for

noise reduction. Pressure from neighbors takes the form of local noise ordinances that specify maximum sound-emission levels at a property line; this pressure is passed on to the manufacturer, as one company pointed out, by dealers or marketing men who are aware of the ordinances.

Dollar sales of room air conditioners grew almost eight-fold in the decade of the 1960's; during that time, indoor quiet emerged as a competitive dimension. Several manufacturers are currently engaged in competitive advertising campaigns to sell the quietness of their room air conditioners and are giving their products brand or model names that imply the quietness. Two large appliance manufacturers independently volunteered the opinion that quiet is becoming more important to purchasers every year. One of these indicated that the fact that air conditioning allows one to close the house against outside noise may soon become a sales argument in air conditioner merchandising. However, one leader in the current "quiet" race indicated that their top-line model is not selling well.

Most quieting effort for air conditioners takes place in modest engineering laboratories that are attached to the local production facilities. One such laboratory reports spending three man-years per year on air conditioner noise control; one man-year per year was a more frequently mentioned level of effort. While the product policy people generally reported that they were making maximal use of available quieting technology, the study project acousticians who initiated the interviews felt that current state-of-the-art technology was not being universally applied.

Two estimates we received indicate that quieting room air conditioners adds 10 to 15% to their price. There may also be an inherent trade-off between quietness and efficiency (since one way to reduce air noise is to decrease air velocity). Sometimes, quieting results in increasing the air conditioner's physical dimensions, thus detracting from appearance as well as from convenience and ease of installation. There may also be a trend toward model lines differentiated by noise output - i.e., an expensive quiet air conditioner and a cheaper noisier model. One manager pointed out that there are anti-trust constraints against organizing industry consensus on noise levels.

Dishwashers and Food Disposers

The mechanical differences between dishwashers and disposers do not alter the fact that noise control pressures are similar and that the manufacturers' approach to quieting is similar. Thus our survey indicates that these two appliances logically group together.

Quiet is a saleable characteristic of dishwashers and disposers, although the pressures for quieting are not so great as for air conditioners. While we are aware of no advertising campaigns built exclusively on quiet, it is advertised with the same prominence given to power and reliability.

Noise levels from dishwashers and disposers are not currently under public regulation, hence the incentive for quiet comes almost exclusively from the purchaser. This gives rise to marked differences between models; if one wishes, one can buy an inexpensive, noisy dishwasher or disposer. Reports from the industry indicate that landlords frequently do just that.

Noise emissions from these two appliances are not so completely under the control of manufacturers as in the case of other appliances; the manner of installation greatly influences structureborne and plumbing-borne noises.

Dishwashers, however, present a promising example of industry's response to the purchaser's desire for lower noise levels. In a 1970 survey by the United States Steel Co., 48% of dishwasher owners had no complaints about their appliance, but of those who did, more complained about noise than about any other aspect of its operation. Both survey data and marketing "lore" indicate that the purchaser who has previously used these appliances puts a higher value on quietness than does the new user.

The costs of quieting were estimated by one dishwasher manufacturer to be 10% and by another to add \$1 to \$2 to manufacturing costs. A disposer manufacturer felt that quieting would add 12% to a product cost, whereas a retailer of disposers estimated 18%. Quietening these machines might deny their availability to those least able to pay.

In the case of dishwashers, one manufacturer indicated the possibility of trade-offs between noise and maintenance costs, and reliability. Another indicated a trade-off between water velocity and quiet but expressed the opinion that there are no serious technical restraints to quieting dishwashers.

In the case of disposers, industry claims inherent problems with water and grinding noise (especially with the noise of grinding bones). Some noise is considered necessary to the user's safety, so he will know when the disposer is operating and when it has finished grinding.

So far, a number of sophisticated techniques have been applied to dishwashers: isolation, damping, and parts re-design. Manufacturers of both dishwashers and disposers have tried to improve the quality of installation by providing carefully drawn instructions and flexible fittings. One company has reduced noise on its top-line dishwasher from 82 to 76 dB(A) (at an unspecified distance) since 1967 and plans a further reduction in the next few years. Another manufacturer expressed only the desire to keep abreast of the competition; this company tests each machine for noise, rejecting something under 1%.

None of the manufacturers interviewed intends to give up his noisier "economy" lines; goals did not seem to be appreciably influenced by the prospects of noise regulation.

The companies interviewed claimed to have adequate acoustic test facilities, although the efforts devoted to testing and to development varied widely in quantity and quality.

Water Closets

If evidence from mail order catalogues is reliable, quietness in water closets is a marketable attribute. Two top-line, "low profile" models prominently feature quiet in their advertising. One manufacturer indicated in an interview that placement of the height of the tank involves a trade-off between quiet and efficiency, and indicated that quiet designs may be less reliable, less efficient, and more expensive. Like dishwashers and food-waste disposers, economy-models are noisier than more expensive ones.

Currently, one company is trying to eliminate a water hiss that occurs when the tank is full.

Other Major Appliances

Quieter clothes washers, clothes dryers, and refrigerators tend to be by-products of engineering originally undertaken with other objectives in mind. The classic case is a washing machine model that was incidentally quieted when two gears were removed from the power train to save cost. In the context of product improvement, noise is generally treated as a secondary design goal, although manufacturers are concerned that engineering changes may produce noisier products. For example, refrigerators are becoming larger and noisier as manufacturers seek to meet the demand for special options such as ice makers; a spinner-type washing machine produced higher noise levels when spinner speed was increased to 2000 rpm.

Two of four manufacturers interviewed make quiet models of washing machines that sell at a \$10 to \$20 premium; sales for both lines are disappointing. None of the other models of these companies is marketed on the basis of quiet nor do the mail-order catalogues feature quiet. The single exception is a spinner-type washer in which "quiet operation" appears in the small-type description. There is, then, relatively little evidence of pressure for quieting appliances of this type.

Yet, despite the weakness of market pressures, considerable quieting effort has gone into the design of these appliances, especially washing machines. One manufacturer mentioned six different quieting projects that have recently been completed or are underway. A refrigerator manufacturer mentioned an effort to avoid strange or unidentifiable noise. No specific efforts to quiet dryers were uncovered.

Vacuum Cleaners

The manufacturers of vacuum cleaners believe that the market pressures are for noisy machines. The three manufacturers and one large retailer interviewed are all convinced that customers use noise as the basis for judging a machine's power. For example, after concentrated technical effort, a manufacturer had significantly reduced the noise from a canister model without reducing its cleaning capability. Housewives who participated in a marketing trial wanted to know "if the machines were really cleaning".

Neither of the large "private label" retailers we consulted mention quiet as a design goal. In fact, in advertising a nap adjuster, one company writes "... just slide the bar across until you hear the right cleaning purr". One company that carefully analyzes its correspondence from customers finds virtually no noise complaints about vacuum cleaners or any of its other portable appliances.

A reasonable level of engineering effort has produced feasible solutions to vacuum cleaner noise problems; according to all interviewed, however, these solutions are not being applied to products that are sold, because vacuum cleaner manufacturers and retailers do not sense a demand for quieter products. In fact, the sale of upright cleaners, whose beaters make them noisier, is growing at the expense of the sale of canister models. Apparently, the beater action of upright cleaners can better handle the new deep-pile weaves that make modern carpets harder to clean. There are technological limits to the quieting of upright vacuum cleaners, because of the interaction between the beater and the carpet, but the noise levels of production models seems to be determined by customer usage demand rather than by technological limitations.

The company that developed the quiet canister cleaner employs a physicist who works full-time on noise-control studies. The company calls in noise consultants about four times a year and samples its customers at six-month and two-year intervals. They have given considerable attention to the problem of beater noise and estimate that solutions that would not reduce a machine's efficiency would add 50% to its price.

Another large company made a study ten years ago (at a cost of about \$30,000) in which they developed ways of reducing vacuum cleaner noise in middle and high frequencies by about 10 dB(A). They have just contracted for a study of their competitors' canister machines and of the effect of using alternate motors in their own machines. Although they have available technical staff and laboratory facilities in-house, they have never applied the results of their studies to the products they market because of customer attitude toward noise.

Small Appliances

During the interviews incidental information was gathered from five different companies concerning eleven small appliances: blenders, can openers, coffee mills, electric knives, fans, hair dryers, ice crushers, knife sharpeners, mixers, oral lavages, and electric tooth brushes. Manufacturers feel that there is public pressure for these appliances to sound as though they are "really doing their jobs". One manufacturer offered the generalization that, in the small appliance field, the quality of the sound is more important than the quantity. An appliance must sound "right". Some must sound powerful, some reliable, and none as though they are malfunctioning or undergoing excessive wear. This manufacturer expressed the belief that an accurate interpretation of the customers' desires in these areas is a condition for remaining in business.

This market pressure leads to diverse noise-control objectives, both among companies and between product lines produced by a single company. Customer complaints were reported about the noise from fans and hair dryers, and one marketing executive was quoted as believing that quiet is a saleable aspect of mixers. One company which does not manufacture the ice crusher that is sold under its label put a fairly high value on quietness in selecting the model it sells. Yet, none of these small appliances was described as quiet in either of the two mail-order catalogues that we examined. Blenders and electric can openers were specifically described by the managers interviewed as being appropriately noisy. A company which we did not interview was cited as having quieted a blender; in so doing, they slowed it down so that it became less efficient. At least one laboratory is seeking entirely new ways of comminuting foods that could be both quieter and cheaper than blenders. Another is designing a screw-type crushing tool that will substitute a growling sound for the raucous sound of the chipper that current ice crushers employ.

There is also a search for fan blade configurations that will eliminate certain predominant frequencies and produce a more pleasing sound. In addition to room fans, this experimentation includes hair dryers, where quieter designs for air passages are also being sought.

Rubber feet have been added to electric coffee mills to reduce vibration noise, but shielding is not being used because of its adverse effects on costs, size, and aesthetic design. Plastic beaters for mixers promise to reduce both noise and costs.

Many of these appliances are powered by universal-type motors, which are inexpensive, powerful for their size, but noisy. The size-power ratio considered important in such appliances as hand mixers, electric knives, can openers, and motor-in-the-bonnet hair dryers. Conventional hair dryers also embody a trade-off between speed and quiet; one hair dryer model that was marketed as "quiet" took 30 to 75 minutes longer to dry hair than faster, noisier models.

Speed or the potential power that speed permits was cited as important to electric knives, can openers, and blenders. In the case of blenders, one engineer argued that, if they were slowed down, the intensity of the noise would simply be traded for noise duration with no lessening of resulting impact. There is also reported to be a trade-off for electric tooth brushes between noise and cleansing effectiveness.

Cases of limitations on quieting were pointed out for knife sharpeners where there is grinder-blade interaction, as well as for blenders where rotating knives are essential and a glass casing is necessary if the housewife is to monitor the process visually. In the case of blenders, there is hesitation to experiment with consumer preferences since the already intense domestic competition is being raised by the entrance of Japanese products into the market.

Small appliance manufacturers make frequent use of subjective noise judgements in their developmental work. Their product laboratories tend to be less sophisticated than those for major appliances, although many have access to central acoustical laboratories of great sophistication. One small appliance manufacturer tests new products in his employees' homes. If employees object to the noise the new model makes

they are asked if they would be willing to pay for a quieter product. The general result of this approach is to make this manufacturer pessimistic about the economic pay-off from quieter products.

Although specific noise goals are hard to identify in the appliance industry and although some manufacturers seem discouraged with the return on their efforts to date, all those interviewed plan to persist in quieting efforts. Technological limits have not yet been reached. One manufacturer believes that the earlier competition which emphasized compactness has now been replaced with an emphasis on quiet. Accordingly, industry generally plans to hold the size of future models constant and to concentrate on producing quieter models, while presumably keeping prices within competitive limits.

5. CONCLUSIONS AND RECOMMENDATIONS

This report has presented a broad range of facets concerning the noise characteristics of construction, appliances, and building equipment, the influence of this noise on our lives, and the nature of the industries producing and using this machinery. In this section, we summarize our findings and recommend what we believe to be a balanced noise abatement program that may be pursued by EPA.

5.1 Conclusions

One of the most striking factors to emerge from this study is the monumental complexity of the physical, social, and industrial system that we have attempted to understand. There is a wide spectrum of noise-producing machinery types utilized for many different purposes in a nearly endless number of situations. This heterogeneity makes a characterization of even the average properties of the sources and transmission paths difficult at best. Of course, nobody is exposed to average conditions but rather to some part of a multi-variable distribution of circumstances, making some notion of the range of source/path/receiver situation desirable. Furthermore, human response to noise varies widely among individuals and depends not only on the readily measurable aspects of sound such as level and spectrum, but also on such factors as attitudes, predispositions, the information content of the sound, and concurrent nonauditory stimuli. The industrial situation is equally complex, the judgement of industrial leaders and their concomitant directives being influenced by marketplace and legislative demands, as well as by their own personal attitudes. In presenting what we feel are the salient features of this complex system, we claim to have observed no more than the top of the iceberg - and even that at some distance.

5.1.1 Sources

Despite the tremendous range of equipment, the noise-producing mechanisms are often similar and may be identified as part of a much smaller class. The principal source of noise in many types of construction equipment, for example, is the diesel engine. Exhaust noise is most readily identifiable with structural sound radiation and inlet noise is also of importance. Additionally, the hydraulics, fans, and transmissions of construction equipment generate loud and identifiable noise levels. Such heavy equipment often creates levels in excess of 90 dB(A) at 50 ft. Drilling and cutting machinery are also extremely noisy as are impact tools such as riveters, pavement breakers, certain powered wrenches, and most pile drivers. Noise from jack hammers and rock drills often lies between 80 and 100 dB(A) at 50 ft; pile driver noise can exceed 100 dB(A). Almost invariably, construction equipment, regardless of its size, is noisy.

In evaluating the control technology of construction noise, one finds that approximately 10 dB(A) of noise reduction are generally achievable using state-of-the-art techniques; 20 dB(A) could no doubt be achieved with a certain level of technology development. Of course, these are average values. For some equipment, such as that sold without exhaust mufflers, greater noise reduction would probably be easily achieved; for others, such as riveters, considerable effort would be required to meet these objectives.

The noise levels of home appliances span a much broader range than those of construction equipment. Certain appliances such as food freezers or refrigerators are rather quiet at 30 to 40 dB(A), measured at 3 ft; other items such as food blenders can be as noisy as 80 to 90 dB(A) depending on the type, speed,

and food being processed. Garbage disposers may even exceed 90 dB(A). By and large, the noisiest classes of home equipment are powered garden and shop tools. Noise from electric lawn mowers, hedge trimmers, and grass edgers all measured between 80 and 90 dB(A). Some shop tools generated nearly 100 dB(A).

Noise from appliances is attributable to electric motors and cooling fans, plus the components being driven by the motors. For refrigeration equipment, these components are compressors and blowers; for food-waste disposers, they are grinders; for shop tools they are typically cutting or grinding elements, often connected to the motor by noise-producing gears. As with construction equipment, noise reduction levels of 10 dB(A) are generally achievable with state-of-the-art techniques; 20 dB(A) often requires either extensive application of existing techniques or the development of new technology to obtain the same results at less cost.

Building equipment probably has as large a range of noise-making devices and noise levels as construction and appliances combined. Diesel engines, gas turbines, and large electric generators or motors are all utilized, especially in so-called "total energy systems" which supply both electric power and temperature control for buildings. Refrigeration and heating equipment, blowers, diffusers, and fluorescent light transformers all generate noise. Fortunately, the noisiest sources of building equipment are usually remotely located, typically in mechanical equipment rooms. Isolating people from this noise is mainly done through architectural treatment.

5.1.2 Impact

We have tried to measure the impact of noise on people in terms of the levels to which they are exposed, the duration, and the number of people. In a one year period approximately 30 million Americans will find themselves living or working near a construction site. The noise from this site will be sufficiently high to interfere with their conversation most of the day. Three million workers with night shifts and 2.5 million children under four who may require naps live near these sites. Many will either find it more difficult to fall asleep or be awakened during their sleep because of construction noise. On the average, a metropolitan-area resident or worker passes a construction site every other day. Pedestrians can be exposed to noise levels in excess of 90 dB(A). Automobile drivers and passengers will often close their windows, thereby reducing the exposure to approximately 80 dB(A). Although many operators of heavy construction equipment are losing their hearing because of noise [29], hearing damage to persons in the environs of construction sites does not appear to be a substantial problem. Most people residing or working in buildings neighboring construction sites are exposed to less than 70 dB(A) most of the time. Some pedestrians are exposed to levels that could contribute to hearing loss particularly if these people are exposed to high noise levels during other times of the day.

One of the most significant aspects of construction noise is that, in any year, 15% of the population are exposed roughly eight hours a day, five days a week for many weeks or months. They have no control over the noise nor do they have much respite from it. The argument that construction is temporary has little appeal to people living near a several year project or one series of projects after another located all around them - after all, they argue, life itself is temporary.

Appliances have an impact on people in a rather different way. Most appliances affect only the people using them and only for a relatively brief time while they are in operation. For example, a food blender may generate 80 dB(A), but only for 30 seconds, at the end of which the user has a desired product. This leads to quite different attitudes toward appliances *vis a vis* construction equipment as bothersome noise sources. Of course, not all appliances affect only the user and his family. Appliances which affect neighbors are typically those which are built in to the home structure or plumbing and those which are used outside. Thus, food-waste disposers, dishwashers, water valves, and toilets are found to annoy and sometimes interfere with the sleep of people in multifamily dwellings. Powered garden tools such as lawn mowers, hedge clippers, and edge trimmers as well as power tools used outdoors (e.g., circular saws, drills, sanders) also generate sufficiently high noise levels to awaken or annoy neighbors.

One of the most striking aspect of appliances is their number. Roughly one billion appliances now are used in homes throughout the U.S. Virtually everyone owns at least some; e.g., 99.8% of homes are equipped with a refrigerator, over 90% have vacuum cleaners. By and large, people in the upper socio-economic stratum have more appliances. However, the generally increasing affluence of the nation coupled with the relatively constant price of appliances over the past 15 years (despite the inflationary growth of most other consumer items) has stimulated the profusion of appliances into homes at every economic level. This large number of appliances and their year-round use (with certain obvious exceptions) has made the exposure to appliance noise very large indeed. In fact, appliances account for more person-hours of speech interference, sleep interruption, and hearing damage than construction.

However, the impact in terms of annoyance is probably not so great, owing in large part to the controllability of many appliance operation times. For example, one does not have to run the dishwasher while listening to T.V., but it is difficult to ask the pile driver operator outside to cease work until a program of interest is over.

5.1.3 Industry programs

Industry activities in product quieting can best be understood by first considering the pressures they perceive. Demand for quiet appliances reaches manufacturers directly from the purchasers in the marketplace. The people who are exposed to noise, for the most part, are also those who purchase the appliance, or at least influence its selection. Demand for quiet construction equipment is also made by people living or working near construction sites. They generally have no economic influence on the building contractor or equipment manufacturer. Hence, their demands have largely gone unheeded and have been redirected through legislative bodies. A few successes in this arena have begun to create a marketplace demand for quiet equipment by contractors who "see the handwriting on the wall" and are willing to pay something of a premium for equipment that will not be illegal to operate in a few years when anticipated wider-ranging legislative controls are enacted.

The response to pressure for quiet has varied within and across the appliance and construction industries. Some appliance manufacturers have made a credible effort to develop capabilities to deal with noise-control problems and to design appropriate noise-control measures into their products. This has been especially true in the major appliance industry where air conditioners

and, more recently, dish-washers and food-waste disposers are being treated. As one might expect, the objective of disposer treatment is to reduce noise within the kitchen containing the unit. We know of no disposer designed to reduce transmission of noise through plumbing and into adjacent apartments. The disposers that incorporate airborne sound suppression are top-of-the-line items designed for use by the purchaser. Bottom-of-the-line disposers often have no noise treatment whatsoever and are usually installed in multifamily dwellings. Generally speaking, when noise control is introduced in appliances, it is in top-of-the-line items. There, it serves partly as an added luxury and partly as a test of market acceptability. If successful, it will often be introduced in other line items; if unsuccessful (for whatever reason) the notion will often develop and persist that consumers simply do not care about noise.

The construction equipment industry also shows a spectrum of levels of response to pressure for product quieting. A very few companies have foreseen the demand for quiet equipment and have begun a line of products that are significantly quieter than competitive models. Some companies have conducted experimental noise control projects, often with only a modicum of success. Several companies appear to have given noise-control very little effort (e.g., some heavy construction equipment does not even use exhaust mufflers for diesel engines). On the whole, noise has only begun to become a serious factor in the construction industry, which lacks much of the expertise required to deal successfully with it.

5.2 Recommendations

Most of the work presented in this report is of the nature of background material that must be applied to the problem of noise reduction to be of real value. Our recommendations therefore relate to the application of this information and the steps that we feel ought to proceed from it.

There appear to be two primary means by which the EPA can influence industry to bring about noise control. The first is to regulate the maximum allowable noise levels that can be produced by new equipment. The second is by instituting a mechanism for disseminating information to the consumer: namely, requiring the labeling of noisy products. In situations where the party exposed to noise is not the purchaser of the noisy equipment and is not in a position to influence the noise level or operation of the equipment, it appears that noise standards must be generated and applied to bring about noise reduction. This is largely the case in the construction industry, where the principal recourse to construction noise control by the community has been through local legislation. On the other hand, when the purchaser is, for all practical purposes, the only party affected by a noisy source and that source is not likely to contribute seriously to hearing damage, then standards appear to constrain unnecessarily one's freedom of choice. Rather it would seem appropriate to ensure that the purchaser is informed of the levels to which he will be exposed, but that he be allowed the freedom to weigh noise against other factors (e.g., price, size, durability) in reaching a decision among alternative products.

Setting standards and labeling requirements is no mean task. There are technical issues that must be resolved involving the conditions under which noise is to be measured. For example,

the type of sink in which a garbage disposer is installed and the character of food waste being disposed of, must be carefully specified to obtain meaningful and uniform results. Somewhat more difficult is the task of determining the maximum allowable levels for different kinds of equipment. In a sense, these levels invariably represent a compromise between desired values and values that are economically acceptable. This concept may be illustrated qualitatively by Fig. 27 in which we plot cost vs noise reduction. Cost is used to include capital, operation, and maintenance expenditures owing to the application of noise control treatment and whatever performance degradation might occur because of such treatment. Automobile mufflers are a good example; they increase the price of an automobile, often require replacement during the life of an automobile, and slightly degrade engine performance. Results achievable by application of state-of-the-art noise-control techniques are represented by an exponentially increasing curve. The first few dB of noise reduction are typically achieved at low cost; costs gain substantially as greater levels of quieting are sought. Also shown in the Fig. 27 is a cost vs noise reduction curve that might be achievable subsequent to noise-control research and development. In fact, it can probably be said that the sole objective of R&D should be to lower the state-of-the-art curve. The third curve in Fig. 27 shows a relation between cost and noise reduction deemed acceptable by the decision-makers. The curve is concave downward illustrating the notion that as a machine is made quieter, each increment of noise reduction is worth less and less. The intersection of the state-of-the-art curve with the acceptable cost vs noise reduction curve determines the noise reduction one is willing to specify. If this level of reduction is inadequate,

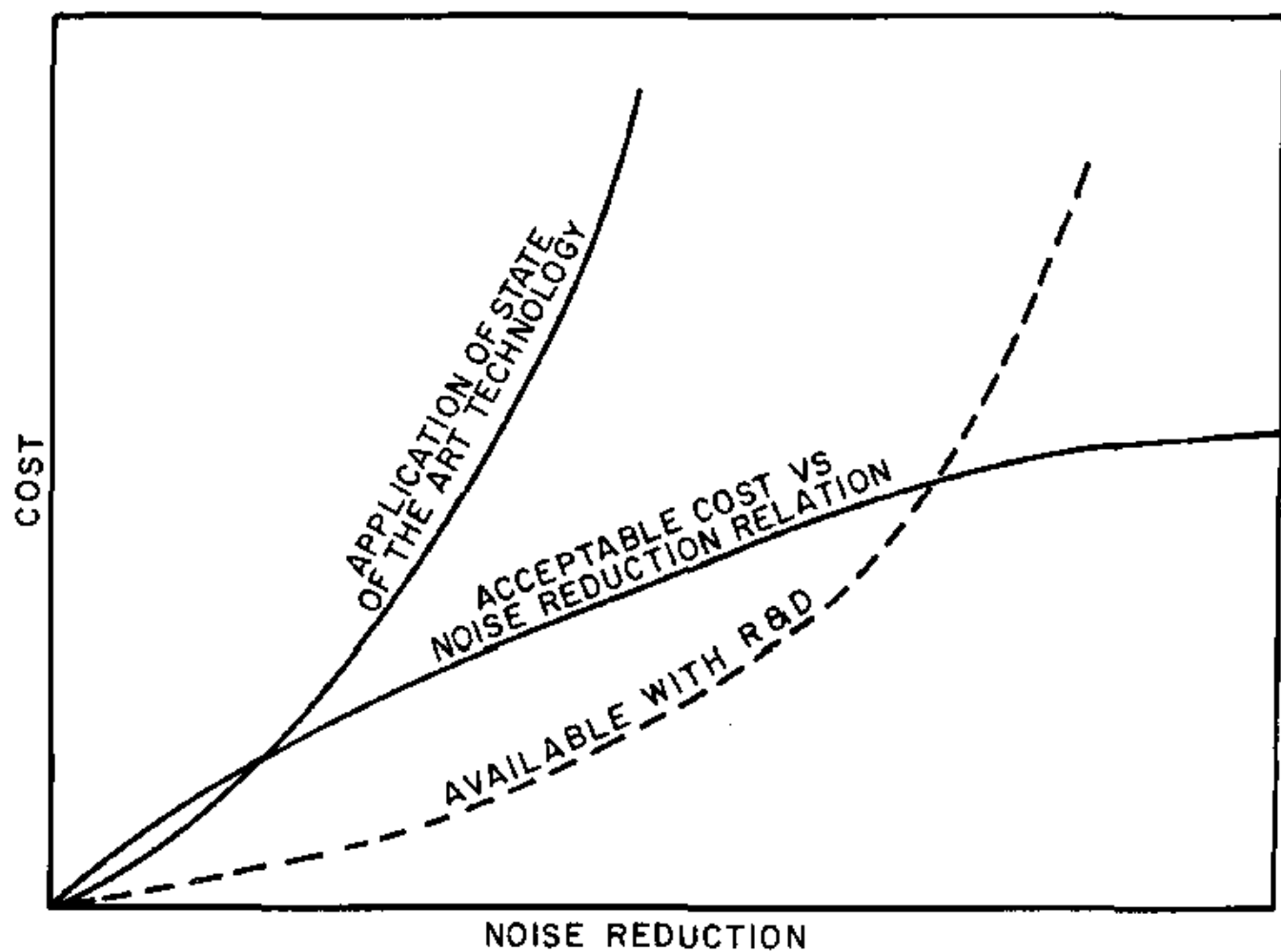


FIG. 27. COST OF NOISE CONTROL VS NOISE REDUCTION

it is necessary to conduct R&D to achieve a lower state-of-the-art curve and increase the level of noise reduction that can be justified economically.

Each party has its own view of the level of the acceptable cost vs noise reduction curve. For equipment manufacturers who find little marketplace demand for quiet products, the curve is low. People living or working near noisy equipment would naturally draw the curve at a higher level, especially if they did not have to bear a significant part of the cost for quieting the machinery. One of the problems that EPA will have to face is to develop an acceptability curve that is, in some sense, fair to all parties. Although it is difficult, if not impossible, to develop such curves quantitatively, it will be necessary for a decision maker to be aware of the pertinent relations between cost and noise reduction and to account for them in selecting the levels to be achieved. To assist in this process, we recommend here studies of the technology and economics of noise abatement, the economic impact of noise control, the type of improved noise criteria that ought to be developed, and social-indicator studies to measure the attitudes of the public to noise and noise control. First, let us consider which equipment ought to be regulated by standards and which by labeling.

5.2.1 Standards and labeling

We recommend that noise sources having a significant impact on parties who derive little direct benefit from the source ought to be controlled by the establishment of maximum allowable noise levels. This would include most construction equipment, construction sites, and certain types of appliances. Among the items of construction equipment requiring standards are all machinery powered by internal combustion engines as well as tools

utilizing impact or cutting mechanisms, such as drills, pavement breakers, and saws. Construction site noise levels ought to be regulated to ensure that the contractor deploy and utilize his machinery in a way that minimizes community noise exposure. Typical appliances requiring regulation are electric garden tools (e.g., lawn mowers, hedge clippers, edge trimmers), food-waste disposers, dishwashers, air conditioners, and shop tools. Because the noise of hazardous tools also serves to inform the user of their operation, minimum as well as maximum levels out to be set.

For standards to be applied in a way that may reasonably be met by industry and yet are sufficient to have an impact, we recommend the establishment of a three-phase program. A decreasing sequence of levels would be established and would go into effect approximately, one, four, and seven years subsequent to the time at which the levels are publicly announced.

One Year

The purpose of the first phase is to ensure that highly effective off-the-shelf noise control equipment is utilized on all new machinery. Thus, all machinery powered by internal combustion engines would be required to be equipped with high-quality mufflers, for example. (This contrasts with the current situation in which some construction equipment is advertised and sold without any muffling whatsoever.) One year appears adequate for manufacturers to order, receive, and install such equipment.

Four Years

The second phase would become effective approximately four years after announcement of levels. These levels would be selected to ensure that state-of-the-art noise control techniques are

incorporated in equipment. To achieve these levels, the manufacturer might have to use sound-absorptive engine enclosures, for example. Appliances might have to incorporate vibration isolators for all motors and pumps. Since the type of treatment envisioned here requires minor changes to equipment, four years appears adequate for manufacturers to design noise treatment and retool selected items of their production lines.

Seven Years

The levels to become effective after a period of seven years should largely represent state-of-the-art advances and should have a significant impact on the level generated by the noise source. Twenty dB(A) of noise reduction for the most offensive construction equipment and appliances would seem reasonable. Seven years allows sufficient time for the research and development needed for state-of-the-art advances and the incorporation of the fruits of this work in production items.

We also recommend labeling of appliances generating significant noise levels affecting primarily the user. Included in a list of items to be labeled are all items controlled by standards, as well as shop tools, vacuum cleaners, food blenders, fans, and hair dryers. Our rationale for labeling rather than standard setting is that a person should be informed of the noise to which he will expose himself and then be free to consider noise as but one of a number of factors accounting for his selection of a particular brand. Noise-control standards would no doubt raise appliance prices, unnecessarily restricting the consumer's range of choice.

5.2.2 Technology evaluation, demonstration, and development

We recommend the expenditure of appropriate levels of effort to evaluate, demonstrate, and develop technology in support of the establishment of standards. These studies are as follows:

Labeling

To make labeling meaningful, a consistent set of test procedures should be developed for each type of appliance or item of building equipment. This is especially important for appliances whose noise characteristics depend heavily on the installation. Prominent among these are food-waste disposers, dishwashers, plumbing fixtures, and vacuum cleaners (which may rest on a rug or a hard floor).

Standards - Phase I

The first recommended phase of standard setting establishes noise levels that can be met if highly effective off-the-shelf noise control devices are used on all equipment. Prior to the establishment of such standards, a program to measure the noise generated by selected machinery samples targeted for incorporation of such devices would seem appropriate.

Standards - Phase II

The second phase of standards would specify levels requiring the application of noise-control treatment. We recommend that EPA conduct noise-control demonstration projects on selected items for three reasons. First, achievable levels of noise reduction can be accurately evaluated, and accordingly specified, only by means of such programs. Without actually implementing noise-reduction techniques there would probably be an unacceptable

level of uncertainty associated with predictions. Furthermore, practical implementation problems are often not uncovered until treatment is actually put into practice. Second, such demonstration of results achievable by means of state-of-the-art noise treatment would put to rest any objections raised by the affected industry concerning the technological feasibility of achieving specified levels. Finally, the technical information generated by a demonstration program would be valuable across the affected industry, especially to small companies who often lack the requisite technical capability in noise control.

Standards - Phase III

The third recommended phase of standards is designed to have a significant impact on noise levels and will probably be achievable only through state-of-the-art advances in noise-control technology. To ensure that the state-of-the-art is appropriately advanced in sufficient time for implementation in new machinery we recommend the immediate commencement of R&D programs dealing with the following important aspects of construction and appliance noise (in approximate order of priority):

- diesel engines
- mufflers
- hydraulic systems
- cooling systems
- impact and cutting tools
- other power plants:
 - gas turbines (for nonaircraft use)
 - electric motors

- transmissions (gears)
- water valves

5.3 Economic Impact Studies

Determining the optimum balance between public's desire for quiet and the distributed costs required to achieve it by means of rigorous systems analysis effort would require a large-scale simulation of the economics of the construction industry and its place in the U.S. economy. Such a study is not feasible if usable results are required in a short time or if expenditure of funds is limited. It is possible, however, to make some choices as to what to quiet and how to quiet it, by doing some fairly unsophisticated investigation of how the quieting costs get distributed through the industry and the economy. We recommend treatment of:

- The impact of noise on various segments of the population. (This has largely been performed under the existing EPA contract and needs but a little expansion.)
- Estimated costs of quieting selected pieces of equipment as a function of degree of quieting. (This would be an order-of-magnitude estimate. Data can be obtained from price information on existing mufflers, heavy casings, absorptive materials, etc., as well as a study of price differentials between existing quieted and unquieted machinery — not just construction equipment. Costs of nonhardware guiding techniques, such as scheduling site operations to avoid using many pieces of equipment at once, would be estimated by constructing typical scenarios and consulting with industry representatives to determine increases in construction cost increases (or decreases). Allowance should be made for uses

in which a change in equipment design or operation results in greater productivity, reliability, etc. The effect of such an occurrence could be a net *negative* quieting cost.)

- The distribution of increased equipment cost among producers, purchasers and the purchaser's customers. (Part of the cost will be absorbed by each, depending on the demand elasticity of the commodity. This information exists in published studies of the economics of the construction industry.)
- Allocation of increased equipment costs/rentals among various types of construction. (The resulting increase in construction costs are a strong function of what is being built. Equipment rental typically makes up 20% of the cost of civil works constructions, 10% of the cost of highways, but only 2% in the case of buildings.)

The above data would be used to compute the economic effect of quieting equipment on the public. The outputs would be:

- The expected increase in costs and rentals of housing, offices, industrial space, etc., as a function of the degree and method of site quieting. Also of interest is the degree of intersection of the sets of: (1) surrounding inhabitants, who get the benefits of quiet sites, and (2) building users, who pay the cost, or part of it.
- Expected increase in state, municipal, and federal taxes as a result of increased cost of public works construction, etc.

The net result of the study would be recommendations for an orderly construction quieting program based on the information developed above. The criteria by which specific techniques or regulations would be judged are:

- Cost-effectiveness (the degree of quieting achieved per dollar expended).
- Cost-benefits (the reduction in community noise exposure as a function of quieting cost).
- Equitability (the degree to which the beneficiaries of a quieting program bear the expense of that program).

5.4 A Program of Public Support Development

Our contact with managers of construction equipment and home appliance manufacturing companies has convinced us that their perspective on and attitudes toward noise control programs will strongly influence the efforts they make to quiet their products. This is even more true of the values they hold regarding the legitimacy and worth of quiet environments. Indeed, we regard the public support of noise abatement efforts as a crucial variable in the success of these efforts.

We would, therefore, recommend a continuous program to diagnose and develop public support for noise abatement. Such a program would embrace five activities:

Exploration of Programs in Other Areas

We visualize this as an inquiry both into the theory of public opinion, attitude change, and shifts in basic values and into the actual techniques of public support development that have been employed in other contexts.

A Continuous Inventory of Opinion-Leader Attitudes

This would be a program of interviews with opinion leaders who are dealing with noise abatement. It would include leaders

in government, business, relevant professions, and consumer- and ecology-advocate groups.

A Continuous Inventory of Public Awareness, Attitudes, and Values

These should be measured on a well-designed material sample on a continuous basis so that trends over time could be assessed concerning public knowledge, attitudes, and values.

Program Development

A program, based on information obtained from the three activities above, should be developed (1) to optimize the kind and degree of regulation which can be supported by the public opinion that exists, (2) to prescribe a public information program that will improve the quality of public opinion, and (3) to identify profitable areas for demonstration programs.

The Development and Administration of Pilot Programs of Noise Abatement

These pilot programs should test the relation of regulation to various levels of public support in the same sense that pilot programs that test innovative technological prototypes are developed.

We should like to say a word regarding the usefulness and feasibility of the continuous inventories of leader opinion and public opinion — activities 2 and 3 above.

Field research in the behavioral sciences has now reached the point that useful social indicators can often be developed if their development is undertaken on a pragmatic basis. We do

not visualize that these survey activities will be conducted at the level of public-opinion polls. Again, the behavioral sciences have matured to the point that much more useful kinds of information can be gathered. We know from previous noise surveys that socio-economic status and attitudes toward noise makers influence noise annoyance and noise complaints. A recent study of motor vehicle noise that we have conducted indicates that the necessity of the noise, and the degree to which one perceives the noise as an intrusion, influences the level of annoyance. The survey efforts proposed would tap values that would assist in the formulation of noise criteria. Are people willing to put up with "bearable" levels of noise or do they now demand reduction to "comfortable" levels? Of greatest importance may be attitudes toward the regulating process itself. By now it is well-established in social psychology that basic orientations towards the sources of influence alter behavior. With regard to the product manufacturer who promises to become an object of regulation, theory would predict that one's enforcement problems would be quite different if the manufacturers complied to regulation because of fear, because compliance was expected by his reference groups, or because his own values induced compliance. These psychological orientations can be measured through interviews.

5.5 Social Impact

The following recommendations are made to evaluate the impact of noise not only from the sources under consideration in the current report but also from other sources.

1. The most fundamental action that can be taken to further the assessment of noise impact is to initiate research leading

to development of an absolute scale of annoyance for all noise exposure. The first stage of such a research program would obviously be a planning effort to structure the task and prepare detailed plans for its execution.

The need for such research is immediate. Existing methods for estimating annoyance are relative rather than absolute, limited in scope and application, not widely accepted, and of dubious utility. The intended research would entail simultaneous measurement of both complaint behavior and the offending acoustic signals producing complaints, *at the time of annoyance*. A continuous survey of residential noise annoyance over a considerable period of time is needed, as are surveys of noise annoyance in other environments. Until a well-founded research program of this sort is undertaken, one must continue to rely upon personal experience or the distortions of the popular press for estimates of the true magnitude of the annoyance problem.

2. Since speech interference proved to be such a widespread consequence of exposure to the noise sources considered in this report, research should be conducted to determine how accurately speech interference predictions made on the basis of laboratory data may be extended to real-life situations. Almost all current knowledge of speech interference effects has been produced by studies employing steady-state noise as the interfering signal. No research has been conducted on potentially crucial effects of temporal parameters of noise distributions (including frequency, duration, and periodicity of interference) on verbal communication. Further, little if anything is known of the annoyance value of speech interference. Trade-offs governing the relative annoyance of frequent but short interruptions vs infrequent but long interruptions of verbal communication have not been investigated. It therefore remains impossible to predict whether people would

suffer more speech interference from one type of appliance than another; whether redesign of machinery for longer duration but lower level noise output would be helpful; whether scheduling changes in the operation of construction machinery would reduce speech interference; and so forth.

3. Noise education programs should be designed to provide the public with the information needed to make decisions about the desirability of noise exposure. A noise-conscious public can exercise a modicum of control over its noise exposure through its purchasing power and its demands for noise control legislation. Consideration should be given to preparation of public information pamphlets, recordings, or other means of increasing public awareness of noise exposure.

REFERENCES

1. Schultz, T.J., "Community Noise Ratings: A Review," Supplement No. 1, *Applied Acoustics*, 1971.
2. Robinson, D.W., "The Concept of Noise Pollution Level," National Physics Laboratory Aero Report AC 38, March 1969.
3. Schultz, T.J., "Technical Background for Noise Abatement in HUD's Operating Programs," BBN Report No. 2005, September 1970.
4. Beranek, L.L., *Noise and Vibration Control*, McGraw-Hill Book Company, New York (1971).
5. "The Auditory Environment in the Home," a report by the Environmental Design Department, University of Wisconsin for Koss Electronics, Inc., Milwaukee, Wisconsin.
6. Mikeska, E.E., "Noise in the Modern Home," *Noise Control*, May 1958, p. 40.
7. BBN data measured in 1971.
8. Mikeska, E.E., "Noise Levels in Homes," *Noise Control*, May 1957, pp. 11-14.
9. "Field Study of Residential Acoustics: Acoustical Performance of Apartments and Occupants' Responses," NAHB Research Foundation, Inc., Rockville, Maryland, 1967.
10. Beranek, L.L., *Noise Reduction*, McGraw-Hill Book Company, New York (1960).
11. "Noise Study of a Domestic Dishwasher," BBN Rept. No. 979, March 1963.
12. "Water Closet Noise Studies," BBN Rept. No. 1402, Dec. 1968.
13. Cohen *et al*, "Sociocusis-Hearing Loss from Non-Occupational Noise Exposure," *Sound and Vibration*, November 1970, pp. 12-20.
14. Kryter, K., "Hazardous Exposure to Intermittent and Steady-State Noise," Report of Working Group 46 NAS-NSC Committee on Hearing and Bioacoustics, January 1965.

REFERENCES (Continued)

15. Kryter, K., *The Effects of Noise on Man* (Academic Press, N.Y., 1970).
16. Miller, J., personal communication, 1971.
17. Webster, J.C., "SIL - Past, Present and Future," *Sound and Vibration* 3(8):22-26, August 1969.
18. Beranek, L.L., "Criteria for Office Quietening Based on Questionnaire Rating Studies," *J. Acoust. Soc. Amer.*, 28, Sept. 1956, pp. 833-852.
19. "Urban Traffic Noise: Status of Research and Legislation in Different Countries," Draft Report of the Consultative Group on Transportation Research, DAS/CSI/68.47 Revised; Organisation for Economic Cooperation and Development, Paris, France, 4 March 1969.
20. Lang, J., and Jansen, G., "Report on the Environmental Health Aspects of Noise Research and Noise Control," United Nations, World Health Organization, May 1967.
21. Schieber, J.P., "Problemes Acoustiques du Confort de Nuit", (Acoustical Problems Concerning Nighttime Comfort), Cahiers du Centre Scientifique et Technique du Batiment, No. 100; Cahier 869, June 1969, Paris; p. 36.
22. Metz, B., "Étude Analytique en Laboratoire de l'Influence du Bruit sur le Sommeil," (Analytical Laboratory Study of the Influence of Noise on Sleep), No. 63 FR 138, University of Strasbourg, 1968.
23. Schieber, J.P., "Contributions des Études de la Physiologie au Probleme de la Determination des Zones de Confort Acoustique au Cours de Sommeil," (Contributions of Physiological Studies to the Problem of Determining Areas of Acoustic Comfort during Sleep), presented at a Colloquium on the Definition of Human Requirements with Regard to Noise, 18 & 19 November 1968, Paris; published in *Revue d'Acoustique* 3(10): 104-112 (1970).
24. Hildebrand, J., "Noise Pollution: An Introduction to the Problem and an Outline for Future Legal Research," *Columbia Law Review* 70, April 1970.

REFERENCES (Continued)

25. Kryter, K., "Laboratory Tests of Physiological-Psychological Reactions to Sonic Booms," *J. Acoust. Soc. Amer.*, 39(5) 1966.
26. *Noise: Final Report*, Committee on the Problem of Noise, Sir Alan Wilson, Chairman, Her Majesty's Stationery Office, London, July 1963.
27. Geber, W., Anderson, T., Van Dyne, B., and Vermillion, S., "Physiologic Responses of the Albino Rat to Chronic Noise Stress," *Arch. Environ. Health*, 12:751, 1966.
28. Dougherty, J., in "Human Response to Sonic Booms: A Research Program Plan," FAA Report No. 70-2, 1970 (BBN Report No. 1831).
29. Woodhead, M.M., "Effect of Brief Loud Noise on Decision Making," *J. Acoust. Soc. Amer.*, 31(10):1329-1331, 1959.
30. Corcoran, D., "Noise and Loss of Sleep," *Quarterly J. Exp. Psych.* (14) 1962.
31. Bureau of the Budget, *Standard Metropolitan Statistical Areas*, 1967.
32. Bureau of the Census, *Statistical Abstract of the United States*, 1970.
33. Business and Defense Services Administration, *Construction Review*, April 1971.
34. *Highway Statistics/1969*, U.S. Dept. of Transportation, Federal Highway Administration, Washington, D.C., Table OMB, p. 167.
35. Bureau of the Census, *U.S. Census of Population*, 1, 1960.
36. Wiener, F.M., Malme, C.I., and Gogos, C.M., "Sound Propagation in Urban Areas," *J. Acoust. Soc. Amer.*, 37, 1965.
37. *Noise in Urban and Suburban Areas: Results of Field Studies*, BBN Report 1395, 1967.

REFERENCES *(Continued)*

38. Department of Agriculture information based on studies of home activities (a long-term interest, which is now being continued under the Agriculture Research Service Division of the Department of Agriculture).
39. New York State College of Human Ecology, Cornell University (both published and unpublished data gathered as part of a 1296-household survey of Syracuse, New York).

APPENDIX A — DETAILED SOURCE CHARACTERIZATION

A.1 Construction Equipment

Of the considerable body of data on the noise of construction equipment, most pertains to the operator position; the available data on noise radiated by this equipment to its surroundings is very limited. The data presented in Fig. 1 (main text) and in this appendix were obtained from

- The open literature [1-4].
- Reports, including those submitted by various manufacturers at the EPA hearings on construction equipment held in Atlanta, Georgia, July 8 and 9, 1971.
- Field measurements conducted for this project at a number of construction sites in the vicinity of Boston.*

A.1.1 Noise spectra

Much of the equipment used at construction sites is powered by diesel engines, which generally constitute the predominant noise sources. Figure A.1 shows the envelope of the 1/3-octave band spectra of noise from 23 different items of diesel-powered construction equipment, rated from 45 to 770 hp and operating at between 1100 and 2700 rpm, at a variety of conditions (i.e., with various degrees of loading, ranging from none to heavy). These spectra were obtained at various locations around the equipment items, which also varied in the degree of exhaust muffling present.

*These measurements were made with a 1-in. Bruel and Kjaer type 4131 condenser microphone, coupled to a Bruel and Kjaer type 2203 sound level meter. The signals were recorded on a Kudelski Nagra type III tape recorder, and later analyzed in the laboratory by means of a General Radio Corp. "Real-Time Analyzer". Calibration was accomplished with the aid of a Bruel and Kjaer type 4220 piston phone.

Figures A.2, A.3, and A.4 show the noise spectra from some typical engine-powered items of equipment. The low-frequency peaks typically correspond to the firing frequency (the number of power strokes per unit time - which depends on the engine speed, number of cylinders, and on the number of power strokes per revolution) and its harmonics. Figure A.2 illustrates the noise made by two tracked bulldozers under various working conditions. These spectra reflect not only the diesel noise but also some noise due to tracks, gears, and scraping of metal components against rock.

Gasoline (spark-ignition) engines have noise spectra that are similar to those of diesel engines. In construction equipment, however, diesel engines tend to be used for all of the higher power applications, with spark-ignition engines relegated to lower power equipment. Spectra corresponding to two types of gasoline-engine powered equipment are shown in Fig. A.3.

Noise spectra for two air compressors - one diesel, one gasoline-engine powered - incorporating no special noise control provisions are shown in Fig. A.4. Figure A.5 shows the noise spectra associated with several pumps and generators; Fig. A.6 shows those levels produced by a vibrator acting on a plywood framework and by various saws cutting wood. Noise spectra produced by various pneumatic tools are shown in Fig. A.7.

The noise from conventional pile drivers is characterized by intense peaks associated with the impacts of the hammer against the pile. The peak levels associated with these impacts are indicated in Fig. A.8 for two conventional pile drivers, together with the noise levels produced by a sonic (vibratory, nonimpact) pile driver.

A.1.2 Average construction site noise pollution levels

Based on an analysis of the activities that occur during each phase of construction at the various types of sites, a listing of the equipment active during each phase was developed. This listing, together with an estimate of the fractional number of sites that involve each equipment item, appears in Table A-1.

For site noise analysis, this large table was simplified by averaging equipment usage over similar sites and by grouping together equipment items with similar noise characteristics. For the calculations, equipment with noise characteristics that were not known directly was replaced by equipment expected to have similar (known) noise characteristics (e.g., back fillers and trenchers were replaced by backhoes and loaders). Equipment known to be extremely quiet (e.g., electric cranes, electric fork lifts) was totally omitted from the calculations.

Since a given item of equipment is present at only a fraction of all sites and only during part of each phase, and since it only operates part of the time that it is present, a usage factor was assigned to each equipment item. This factor was calculated as the product of three factors: (1) the fractional number of sites at which the equipment is used (based on Table A-1), (2) the estimated fraction of the phase duration during which the equipment is on site and (3) the duty cycle, i.e., the fractional time that this equipment is operating while on site [5]. The resulting usage factors are summarized in Table A-2.

In order to calculate the site NPL, defined as the sum of the energy-average SPL in dB(A) and 2.56 times the Standard Deviation of A-scale SPL [6], one needs to know not only the average sound

133:1 3-11. 112 24 170 084K' 6' 1.115, 0.11' 04 5' 115

[illegible]

- * X = present at all sites
- (X) = may be present
- [X] = infrequently present

1. 2. 3. 4. 5. 6. 7. 8. 9. 10. 11. 12. 13. 14. 15. 16. 17. 18. 19. 20. 21. 22. 23. 24. 25. 26. 27. 28. 29. 30. 31. 32. 33. 34. 35. 36. 37. 38. 39. 40. 41. 42. 43. 44. 45. 46. 47. 48. 49. 50. 51. 52. 53. 54. 55. 56. 57. 58. 59. 60. 61. 62. 63. 64. 65. 66. 67. 68. 69. 70. 71. 72. 73. 74. 75. 76. 77. 78. 79. 80. 81. 82. 83. 84. 85. 86. 87. 88. 89. 90. 91. 92. 93. 94. 95. 96. 97. 98. 99. 100. 101. 102. 103. 104. 105. 106. 107. 108. 109. 110. 111. 112. 113. 114. 115. 116. 117. 118. 119. 120. 121. 122. 123. 124. 125. 126. 127. 128. 129. 130. 131. 132. 133. 134. 135. 136. 137. 138. 139. 140. 141. 142. 143. 144. 145. 146. 147. 148. 149. 150. 151. 152. 153. 154. 155. 156. 157. 158. 159. 160. 161. 162. 163. 164. 165. 166. 167. 168. 169. 170. 171. 172. 173. 174. 175. 176. 177. 178. 179. 180. 181. 182. 183. 184. 185. 186. 187. 188. 189. 190. 191. 192. 193. 194. 195. 196. 197. 198. 199. 200. 201. 202. 203. 204. 205. 206. 207. 208. 209. 210. 211. 212. 213. 214. 215. 216. 217. 218. 219. 220. 221. 222. 223. 224. 225. 226. 227. 228. 229. 230. 231. 232. 233. 234. 235. 236. 237. 238. 239. 240. 241. 242. 243. 244. 245. 246. 247. 248. 249. 250. 251. 252. 253. 254. 255. 256. 257. 258. 259. 260. 261. 262. 263. 264. 265. 266. 267. 268. 269. 270. 271. 272. 273. 274. 275. 276. 277. 278. 279. 280. 281. 282. 283. 284. 285. 286. 287. 288. 289. 290. 291. 292. 293. 294. 295. 296. 297. 298. 299. 300. 301. 302. 303. 304. 305. 306. 307. 308. 309. 310. 311. 312. 313. 314. 315. 316. 317. 318. 319. 320. 321. 322. 323. 324. 325. 326. 327. 328. 329. 330. 331. 332. 333. 334. 335. 336. 337. 338. 339. 340. 341. 342. 343. 344. 345. 346. 347. 348. 349. 350. 351. 352. 353. 354. 355. 356. 357. 358. 359. 360. 361. 362. 363. 364. 365. 366. 367. 368. 369. 370. 371. 372. 373. 374. 375. 376. 377. 378. 379. 380. 381. 382. 383. 384. 385. 386. 387. 388. 389. 390. 391. 392. 393. 394. 395. 396. 397. 398. 399. 400. 401. 402. 403. 404. 405. 406. 407. 408. 409. 410. 411. 412. 413. 414. 415. 416. 417. 418. 419. 420. 421. 422. 423. 424. 425. 426. 427. 428. 429. 430. 431. 432. 433. 434. 435. 436. 437. 438. 439. 440. 441. 442. 443. 444. 445. 446. 447. 448. 449. 450. 451. 452. 453. 454. 455. 456. 457. 458. 459. 460. 461. 462. 463. 464. 465. 466. 467. 468. 469. 470. 471. 472. 473. 474. 475. 476. 477. 478. 479. 480. 481. 482. 483. 484. 485. 486. 487. 488. 489. 490. 491. 492. 493. 494. 495. 496. 497. 498. 499. 500. 501. 502. 503. 504. 505. 506. 507. 508. 509. 510. 511. 512. 513. 514. 515. 516. 517. 518. 519. 520. 521. 522. 523. 524. 525. 526. 527. 528. 529. 530. 531. 532. 533. 534. 535. 536. 537. 538. 539. 540. 541. 542. 543. 544. 545. 546. 547. 548. 549. 550. 551. 552. 553. 554. 555. 556. 557. 558. 559. 560. 561. 562. 563. 564. 565. 566. 567. 568. 569. 570. 571. 572. 573. 574. 575. 576. 577. 578. 579. 580. 581. 582. 583. 584. 585. 586. 587. 588. 589. 590. 591. 592. 593. 594. 595. 596. 597. 598. 599. 600. 601. 602. 603. 604. 605. 606. 607. 608. 609. 610. 611. 612. 613. 614. 615. 616. 617. 618. 619. 620. 621. 622. 623. 624. 625. 626. 627. 628. 629. 630. 631. 632. 633. 634. 635. 636. 637. 638. 639. 640. 641. 642. 643. 644. 645. 646. 647. 648. 649. 650. 651. 652. 653. 654. 655. 656. 657. 658. 659. 660. 661. 662. 663. 664. 665. 666. 667. 668. 669. 670. 671. 672. 673. 674. 675. 676. 677. 678. 679. 680. 681. 682. 683. 684. 685. 686. 687. 688. 689. 690. 691. 692. 693. 694. 695. 696. 697. 698. 699. 700. 701. 702. 703. 704. 705. 706. 707. 708. 709. 710. 711. 712. 713. 714. 715. 716. 717. 718. 719. 720. 721. 722. 723. 724. 725. 726. 727. 728. 729. 730. 731. 732. 733. 734. 735. 736. 737. 738. 739. 740. 741. 742. 743. 744. 745. 746. 747. 748. 749. 750. 751. 752. 753. 754. 755. 756. 757. 758. 759. 760. 761. 762. 763. 764. 765. 766. 767. 768. 769. 770. 771. 772. 773. 774. 775. 776. 777. 778. 779. 780. 781. 782. 783. 784. 785. 786. 787. 788. 789. 790. 791. 792. 793. 794. 795. 796. 797. 798. 799. 800. 801. 802. 803. 804. 805. 806. 807. 808. 809. 810. 811. 812. 813. 814. 815. 816. 817. 818. 819. 820. 821. 822. 823. 824. 825. 826. 827. 828. 829. 830. 831. 832. 833. 834. 835. 836. 837. 838. 839. 840.

1. *Journal of the American Medical Association*
 2. *Journal of the American Medical Association*
 3. *Journal of the American Medical Association*
 4. *Journal of the American Medical Association*
 5. *Journal of the American Medical Association*

[illegible]

* χ^2 test for independence, $p < 0.05$.

TABLE A-2a. USAGE FACTORS OF EQUIPMENT
IN DOMESTIC HOUSING CONSTRUCTION*

| Equipment† | | Construction Phase | | | | |
|-------------------|-------|--------------------|------------|------------|----------|-----------|
| | | Clearing | Excavation | Foundation | Erection | Finishing |
| Air Compressor | [81] | | .1 | | | .25 |
| Backhoe | [85] | .02 | .04 | | | .02 |
| Concrete Mixer | [85] | | | .4 | .08 | .16 |
| Concrete Pump | [82] | | | | | |
| Concrete Vibrator | [76] | | | | | |
| Crane, Derrick | [88] | | | | | |
| Crane, Mobile | [83] | | | | .1 | .04 |
| Dozer | [80] | .04 | .08 | | | .04 |
| Generator | [78] | .4 | | | | |
| Grader | [85] | .05 | | | | .02 |
| Jack Hammer | [88] | | | | | .025 |
| Loader | [79] | .04 | .08 | | | .04 |
| Paver | [89] | | | | | .025 |
| Pile Driver | [101] | | | | | |
| Pneumatic Tool | [85] | | | .04 | .1 | .04 |
| Pump | [76] | | .4 | .7 | | |
| Rock Drill | [98] | | .01 | | | .005 |
| Roller | [74] | | | | | .04 |
| Saw | [78] | | | .04(2) | .1(2) | .04(2) |
| Scraper | [88] | .05 | | | | .01 |
| Shovel | [82] | | .02 | | | |
| Truck | [91] | .16 | .4 | | | .16 |

* Numbers in parentheses represent average number of items in use, if that number is greater than one. Blanks indicate zero or very rare usage.

† Numbers in brackets [] represent average noise levels [db(A)] at 50 ft.

TABLE A-2b. USAGE FACTORS OF EQUIPMENT
IN NONRESIDENTIAL CONSTRUCTION*

| Equipment† | | Construction Phase | | | | |
|-------------------|-------|--------------------|------------|------------|----------|-----------|
| | | Clearing | Excavation | Foundation | Erection | Finishing |
| Air Compressor | [81] | | 1.0(2) | 1.0(2) | 1.0(2) | .4(2) |
| Backhoe | [85] | .04 | .16 | | | .04 |
| Concrete Mixer | [85] | | | .4 | .4 | .16 |
| Concrete Pump | [82] | | | .4 | .08 | .08 |
| Concrete Vibrator | [76] | | | .4 | .1 | .04 |
| Crane, Derrick | [88] | | | | .16 | .04 |
| Crane, Mobile | [83] | | | | .16(2) | .04(2) |
| Dozer | [80] | .16 | .4 | | | .16 |
| Generator | [78] | .4(2) | 1.0(2) | | | |
| Grader | [85] | .08 | | | | .02 |
| Jack Hammer | [88] | | .1 | .04 | .04 | .04 |
| Loader | [79] | .16 | .4 | | | .16 |
| Paver | [89] | | | | | .1 |
| Pile Driver | [101] | | | .04 | | |
| Pneumatic Tool | [85] | | | .04 | .16(2) | .04(2) |
| Pump | [76] | | 1.0(2) | 1.0(2) | .4 | |
| Rock Drill | [98] | | .04 | | | .005 |
| Roller | [74] | | | | | |
| Saw | [78] | | | .04(3) | 1.0(3) | |
| Scraper | [88] | .55 | | | | |
| Shovel | [82] | | .4 | | | |
| Truck | [91] | .16(2) | .4 | | | .16 |

* Numbers in parentheses represent average number of items in use, if that number is greater than one. Blanks indicate zero or very rare usage.

† Numbers in brackets [] represent average noise levels [db(A)] at 50 ft.

TABLE A-2c. USAGE FACTORS OF EQUIPMENT
IN INDUSTRIAL CONSTRUCTION*

| Equipment† | Construction Phase | | | | |
|------------------------|--------------------|------------|------------|----------|-----------|
| | Clearing | Excavation | Foundation | Erection | Finishing |
| Air Compressor [81] | | 1.0 | .4 | .4 | .4 |
| Backhoe [85] | .04 | .16 | | | .04 |
| Concrete Mixer [85] | | | .4 | .16 | .16 |
| Concrete Pump [82] | | | .4 | | .08 |
| Concrete Vibrator [76] | | | | | |
| Crane, Derrick [88] | | | | .04 | .02 |
| Crane, Mobile [83] | | | | .08 | .04 |
| Dozer [80] | .04 | .16 | | | .04 |
| Generator [78] | .4 | .4 | | | |
| Grader [85] | .05 | | | | .02 |
| Jack Hammer [88] | | .1 | .04 | .04 | .04 |
| Loader [79] | .16 | .16 | | | .04 |
| Paver [89] | | | | | .12 |
| Pile Driver [101] | | | .04 | | |
| Pneumatic Tool [85] | | | .04 | .1(3) | .04(2) |
| Pump [76] | | .4 | 1.0(2) | .4 | |
| Rock Drill [98] | | .04 | | | .05 |
| Roller [74] | | | | | .1 |
| Saw [78] | | | .04(2) | .1(2) | |
| Scraper [88] | .14 | | | | .08 |
| Shovel [82] | | .2 | | | .06 |
| Truck [91] | .16(2) | .16(2) | | | .16 |

* Numbers in parentheses represent average number of items in use, if that number is greater than one. Blanks indicate zero or very rare usage.

† Numbers in brackets [] represent average noise levels [db(A)] at 50 ft.

TABLE A-2d. USAGE FACTORS OF EQUIPMENT
IN PUBLIC WORKS CONSTRUCTION*

| Equipment [†] | Construction Phase | | | | |
|------------------------|--------------------|------------|------------|----------|-----------|
| | Clearing | Excavation | Foundation | Erection | Finishing |
| Air Compressor [81] | | 1.0(2) | .4 | .4 | .4(2) |
| Backhoe [85] | .04 | .4 | | | .16 |
| Concrete Mixer [85] | | | .16(2) | .4(2) | .16(2) |
| Concrete Pump [82] | | | | | |
| Concrete Vibrator [76] | | | | | |
| Crane, Derrick [88] | | 0.1 | .04 | .04 | |
| Crane, Mobile [83] | | | | .16 | |
| Dozer [80] | .04 | .4 | | | .16 |
| Generator [78] | 1.0(2) | .4(2) | .4(2) | .4 | .4(2) |
| Grader [85] | .08 | | | .2 | .08 |
| Jack Hammer [88] | | | | .04 | .1(2) |
| Loader [79] | .04 | .4 | | | .16 |
| Paver [89] | | | | | |
| Pile Driver [101] | | | | | |
| Pneumatic Tool [85] | | | .04(2) | .1 | .04 |
| Pump [76] | | .4(2) | 1.0(2) | .4(2) | |
| Rock Drill [98] | | .04 | | | |
| Roller [74] | | | .01 | | |
| Saw [78] | | | .04(2) | | |
| Scraper [88] | .08 | | .2 | .08 | .08 |
| Shovel [82] | .04 | .4 | .04 | | .04 |
| Truck [91] | .16(2) | .16 | .4(2) | | .16(2) |

* Numbers in parentheses represent average number of items in use, if that number is greater than one. Blanks indicate zero or very rare usage.

[†] Numbers in brackets [] represent average noise levels [db(A)] at 50 ft.

pressure, but also enough about its time-variation so that one can determine its standard deviation. In addition, the background noise levels enter in the evaluation of both of these quantities. Accordingly, representative background noise levels were selected as 50 dB(A) for residential, suburban, and rural sites and 70 dB(A) for commercial and industrial (urban) sites, on the basis of data for various U.S. and foreign locations [7].

Representative time-variations of noise were generated by dividing each construction phase into 50 equal time intervals. The start (or "turn-on") times for each individual item listed in Table A-2 were determined at random (by means of a computer random number generator), and the fractional "on-time" duration for each item was taken as its usage factor (Table A-2). From the noise level for each item of equipment, the total noise level in each time interval was then calculated, and from this ensemble of values the desired average and standard deviations were evaluated. For test purposes, the calculations for several sites/phases were repeated several times, with different randomly selected start times; the resulting NPL values were always found to lie within a 3 dB(A) interval. Although such repetitive calculations were not carried out for all sites/phases, the reported site NPL values may be considered as valid within ± 2 dB(A).

A.2 Appliances

In the following sections, brief discussions are presented of appliances not covered in the body of the report. We measured the noise levels of many of these appliances; these measurements are presented here as 1/3-octave band sound pressure data.

A.2.1 Can opener, electric

Noise of electric can openers is generated by the reducing gears, the electric motor, and the grating of the clamp against the moving lip of the can. Additional noise is radiated from the plastic or metal panels of the unit. Can openers are usually mounted on small rubber feet which partially isolate the vibration from the work surface; however, wall mounting of the opener can short-circuit this isolation. The A-weighted sound level at a distance of 3 ft was measured for seven electric can openers; the mean level was 66 dB(A).

Figure A.9 shows 1/3-octave band plots of the sound pressure levels measured at a distance of 3 ft for two different can openers. The peaks at 63 and 125 Hz are probably motor-induced while the higher frequency peaks are probably related to the number of teeth in the reducing gears.

A.2.2 Clothes dryer

Clothes dryers are relatively quiet appliances which consist of a rotating drum within a metal enclosure; heat is supplied by either electric coils or a gas flame. The constant noise of the motor and the rumble of the drum, plus the combustion roar in a gas dryer, are punctuated by the noise of buttons or zippers impacting with the metal chamber. A range of sound levels from 51 dB(A) to 66 dB(A), with a mean level of 58 dB(A), was measured at a distance of 3 ft for eleven gas and electric dryers. Figure A.10 shows 1/3-octave band sound pressure level data for five different dryers.

A.2.3 Clothes washer

The noise generating components of clothes washers include:

- water noise during the filling, agitation, and spinning cycles
- unbalanced loads, which cause excessive vibration to be transmitted into piping and floor
- motor
- pump

Figure A.11 presents the noise levels for the wash cycle of five different machines; Fig. A.12 shows noise levels for the spin cycle of four of these five machines. The peaks in the low-frequency bands probably represent motor-induced noise while those in the mid-frequency bands may be related to spinning of the tub.

A.2.4 Coffee mill

A coffee mill consists of a grinding mechanism that is driven by a motor to produce fine to coarse ground coffee. Motor-induced noise is radiated from the casing and the coffee bean enclosure. Rubber feet are provided for vibration isolation. Measurements were made at a 3 ft distance on two coffee mills: the two sound levels were 75 dB(A) and 78 dB(A).

A.2.5 Dehumidifier

In a home humidifier, a small fan draws air across condensing coils, collecting the moisture in a removable pan. Noise measurements were made of four dehumidifiers; the noise varied from 52 dB(A) to 62 dB(A).

Figure A.13 present 1/3-octave band data for the quietest of these units. The broad peak in the vicinity of 120 Hz is motor induced; mid-frequency noise is dominated by the fan. Although compressors may be vibration isolated, the casing of a unit is likely an important radiator.

A.2.6 Edger and trimmer

An edger and trimmer consists of a high-speed motor directly driving a two-bladed knife. This lawn tool is used to trim the grass along walkways and the brush along garden paths.

Figure A.14 presents 1/3-octave band data on one unit; the sound level was 81 dB(A). The peaks in the frequency spectrum seem to be the 1st, 2nd, 3rd, 6th, and 20th harmonics of 400 Hz. It is anticipated that narrower band analysis would reveal more tonal components that are related to the blade passage of the cutting edge.

A.2.7 Fan

There are three general categories of fans found in the home: window fans, floor fans, and stove hood and bathroom exhaust fans.

- Window fans are usually standardized to a 14-in. or 22-in. size (12-in. and 20-in. diameter blades respectively). Features on deluxe models include thermostatic control and reversible direction of air flow. Twelve noise measurements of window fans ranged from 47 dB(A) to 66 dB(A); the mean was 57 dB(A). Low-speed to high-speed mean values showed a spread of 17 dB(A).

Figure A.15 presents 1/3-octave band noise measurements for three window fans for both low and high speed. The tonal components are likely related to the blade passage frequency of the fan, the motor, the blade tip velocity, and the blade design.

- Floor fans or table fans usually consist of a base, a small electric motor, and a blade with protective cage. They often rotate back and forth to spread air movement around an arc of 90° or so and are usually designed to run at various operating speeds. Twenty-two measurements at a 3 ft distance yielded a range of sound levels from 38 dB(A) to 67 dB(A); the mean level was 54 dB(A).

Figure A.16 presents 1/3-octave band data for three floor fans for both low and high speed. The noise sources are very similar to those of window fans.

- Stove hood exhaust fans and bathroom exhausts are typically small axial flow fans mounted directly above the stove to exhaust cooking odors or in the bathroom ceiling to exhaust hot air. The mean dB(A) level of ten measurements at a 3 ft distance was 63 dB(A).

Figure A.17 presents narrowband data for four speeds for one particular stove hood exhaust fan. Again, the tones are related to motor noise and blade passage fan noise. Through the use of appropriate lining it should be possible to reduce the noise of stove hood exhaust fans and bathroom exhaust fans by up to 15 dB(A).

A.2.8 Food blender

The electrical motor control system on food blenders is designed to drive the cutting blades (located at the bottom of a removable container) at a wide range of speeds in order to perform various food blending tasks. Speed control may be achieved by using a variable-speed motor or solid state electronic networks. The primary sources of noise are the motor, the whirling of the blades causing radiated noise, structureborne noise, and agitating noise of the fluid. From measurements of the noise generated by foreign and domestic food blenders, the sound level ranged from 62 to 88 dB(A) with a mean level of 75 dB(A). The container was half full of water during most of these measurements. Figure A.18 presents a series of narrowband measurements representing the noise levels generated by one food blender running at each of nine different speeds. The peaks in the spectrum shift upward in frequency with increased speed, suggesting a dependence on the blade passage frequency of the cutting edges. Figure A.19 shows the variation in noise level for a maximum speed setting for five food blenders of different manufacture.

A.2.9 Food mixer

Food mixers are available in both portable and table model styles. Portable mixers are lightweight versions of table models -- they have no base but consist of the same basic mechanisms: a set of beaters and a variable-speed motor or a single-speed motor with reduction gears. Twenty-five sound level measurements were made at a 3 ft distance on domestic and foreign, portable and table model food mixers. The mixer was operated in a bowl half-full of water for most of the measurements. The sound level ranged from 49 dB(A) to 79 dB(A) with a mean level of 67 dB(A). Figure A.20 shows narrowband analysis of mixer noise at low speed and at high speed.

A.2.10 Freezer

The mechanical components of a freezer are a compressor, evaporative coils, condensing coils, and one or two fans, as in a refrigerator. Small freezers have the condensing coils spread over the back of the machine. On larger units, with their requirement for forced cooling, the condenser coils are grouped at the bottom and cooled by a fan that also cools the compressor. With the compressor in operation, the sound levels generated by three home freezers were measured; the mean level was 41 dB(A) with a range of 39 to 45 dB(A) at a 3-ft distance. Figure A.21 shows narrowband data for two of the three freezers. The primary noise generators are the motor, fans, and compressor, with some radiation from the casing.

A.2.11 Hair clipper

A measurement of the noise generated by a hair clipper was made at a distance of 3 ft; the sound level was 59 dB(A). The noise is generated by the motor and gears which enable the clipping blades to vibrate.

A.2.12 Hair dryer

Different models of hair dryers all share the design objective of forcing warmed air over wet hair. Table models have a hard-shelled enclosure like that of a professional hairdressers machine. Portable dryers have plastic bonnets connected to the fan and heater by a flexible hose. Noise is generated by the fan, motor and air flow. A faster drying rate is achieved by greater air flow and higher temperatures; this, however, means increased noise from the fan. The latest development of a totally portable unit - with motor and blower attached directly to the bonnet - is the noisiest arrangement because it puts the noise source directly by the ear of the user. Six hair

dryers were measured at a 3-ft distance; the mean level was 61 dB(A). Figure A.22 shows 1/3-octave band sound pressure levels measured at a distance of 3 ft from three units. The low-frequency tonal components are probably motor related, while the high-frequency peaks may relate to the blade passage of the blower.

A.2.13 Heater, electric

Electric heaters used to heat a single room typically have small single-speed fans that blow air past electric coils into the room. The noise generated by these heaters is due to the electric motors, the fans, air flow, and, often, rattling metallic parts. A noise level of 47 dB(A) was measured at 3 ft from an electric heater.

A.2.14 Hedge clippers

The noise of hedge clippers, in which an electric motor runs one or two cutter bars, is mainly generated by the motor and reciprocating gear action. On some models, one bar moves back and forth against a stationary bar; on other models, two cutters reciprocate. Since the latter is a more balanced action, vibration to the user is reduced. We measured a noise level of 84 dB(A) at 3 ft from one unit.

A.2.15 Home shop tools

Electrically-powered shop tools such as drills, saws, sanders, grinders, lathes, and routers have similar noise generating mechanisms. In general, portable shop tools, due to their requirement to be lightweight and high-powered, require forced cooling of the motor and use high-speed universal motors which are often noisy

even when running free. Table model shop tools generally use induction motors which are relatively low speed and quiet when running free.

The portable straight-line or vibration sander is relatively quiet when running free [63 dB(A) at 3 ft] because it has a lower power requirement than most power tools and requires no forced cooling. Figure A.23 shows narrowband data for two operations of a belt sander: running free [82 dB(A)] and sanding wood [86 dB(A)]. The primary noise is the vibrating action of the sander foot.

In drills the gears add to the noise - the more sets of gears required, the noisier the operation. The noise generated by four 1/4-in. drills with a single set of gears measured 76 to 80 dB(A), the noise of two 3/8-in. drills with two sets of gears measured 83 dB(A), and the noise of two 1/2-in. drills with three sets of gears measured 84 and 87 dB(A). Figure A.24 presents noise levels measured near a 1/4-in., a 3/8-in., and a 1/2-in. drill; the peaks in the spectrum are probably related to the speed and the teeth ratios of the gears. Figure A.25 presents narrowband data on two different drill presses, one working metal, the other wood.

Noise levels generated by three different grinders working metal [87 to 97 dB(A)] are shown in Fig. A.26. In Fig. A.27 the noise levels generated by a router running free [81 dB(A)] are compared with the levels when it is working wood [88 dB(A)]. Noise levels of a small metal lathe are shown in Fig. A.28 for a running free condition and for cutting metal. Figure A.29 shows the narrowband data for a sabre saw running free and cutting wood.

Noise levels associated with the cutting of wood by a jig saw, a radial saw, a table saw, and a band saw are shown in Fig. A.30. The tone at 3150 Hz for the table saw may correspond to the frequency of teeth passing a given point [8].

Tools such as a table grinder, lathe, table jig saw, and table band saw generate noise levels in the mid-sixty to mid-seventy dB(A) range at a 3-ft distance while running free. The larger portable tools especially drills and grinders, generate noise levels of 80 to over 90 dB(A) running free.

A.2.16 Humidifier

Room size humidifiers are relatively simple mechanical devices in which a fan forces air through a wetted pad. Humidifiers exemplify the recurring noise problem from air circulation caused by fan, motor, and air movement noise. Figure A.31 shows narrowband data - 41, 51, and 65 dB(A) - for three settings of one humidifier. The higher levels are associated with higher fan speeds and thereby increased flow noise.

A.2.17 Knife, electric

For easy handling in the home, electric knives are designed to be small and lightweight. Therefore, the electric motor and gears for reciprocating blade action are encased in lightweight plastic. While the noise of an electric knife [with a range of 65 to 75 dB(A) and a mean level of 70 dB(A) at 3 ft] can be annoying, it also acts as a signal that the knife is in operation. Figure A.32 shows narrowband data for two of the three samples.

A.2.18 Knife sharpener

Electric knife sharpeners are often attached to electric can openers as well as being separate appliances. The rotation of sharpening stones alone is very quiet since just the motor and shaft rotate; however, the interaction between the stone and the knife during the sharpening process makes an unavoidable grating noise. A single measurement was made at a 3-ft distance; while the noise levels vary depending on the pressure of the knife against the stone, 72 dB(A) is representative of a typical sharpening operation.

A.2.19 Lawn mower, electric

The gears and the A.C. or battery powered engine of the rotary type electric lawn mower are the main sources of noise. The rattling of the engine housing and other metal parts plus the whirling sound of the blade are also identifiable. Although an electric lawn mower is often quieter than a gasoline-powered lawn mower, the two electric ones that were measured registered 81 and 89 dB(A) at a 3-ft distance. The larger the lawn mower, the more powerful an engine is needed to rotate the blade, and thus the noisier the device. Certain possibilities appear feasible for quieting the electric lawn mower such as changes in blade design and speed to reduce vortex noise, tighter construction of the tool, and sound damping for the motor housing and blade covering.

A.2.20 Oral lavage

An oral lavage is a device that uses the squirting force of water to cleanse the mouth. The motor drives a reciprocating pump, connected to a water supply, which forces a tiny stream of water out the end of a tube. Two measurements gave values of 70 and 72 dB(A).

A.2.21 Refrigerator

The majority of the refrigerators sold today are automatically defrosting. Cooling coils are located outside the freezer storage area and cold air is circulated through the freezer unit by a fan. The automatic defrost mechanism periodically melts the ice which forms on the coils. The trend in recent years has been to larger refrigerators with features such as automatic ice cube tray filling, ice cube making, and defrosting. Refrigerators with such features require more power and thus larger compressors with resulting higher noise levels. Better sound isolation around the machinery compartment, sound absorbing material in the machinery compartment, and resilient mounting of the motor and compressor have prevented the noise of the newer machines from greatly increasing. Twelve refrigerators were measured at a distance of 3 ft from the front. The levels ranged from 35 dB(A) to 52 dB(A) with a mean level of 42 dB(A). Figure A.33 presents narrowband data for two refrigerators.

A.2.22 Sewing machine

Sewing machines from the simplest to the most sophisticated and complex ones all have variable-speed electric motors, necessary gear and drive mechanisms, and auxiliary accessories. There is a wide range of controls available such as stitch tension, variable stitch length and width, zig-zag stitching, forward-reverse action, needle orientation, etc. The more versatile sewing machines have insertable cams which can be changed for different stitching patterns. Measurements on two sewing machines in operation gave values of 70 dB(A) and 74 dB(A) measured 3 ft from the machine. Figure A.34 shows narrowband data for these two machines.

possible noise control measures are to reduce noise from the motor, linkages, gears, and clutch by use of different materials and more effective enclosures. Resilient mounting of vibrating parts to reduce structureborne vibration noise is presently used.

A.2.23 Shaver, electric

Electric shavers are run by a compact but powerful electric motor, powered from house current or a rechargeable battery. While shaving mechanisms may vary - using either rotary blades or oscillatory cutting action - the noise is generated by the motor and gears. The mean sound level for men's and women's shavers was 60 dB(A) at a 3 ft distance; the range was 47 to 69 dB(A). Figure A.35 shows narrowband data for four men's shavers and Fig. A.36 presents data for two women's shavers.

A.2.24 Toothbrush, electric

A small, lightweight high-speed motor run by either A.C. power or rechargeable batteries drives the detachable toothbrush. The less expensive models allow rotation in only one plane perpendicular to the axis of the toothbrush. With additional gearing, the more expensive models simultaneously rotate and move laterally to provide better cleaning action.

The main noise sources of an electric toothbrush are the motor and the gears. Typically, the devices with more gears are noisier. The mean sound level of three different electric toothbrushes at a 3 ft distance in bathrooms was 52 dB(A) with a range of 48 to 55 dB(A). At the user distance of about 3 in. from the device, the sound level is about 10 dB(A) higher. Figure A.37 shows narrowband data for an electric toothbrush.

Due to the overriding requirements for small size and light weight, noise control techniques such as improving the sound transmission loss of the casing or adding sound absorptive material are impractical. The most promising noise reduction possibilities will likely come from the development of quieter gear operations through the use of different materials or through designing the gears with closer tolerances or a different configuration.

A.2.25 Water faucets

Noise from water faucets includes water hammer, turbulence and cavitation noise. For particular values of pressure drop, a valve can be designed to minimize cavitation and its resulting noise; however, no valve configuration has been developed to minimize the noise for the full range of pressures that a valve experiences. The measured sound level at a distance of 3 ft for two water faucets was 61 dB(A). If die-casted brass fittings could replace sand-casted ones, there would be a smoother interior finish which would result in less turbulent flow and quieter operation.

A.3 Typical Equipment in Buildings

Many different types of electrical and mechanical equipment are required for the proper operation of modern large buildings. Much of this equipment is hidden in equipment rooms, behind ceilings, in walls, or behind cabinet type exterior enclosures, but the total cost and volume associated with such equipment represents a significant part of the cost and utility of a successful building. The majority of the equipment (including most of the basic heating and cooling system components) is for supplying the building occupants with a suitable amount of air at a comfortable temperature and moisture content. In addition, pumping and piping systems are

used for water and fluid circulation, elevators and escalators are used for movement of persons, and various conveyance systems are used for movement of material. In this section, the use and function of building equipment are briefly described. Where available, typical noise levels are presented for the equipment. For detailed information and procedures, the reader is referred to Refs. 9, 10, 11, and 12 at the end of this Appendix.

A.3.1 Prime movers

The function of prime movers is to transform energy -- in the form of electric power or combustible fuel -- into rotational movement for use in driving other equipment.

Electric Motors are the most widely used of the prime mover devices. They range in capacity from fractional hp up to several thousand hp; most motors fall in the speed range of about 450-3600 rpm. Motor noise is generated by aerodynamic, mechanical, and electrical forces. Aerodynamic noise, often the most prominent noise source, is generated by air turbulence due to movement of the blades of the cooling fan and the slots in the rotor. Recent designs have used higher cooling air velocities, thereby increasing the noise level.

Mechanical noise is due to bearings and shaft unbalance. Although mechanical noise can be identified in rotating machinery, low-frequency vibration rather than noise *per se* is the usual problem. Bearing noise is due to the sliding contact of sleeve bearings and the rolling contact of ball and roller bearings. When new, precision ball bearings are often quieter than sleeve bearings; however, after much use, they are much noisier. In new equipment, unbalance forces are usually small. Wear or build-up of dirt on the rotating component often increases the unbalance in a motor,

resulting in the generation of vibration at the rotational frequency and its integral multiples; e.g., since the shaft of a 3600 rpm motor turns at $3600 \text{ rpm} \div 60 \frac{\text{sec}}{\text{min}} = 60 \frac{\text{rev}}{\text{sec}}$, energy will be concentrated at 60, 120, 180 Hz, etc. with the 60-Hz component being the strongest.

Electrical noise is generated by magnetostriction — where a component (iron laminations) contracts and expands in response to an alternating magnetic field. Such effects are particularly noticeable when D.C. or variable-speed motors are supplied rectified A.C. current. The wave-form of the rectified current contains high-frequency components that generate noise in the more audible frequency ranges. The primary excitation frequency for magnetostriction is twice the main power frequency, e.g., in the USA, $2 \times 60 \text{ Hz}$ or 120 Hz.

In the past, motor noise was generally less than the noise produced by the driven component. However, motors designed for high-temperature rises or powered by rectified current may now be the controlling noise sources. Even in the case of relatively quiet motors, motor noise often becomes predominant when the driven component is quieted. Figure A.38 presents a range of noise levels typical of a 3 ft measurement position for the many different sizes of motors used in buildings.

Diesel and Natural or LP (Liquified Propane) Gas Internal Combustion Engines are sometimes used when special conditions make them economically feasible. They are often used in emergency power systems, in total energy systems, and for driving large machines such as chillers. Noise generated by internal combustion engines consists of contributions from the intake and the exhaust and radiation from the casing. Although improperly muffled exhaust may be a source of community concern, the intake and radiation from

the casing are typically greater problems for buildings and considerable detail must be given to controlling the noise. Figure A.39 shows a range of noise levels measured at 3 ft from internal combustion engines found in buildings.

Gas Turbines are used almost exclusively in emergency power and "total energy" systems. A total energy system makes use of the fact that only about 20-30% of the heat energy of most fuels can be turned into mechanical power; the rest is rejected in the form of heat to cooling water and exhaust gases. A total energy system salvages some of the energy which is usually lost and uses it to heat water, etc. The advantages of turbines over equivalent internal combustion engines are their light weight, smaller size, and lower vibration, which can be governing factors for upper story installations. Figure A.40 presents noise levels representative of the noise generated by gas turbines.

Steam Turbines are sometimes used as high horsepower (over 50 hp) prime movers when high-pressure steam is available as a public utility service. Figure A.41 shows the range of noise levels typically found near steam turbines.

Transformers, although their function differs from that of the prime movers listed above, supply primary electrical input power; their output is an altered form of electrical power (higher amperage and lower voltage) rather than motion. The use of transformers permits large amounts of electrical energy to be supplied to a building with relatively small supply cables. Noise generated by transformers is due primarily to the magnetostrictive effect in the transformer cores. Thus, the noise consists of a harmonic series of component tones with a fundamental frequency equal to

twice the main power frequency. The range of noise levels generated by transformers typically housed in buildings is presented in Fig. A.42.

Generators or Convertors are used to produce local electricity in emergencies when electrical power is unavailable from outside sources, to produce direct current electricity, or to convert power from one frequency to another. The noise generating characteristics and noise levels of generators are similar to those of electrical motors.

A.3.2 Fluid handling units

Pumps may be the common centrifugal type that uses an electric motor drive, or the diaphragm or piston or gear-rotor types that are positive displacement units. Many of the pumps in a building are part of the overall air-conditioning system. They convey water to and from cooling towers, chillers, boilers, and coil decks in airconditioners, humidifiers, unit heaters, unit ventilators, and induction units. Pumps may also be used to supply fuel oil to boilers, domestic water to upper floors, emergency fire-fighting water, hot water for various uses such as convectors, ice melting, radiant heating, etc., and for sewerage ejection from low levels.

Noise problems due to pumps are usually caused by mechanical forces and turbulence. Noise is radiated by the casing of the pump and associated piping. In order to prevent the tonal components at the impeller passage frequency (the impeller speed in revolutions per second multiplied by the number of impellers) from being detectable at remote locations, a vibration break or flexible connections in the piping is sometimes provided. However, sound

energy in the fluid may flank this flexible connection so that the pipe walls are excited downstream of the pipe break. Figure A.43 shows a range of noise levels typical of many pumps used in buildings.

Steam Valves may be used either to control volume flow or to reduce the pressure from the main supply system. A steam valve, like any valve, is noisiest when there is a large pressure differential between the upstream and downstream of the valve. A typical spectrum for steam valve noise is presented in Fig. A.44.

A.3.3 Air handling

Fans are the driving mechanism for moving air about a building. Propeller-type fans may be used to distribute large quantities of air at little pressure drop across the fan; centrifugal and axial-flow type fans may build up relatively large static pressures in an air handling system and thus are used mostly in ducted ventilation systems in large buildings. In a ducted system, the air will tend to flow toward regions of lesser static pressure, eventually to be released at ambient pressure in the building proper.

Fan noise is generated by mechanical and aerodynamic sources. Bearings and unbalanced shafts are the primary mechanical sources; with proper construction and maintenance, fan noise from these sources can be minimized. Aerodynamic noise may be divided into components due to rotation and due to vortex shedding. Since an impulse is imparted to the air each time a fan blade passes a given point, the rotational component consists of a series of tones at multiples of the blade passage frequency (rotational speed in revolutions per second times the number of blades). The vortex

component is primarily the result of the shedding of vortices from the fan blades; it is an example of broadband random noise. Depending upon the type, size, and geometry of a particular fan, the total noise generated will have varying contributions from vortex and rotational noise.

The horsepower, volume flow, and static pressure, and thus the mechanical efficiency, are important indicators of the noise that will be generated by a particular type of fan. Figure A.45 shows estimated levels for a range of fans utilized in buildings. The noise problems that do occur are usually due to either a failure by the mechanical or acoustical system designer to consider an important source or path, or a failure of the builder to incorporate properly the designed noise control features in the building.

Air Control Units and Mixing Boxes comprise a family of supply air control and treatment devices that provide air at the proper volume, pressure, and temperature to a room. These devices include: constant volume control (CVCs), terminal reheat units (TRs), variable volume controls (VVCs), and dual duct mixing boxes. Their function, in many instances, is analogous to steam valves - they take air which has passed through a small duct at high velocity and pressure and reduce its pressure and control its volume flow. A constant volume control takes in air at varying pressure (caused by changing demands elsewhere in the system) and discharges a constant volume of air at a constant pressure. A terminal reheat unit adds the capability of heating the air by passing it over an electric or hot water coil before it is discharged. A variable volume control meters out an amount of heating or cooling air as demanded by a local thermostat and reduces the static pressure of the air to obtain the desired volume. Each of these units is usually located toward the end of supply ducts

near the space it serves. Noise generated by air control units and mixing boxes is a function of the pressure drop across the device and the volume of air flow. Figure A.46 presents a range of noise levels typical of a 3 ft distance from these units.

Diffusers, Grilles, Registers, and Louvers. After a supply of air at the correct pressure, temperature, and volume has been provided to the vicinity of a room, it must be introduced and distributed into the room without causing drafts. Portions of the air should be directed toward windows and other exterior surfaces that are too cold in the winter and too hot in the summer, while all the air should be distributed so as to provide ventilation to all parts of the space. This is done with various diffusing or direction-controlling devices, usually fabricated from sheet metal, consisting of fins, blades, vanes, etc., that are located at the end of the duct. Perforated grilles, registers, or other similar devices are used to receive the air to be returned to the distribution system. The noise generated by terminal devices, such as diffusers, is dependent on the pressure drop across the device, the volume of air flow, the cross-sectional area, and the spacing between vanes. Figure A.47 illustrates the range of noise levels possible with various diffusers, grilles, etc.

Air Compressors are the source of high-pressure air which is used by many large buildings as an energy source for pneumatic control devices throughout the ventilation system. Such controllers include fresh air intake dampers, zone control dampers, induction units, unit ventilators, mixing valves in mixing boxes, and control valves in CVC and VVC units. The high-pressure air provided by the compressor must be piped throughout the building, first to thermostats and then to the pneumatic operators. Buildings which

have laboratory or workshop facilities usually supply compressed air to those spaces. Air compressors are most often of the piston type and, depending upon the size of the unit, the reciprocating action of this type of compressor may make satisfactory vibration isolation difficult. Figure A.48 is an example of noise levels generated by reciprocating compressors.

A.3.4 Airconditioners

The usual functions of an airconditioner are to filter particulate matter and odors from the air, to regulate air temperature and humidity, and to propel the conditioned air to its destination. The fan in the airconditioner serves two purposes:

1) to move the air through the filters and heating and cooling coils, and 2) to provide enough static pressure to push the air throughout the duct system to the desired spaces. The heating and cooling coils are liquid-to-air heat exchangers, receiving warm or cold water or refrigerant from other machines and transferring warmth to or from the air carried past them.

Central Station. Strictly speaking, "central station" refers to the entire collection of equipment that has a part in conditioning the air that is ultimately distributed to the building. In its more limited use here, "central station" refers to the fan plenum equipment of the airconditioner. The equipment includes controllers and filters on the inlet side and heating and cooling coils, and temperature controllers and, possibly, zone controllers on the discharge side. The cooling coils act as dehumidifiers in that warm, moisture-laden air condenses on them. Occasionally, a humidifier is incorporated to add humidity for special needs. Central station units are most common in large multistory buildings. The size of a particular unit will depend upon the service that it is supplying. Noise levels for units typically found in buildings are presented in Fig. A.49.

Unitary Rooftop Units are usually found on one- or two-story buildings. They perform the same function as the larger central station units but do not rely on other machines to provide hot or cold fluid to their heating and cooling coils; in other words, these units include their own compressors, condensers, etc. In a large one-story building or building complex, this can represent a savings on the heating and cooling water piping which would be needed if the units were dependent on other machines. Figure A.50 presents noise levels measured near both small (the lower curve) and large units.

Unitary Split System Units are usually found in small buildings. They are almost identical in function to rooftop units, but they are located on occupied floors in the building. Thus, a remote heat exchanger (either a condenser or cooling tower) must be provided to reject waste heat when the units are cooling. The refrigerant compressor may be located remote from the unit together with the condenser.

Fan Coil Units are rather like miniature central station air-conditioners in that they draw in fresh air and rely on outside sources for hot water, cold water, or steam for their heating and cooling coils. They are small units, usually enclosed within a cabinet and placed under or near windows. Some units, rather than relying on hot water, use electric heating coils. Typical noise levels for fan coil units are presented in Fig. A.51.

Induction Units are similar in appearance and location to fan coil units but receive air from a central station unit at a rather high pressure, 1 to 4-in. static pressure, as compared to less than 1-in. operating static pressure for unit ventilators. This

air is used to induce circulation of the room air. Such units are also provided with heating and cooling coils to temper the air which they receive from the central supply. A range of noise levels for typical induction units are shown in Fig. A-52.

Humidifiers, Dehumidifiers, Heaters and Furnaces, although grouped under the heading of air conditioners, have only one function: to increase or decrease humidity, or to heat.

- *Humidifiers* are of two general types: 1) those that add steam to the air, and 2) those that blow the air through or over moist surfaces to add water to the air. Both types can be built into ductwork or can stand alone to serve a particular space. The steam type consists of a steam nozzle, a control valve, and possibly a fan. The moist surface type consists of a fan (if not located in ductwork), a water pump, and a moving porous belt or disk which passes through the water and then through the moving air.
- *Dehumidifiers*, if required, may be located in the ductwork where air flow is provided by the system fan. The primary element is a cooling coil which condenses moisture out of the passing air. In such an installation, a heating coil may be provided to temper the excessively cooled air that leaves the cooling coil. A self-contained unit will include a fan but usually not a heating coil.

Unit Heaters consist of a remote fan and heating coil, which may be either electric or mechanical, and receive hot water or steam from an external source. Such units are often used in little-occupied spaces such as mechanical equipment rooms, storage spaces, garages, stairways, etc.

- *Warm Air Furnaces* burn gaseous or oil fuel and use an integral air-to-air heat exchanger to heat the air. They usually have two built-in-fans, one to circulate the air, the other to provide air for combustion. They are often used in small buildings which do not have access to large quantities of hot water or steam.

A.3.5 Boilers

For supplying warm air to a building, most air conditioning systems use hot water or steam supplied by a boiler that may be located either nearby or remote from the building. (In total energy systems, waste heat from the engines may be captured to heat water in place of or in addition to a boiler.) Boilers heat water or generate steam by burning a fuel and passing the water through or around the fire in a gas-to-liquid heat exchanger. There are two principal types of boilers: water tube and fire tube. In the water tube boiler the tubes are filled with water and pass through the fire. In the fire tube boiler, the boiler is filled with water and combustion takes place in tubes that pass through the water. Steam boilers are usually of the water tube type, while hot water boilers may be either type. Figure A-53 shows a range of noise levels typical of boiler operations; fire tube boilers are represented by the upper part of this range and water tube boilers by the lower parts. Gas-fired burners in boilers are much quieter than oil-fired burners.

A.3.6 Refrigeration machines or chillers

Refrigeration machines or chillers use various methods to remove heat from water supplied to cooling coils (the "chilled water") and transfer that heat to other water for eventual rejection.

Absorption/Cycle Machines use heat energy and a salt solution to transfer heat from the chilled water system to the reject heat system. The machine is composed of tanks, condensers, evaporators, heat exchangers, pumps, and controls. On a per ton capacity basis, they are larger than vapor compression cycle machines. Figure A-54 presents noise levels typical of these machines for building use.

Vapor Compression Cycle Machines, which are commonly called chillers, use a compressor to compress the refrigerant; the resulting hot compressed gas passes through a condenser where it is cooled and changed to a liquid. The refrigerant is then allowed to expand, further cooling it. The "chilled water" is then passed through a heat exchanger with the cooled gas and is cooled. The resulting heated refrigerant is again compressed and the cycle repeated. Chillers use various types of compressors: the positive displacement (piston and rotary screw) and the centrifugal types; noise levels representative of these types are presented in Figs. A-55, A-56, and A-57 respectively.

Small Hermetic Refrigerant Compressors are used in small airconditioners in conjunction with integral or remote air-cooled condensers. These units function exactly the same as the compressors in vapor compression cycle machines except that the refrigerant is cooled in an air-cooled condenser rather than by a reject-heat water-circuit condenser.

A.3.7 Heat rejectors

In most refrigeration machines, rejected heat is transferred to water, which may be used once, e.g., river water, or repeatedly, in which case it must be cooled for re-use. Cooling towers, spray ponds, and air-cooled condensers are used to cool the water.

Cooling Towers receive large volumes of warm (typically 85° to 75°F) water and cool it a few degrees. In the process, the incoming warm water is sprayed onto the cooling tower "fill," a stack of wood, plastic planks or sheets, or ceramic blocks which have a large surface area. Typically, a fan is used to force air through the fill, cooling the water by evaporation. The air is expelled in a saturated or near-saturated condition and is usually a few degrees warmer. Noise is generated by the fan and by the water falling into the basin. Centrifugal cooling towers (using centrifugal fans) are quieter than propeller-fan towers. Figure A-58 presents a range of noise levels typical for both centrifugal and propeller towers.

Condensers of the liquid-cooled type are used in all large refrigeration machines; smaller machines use directly air-cooled condensers. In a condenser, the entering gaseous refrigerant is cooled as it passes through the gas-to-air exchanger, where the gas condenses to its liquid form, and the resulting liquid is returned to the refrigeration machine. A fan is frequently used to force air flow through the heat exchanger. Figure A-59 presents a range of noise levels representative of air-cooled condenser noise.

A.3.8 Conveyance systems

In multistory buildings, it is necessary to transport large numbers of people quickly. It is also desirable to transport heavy objects from one floor to another, and in hotels, hospitals, and apartments, to transport trash and soiled laundry to their respective collection areas from many locations in the buildings. Elevators, escalators, and pneumatic transport systems are examples of the conveyance systems used in buildings.

Elevators consist of three major components: the cab, hoist cables and counterweights, and the hoist motors or hydraulic lift piston. The weight of the cab is partially balanced by the counterweights which are lowered as the cab is raised. The hoist motors are DC-powered, which is best suited to the frequent starting, acceleration, and stopping operations of elevators. Supply current is generated by accompanying motor-generator sets (using standard AC motor drives) or large rectifiers. The hoist motors are located directly over the elevator shaft, usually on the roof of a building, or at various upper floor levels. Hydraulic power is sometimes used for distances of under 60 ft. A hydraulic pump provides the driving force. Figure A-60 presents noise levels typically found in elevator machinery rooms.

Escalators are comprised of two major components: the stairs with tracks and the drive motors. The motors are usually located beneath the lowest flight, the upper flights being driven by those below.

Pneumatic Transport Systems use low-pressure differentials exerted over large or small areas to move comparable sized loads. The chief components are a high-pressure fan, a duct system, loading and unloading stations, and control devices. In a typical system, the fan is run at an idle speed (say 1/2 full speed which requires only 1/8 of the full-speed hp) until the loading station signals for full-speed operation. The load is then conveyed through the duct system to the desired unloading station. At the unloading station, the passage of the load signals the blower which then drops to idle speed.

A.3.9 Ballasts

Fluorescent and mercury arc lights require higher voltage power than the normal 115v line current. Ballasts are essentially small transformers which alter the voltage to suit this need. Ballasts are usually mounted rigidly to light sheet metal panels in order to provide the required cooling area. These panels often serve as very effective radiators of sound; thus, the noise levels may vary considerably. Figure A-61 presents measured data for one installation. Noise levels in other installations with different ballasts and fixtures may be as much as 10 dB quieter or noisier than the curve presented.

REFERENCES

1. Rathé, E.J., "Gerauschnessungen an Baumaschinen," *Acustica* 23(3) 1970, pp. 149-155.
2. "Sound Data from Nebraska Tests," *Implement and Tractor*, April 7, 1971.
3. *Noise: Final Report*, Committee on the Problem of Noise, Sir Alan Wilson, Chairman, Her Majesty's Stationery Office, London, July 1963.
4. LaBenz, P., Cohen, A., and Pearson, B., "A Noise and Hearing Survey of Earth-Moving Equipment Operators," *Amer. Ind. Hygiene J.*, March-April 1967.
5. Based on estimates, including those appearing in "A Study of Noise-Induced Hearing-Damage Risk for Operators of Farm and Construction Equipment, Southwest Research Institute for the Society of Automobile Engineers," Technical Report, SAE Research Project R-4, December 1969.
6. Robinson, D.W., "The Concept of Noise Pollution Level," National Physics Laboratory Aero Report AC 38, March 1969.
7. Schultz, T.J., "Technical Background for Noise Abatement in HUD's Operating Programs," BBN Report No. 2005, September 1970.
8. Dugdalc, D.S., "Discrete Frequency Noise from Free Running Circular Saws," *J. Sound Vib.* 10(2):296-304 (1969).
9. Beranek, L.L., *Noise Reduction*, McGraw-Hill Book Company, New York (1960).
10. Beranek, L.L., *Noise and Vibration Control*, McGraw-Hill Book Company, New York (1971).
11. Miller, L.N., "Noise and Vibration Control for Mechanical and Electrical Equipment in Buildings," Bolt Beranek and Newman Inc. TIR No. 73, February 1970.
12. *ASHRAE Guide and Data Book-Systems* (1970).

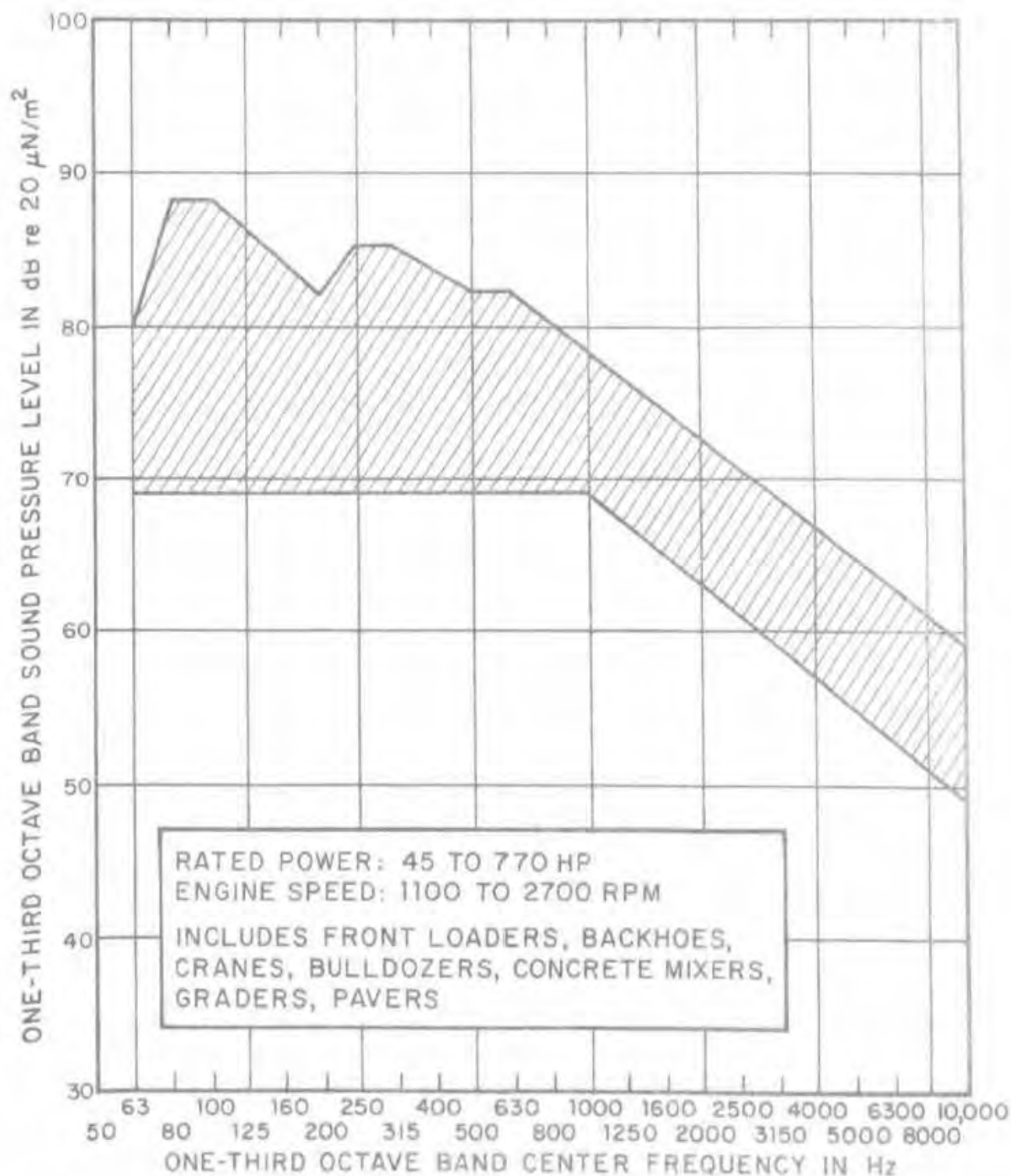


FIG. A.1 ENVELOPE OF SOUND PRESSURE LEVELS FROM 2% DIESEL-POWERED ITEMS OR CONSTRUCTION EQUIPMENT (MEASURED AT 50 FT)

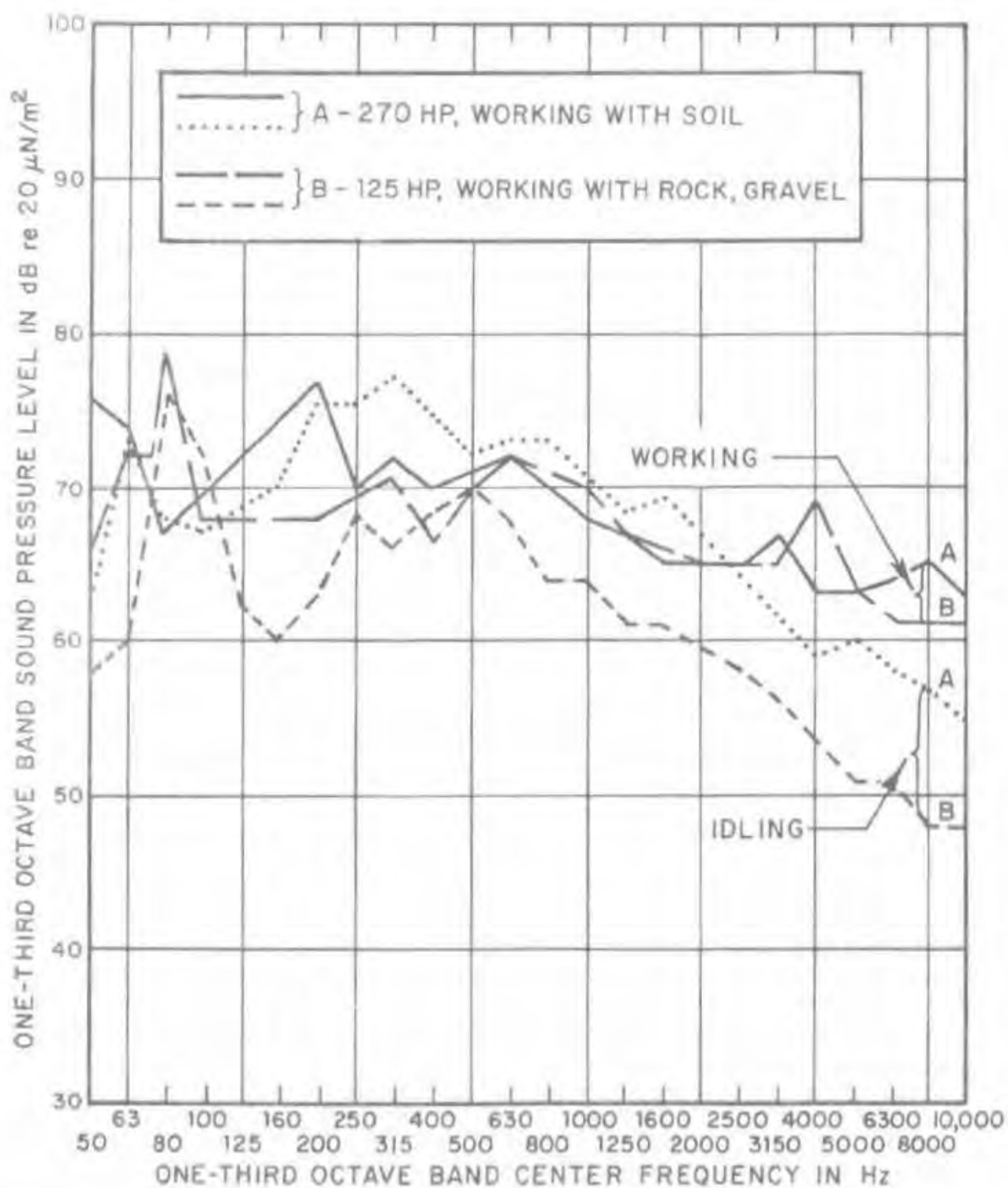


FIG. A.2 SOUND PRESSURE LEVELS FROM TWO BULLDOZERS UNDER VARIOUS CONDITIONS (MEASURED AT 50 FT)

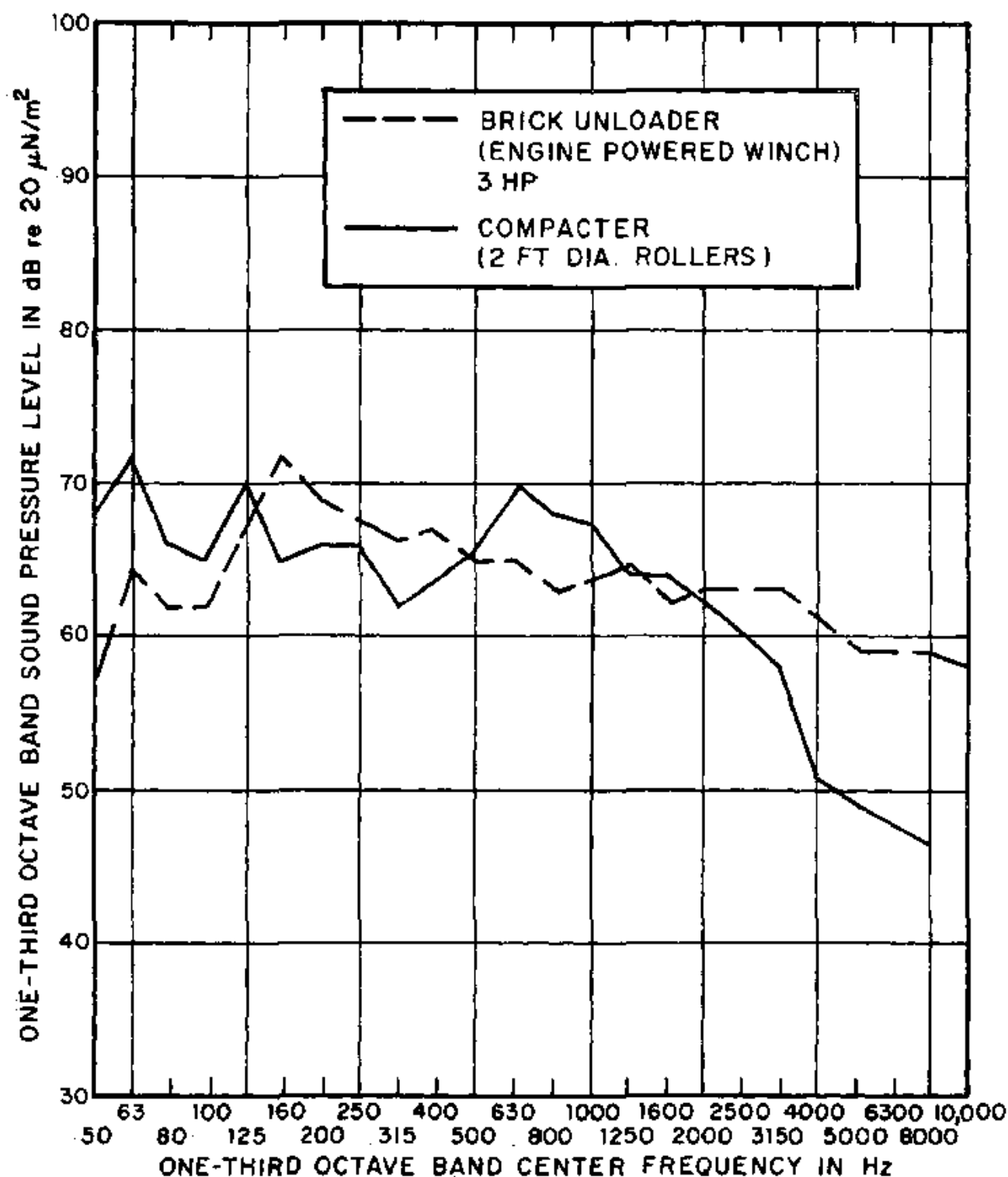


FIG. A.3 SOUND PRESSURE LEVELS FROM TWO GASOLINE-ENGINE POWERED ITEMS OR CONSTRUCTION EQUIPMENT (MEASURED AT 50 FT)

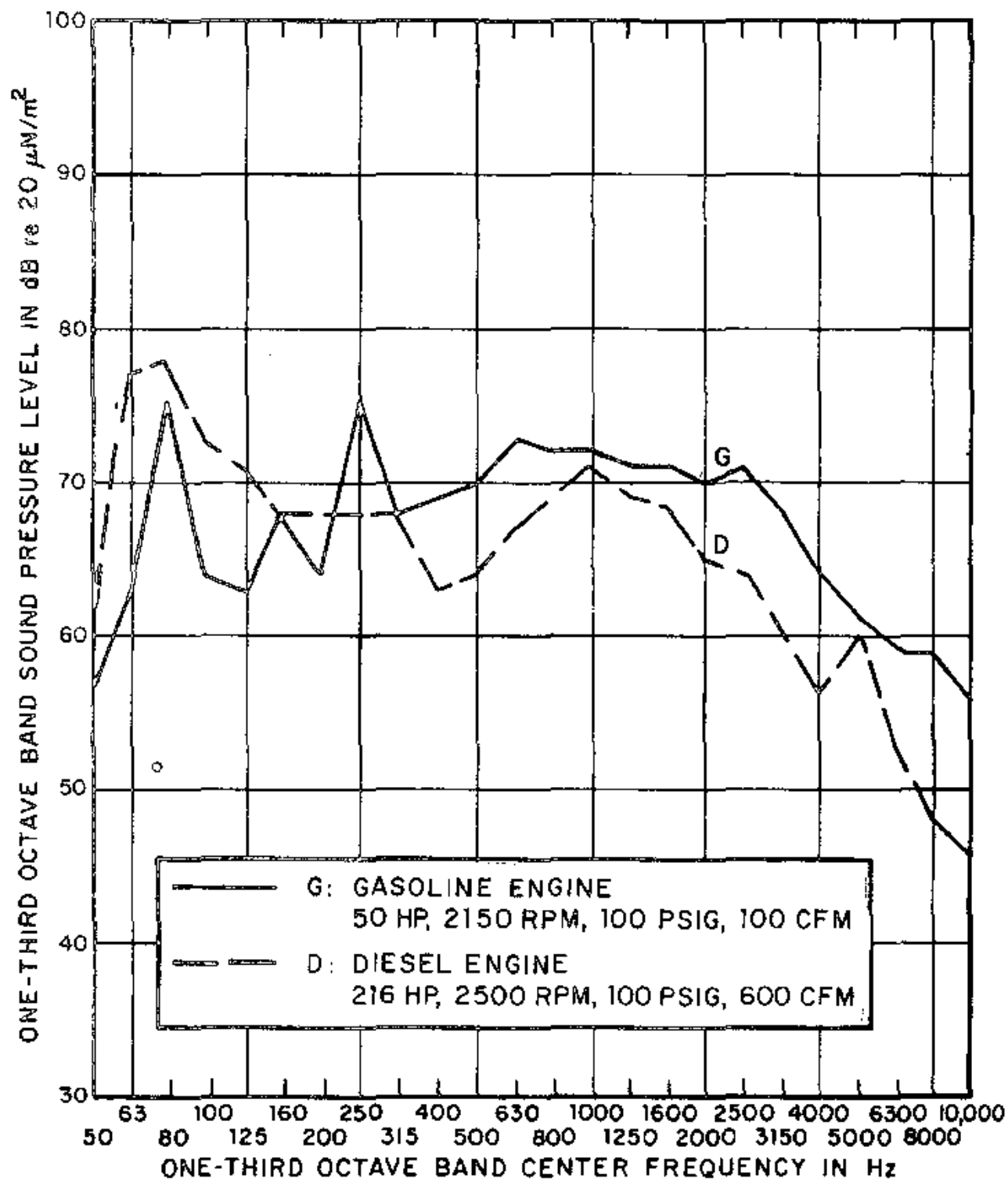


FIG. A.4 SOUND PRESSURE LEVELS FROM TWO AIR COMPRESSORS
(MEASURED AT 50 FT)

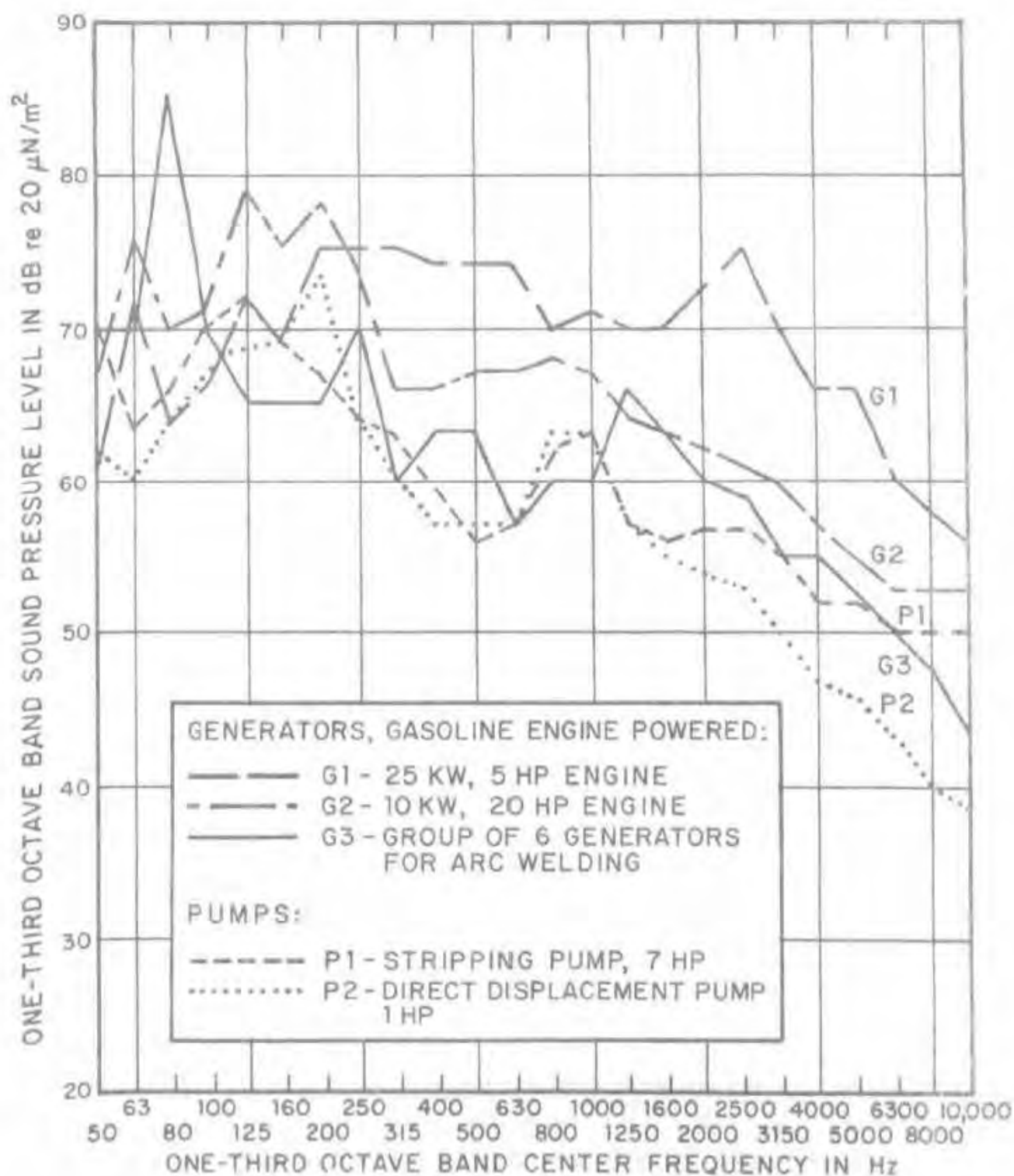


FIG. A.5 SOUND PRESSURE LEVELS FROM GENERATORS AND PUMPS
(MEASURED AT 50 FT)

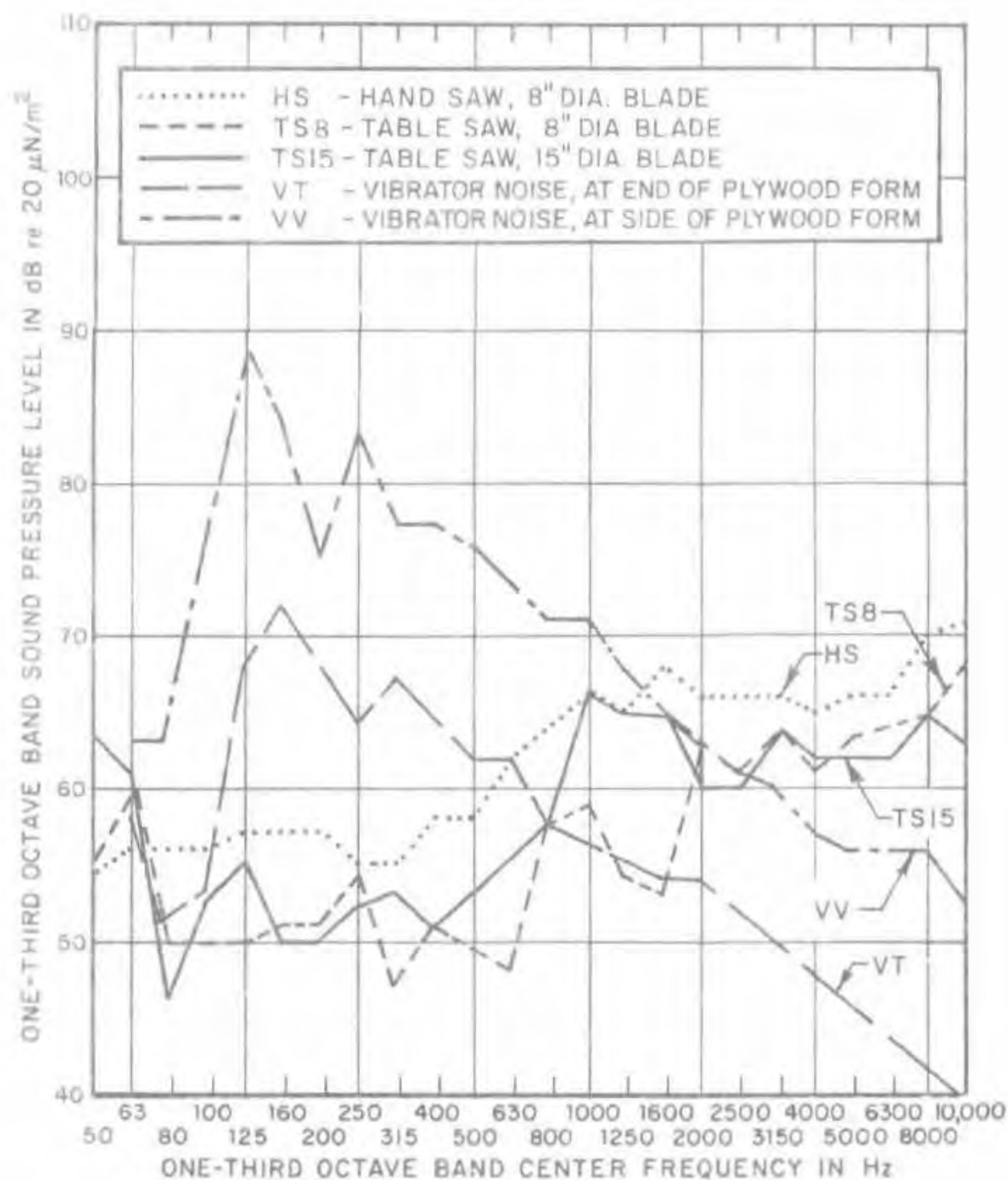


FIG. A.6. SOUND PRESSURE LEVELS FROM VIBRATOR AND SAWS
(MEASURED AT 50 FT)

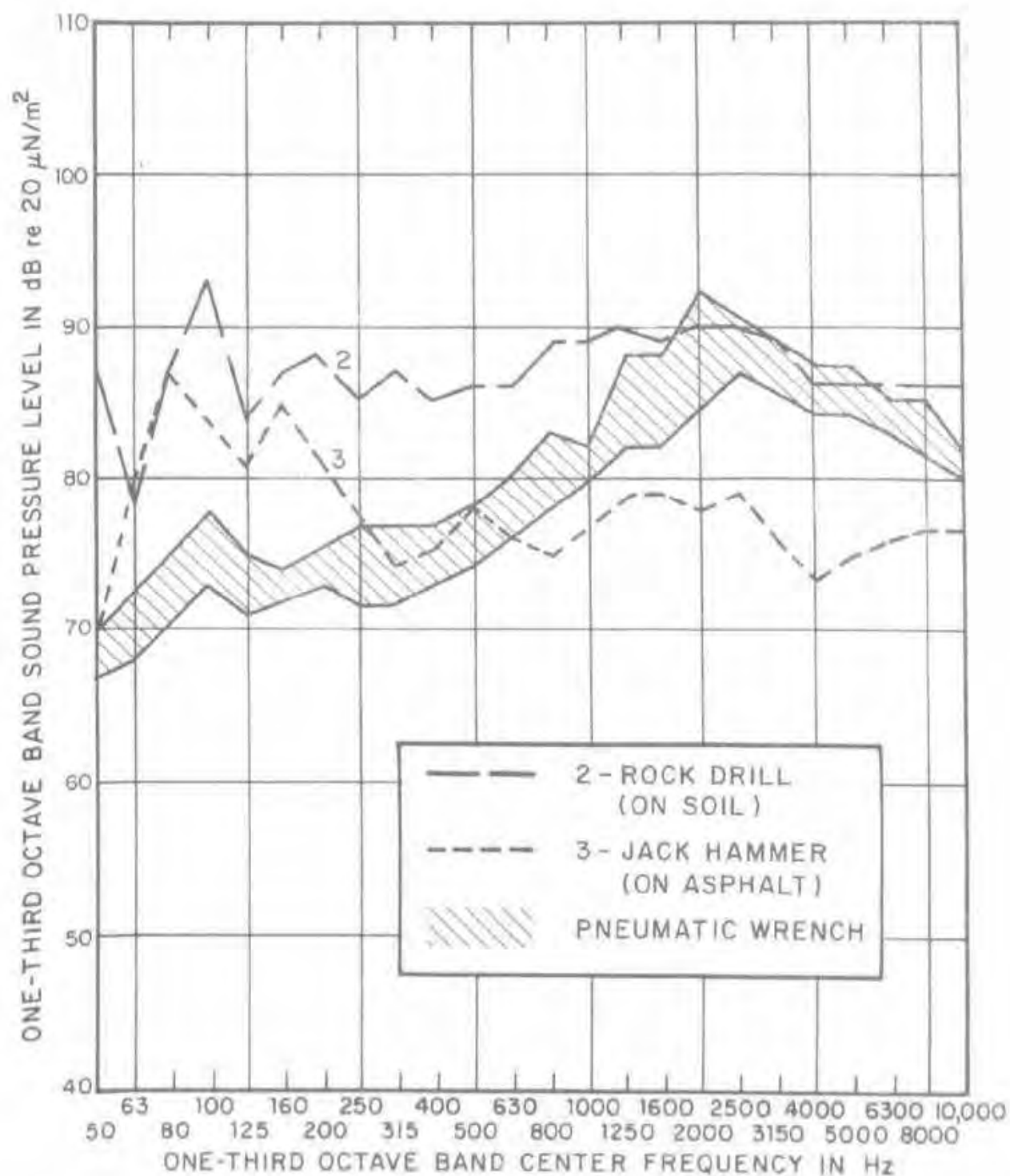


FIG. A.7 SOUND PRESSURE LEVELS FROM VARIOUS PNEUMATIC TOOLS (MEASURED AT 50 FT)

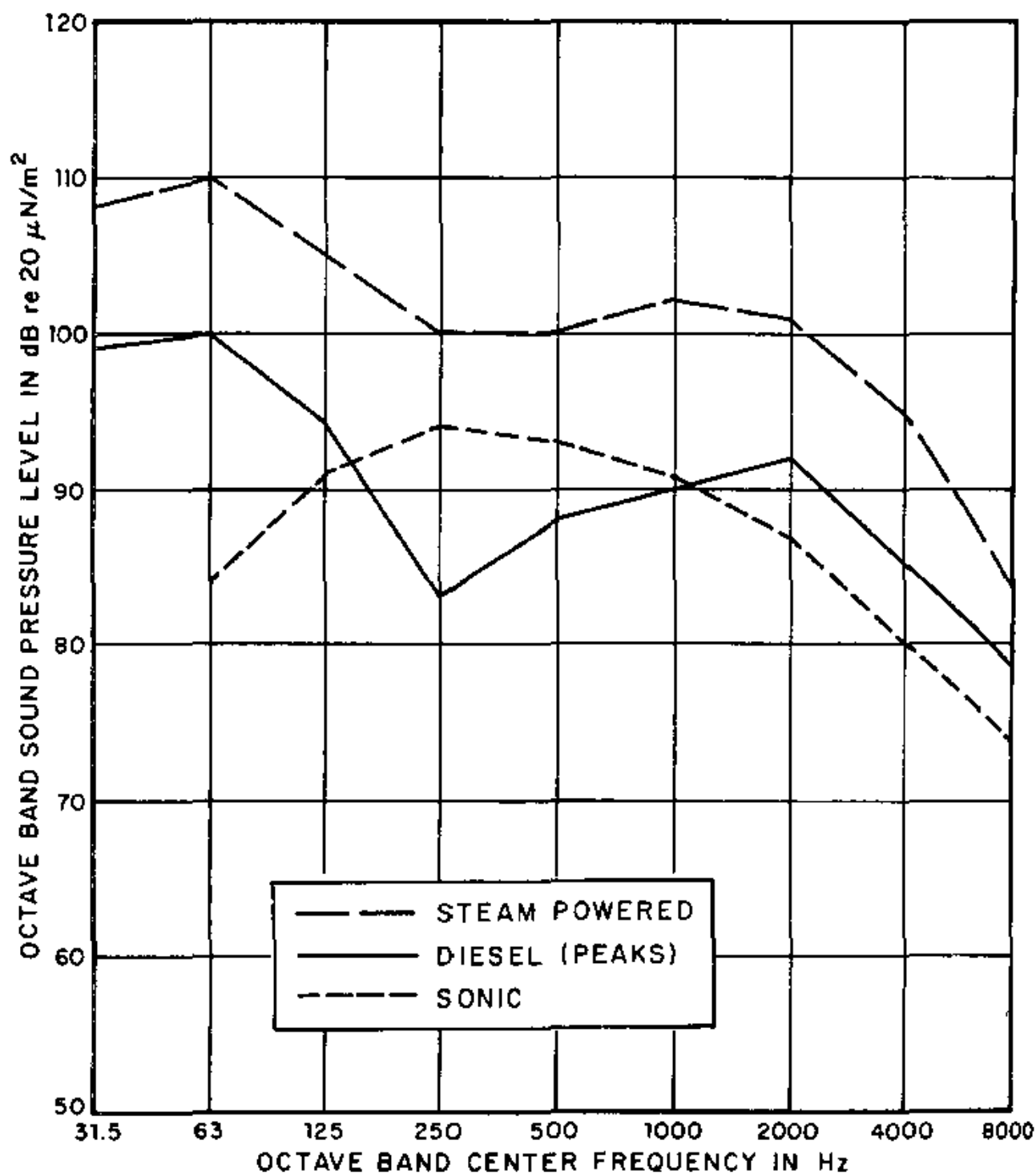


FIG. A.8 PEAK SOUND PRESSURE LEVELS FROM PILE DRIVERS, DRIVING 14-IN. DIAMETER PIPE PILES (MEASURED AT 50 FT)

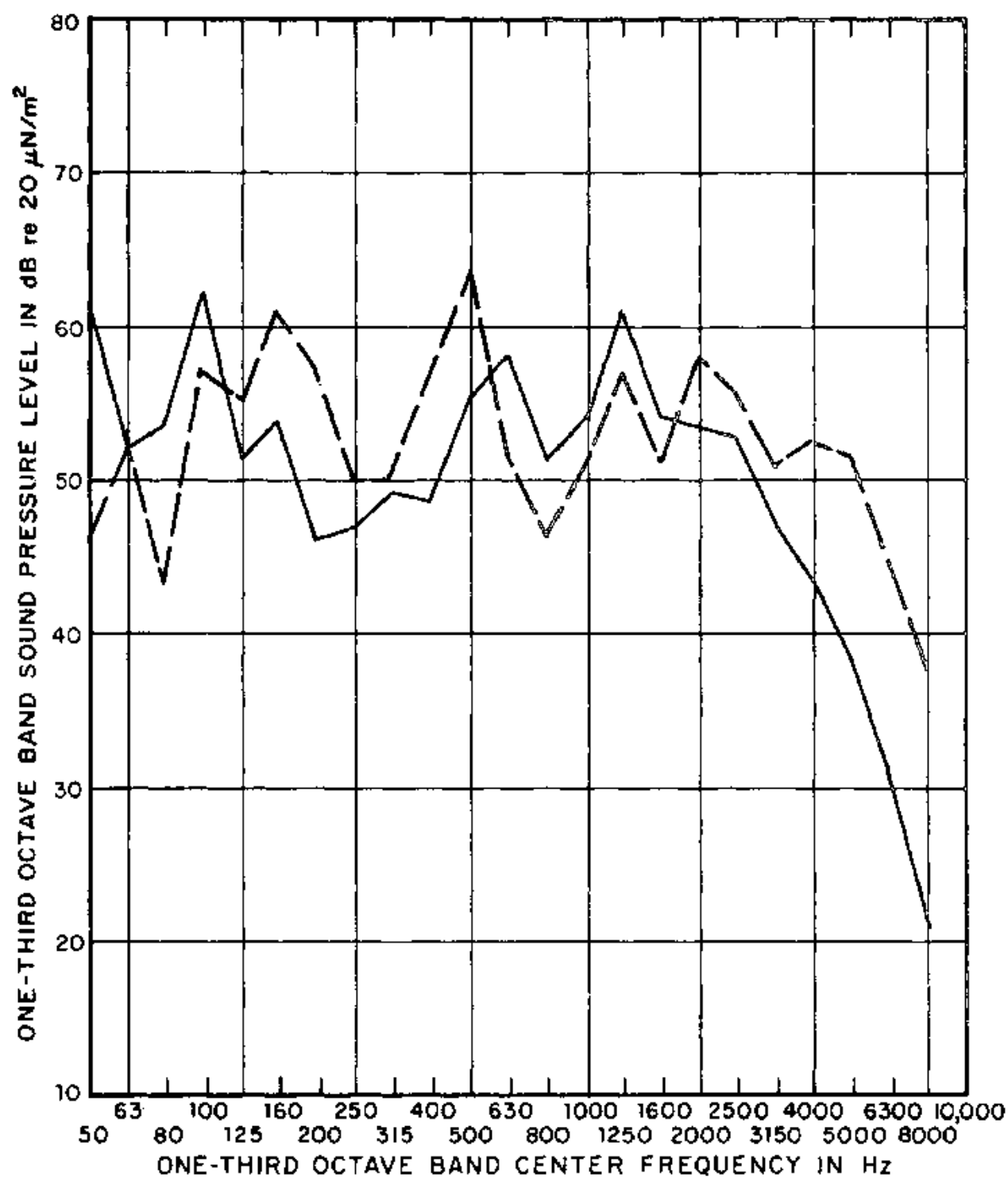


FIG. A.9 SOUND PRESSURE LEVELS FROM TWO CAN OPENERS
(MEASURED AT 3 FT)

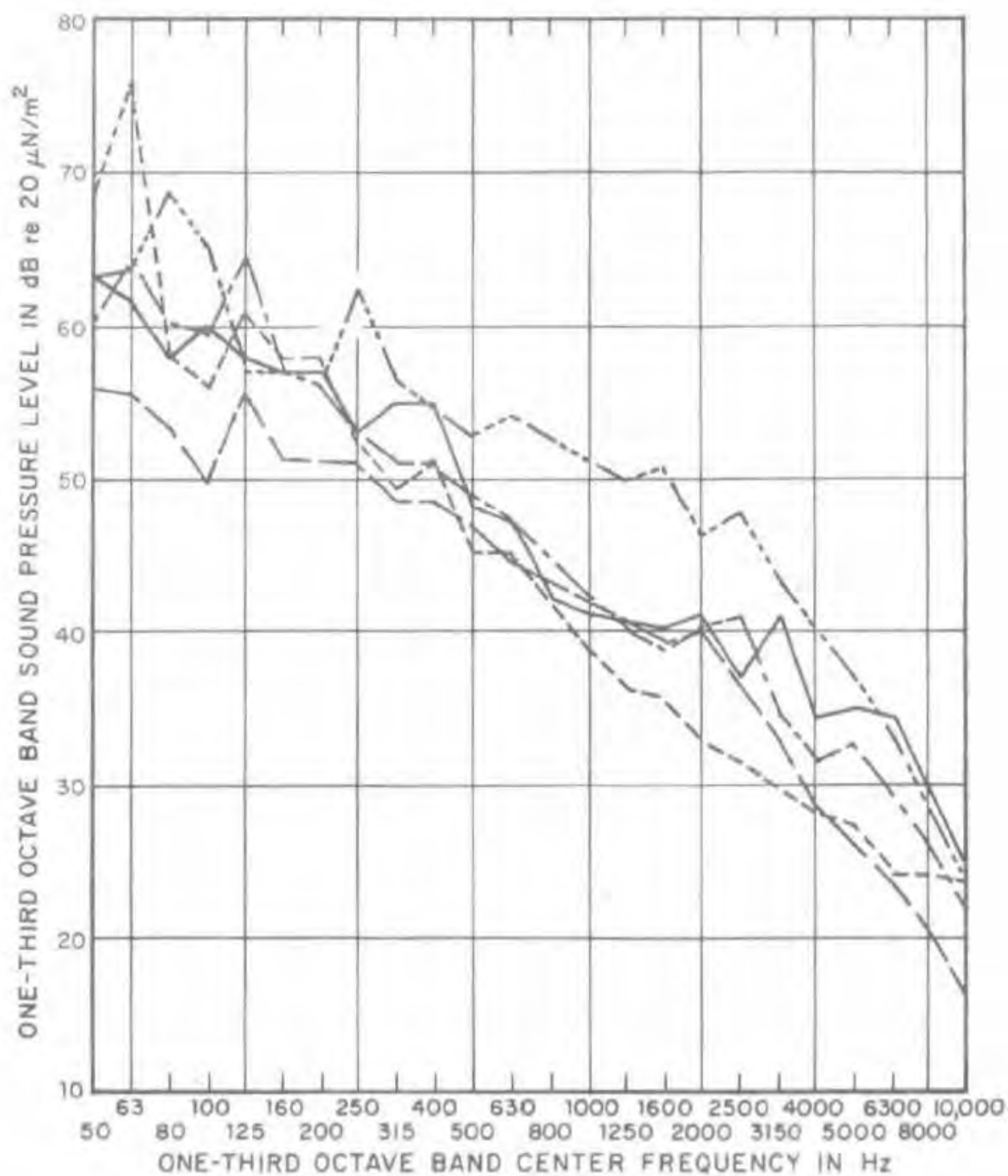


FIG. A.10 SOUND PRESSURE LEVELS FROM FIVE CLOTHES DRYERS
(MEASURED AT 3 FT)

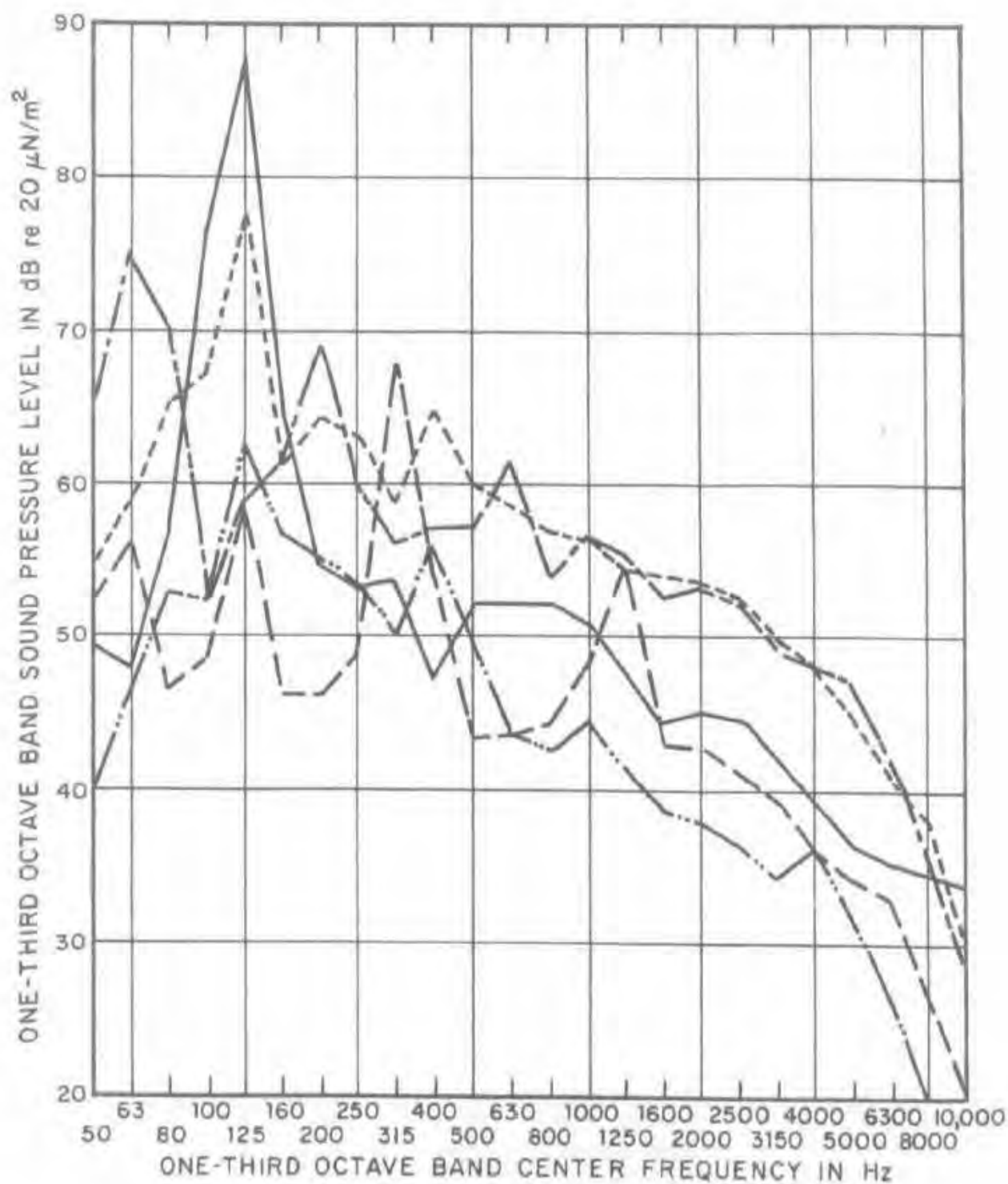


FIG. A.11 SOUND PRESSURE LEVELS FROM FIVE CLOTHES WASHERS DURING THE WASH CYCLE (MEASURED AT 3 FT)

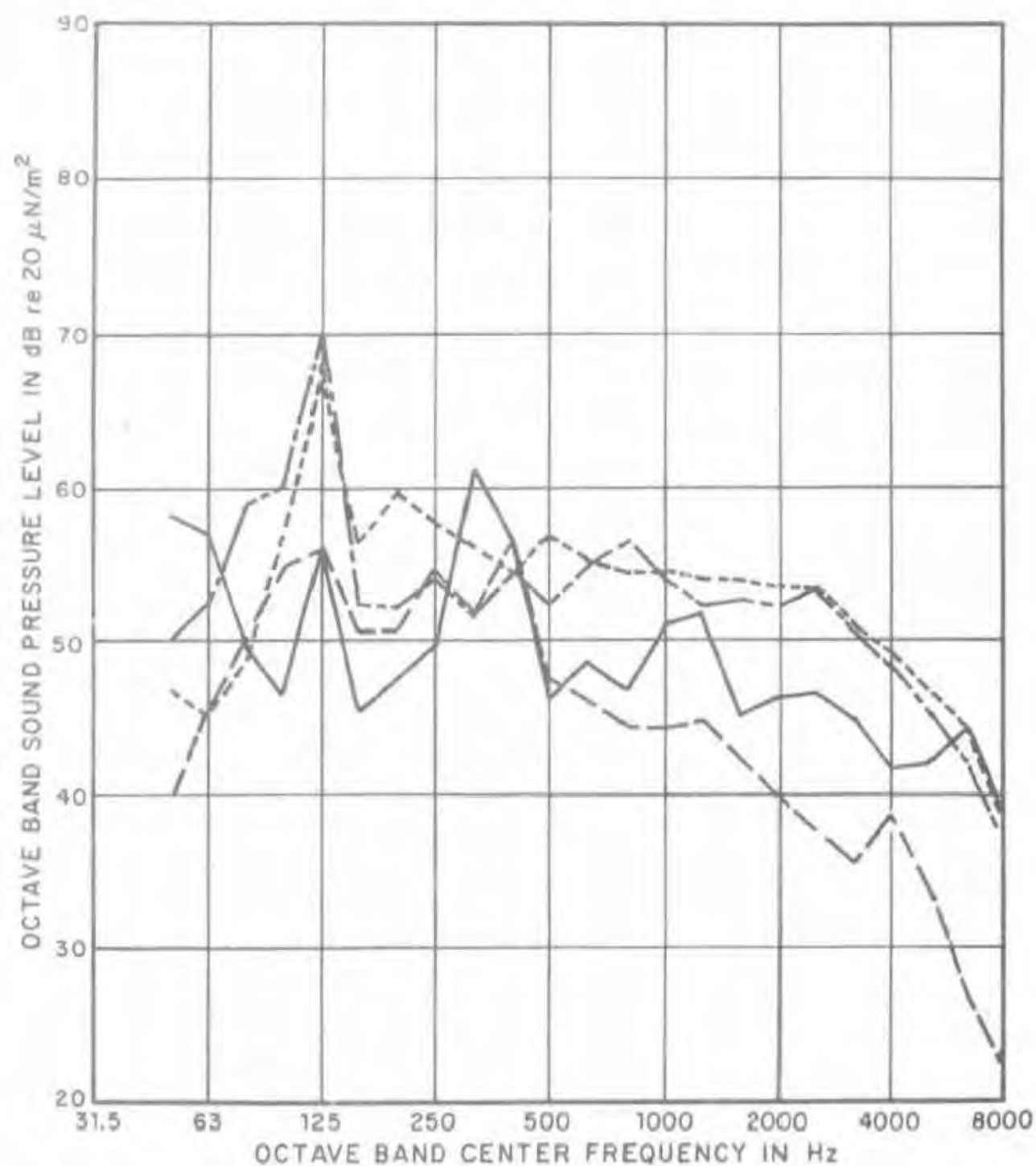


FIG. A.12 SOUND PRESSURE LEVELS FROM FOUR CLOTHES WASHERS DURING THE SPIN CYCLE (MEASURED AT 3 FT)

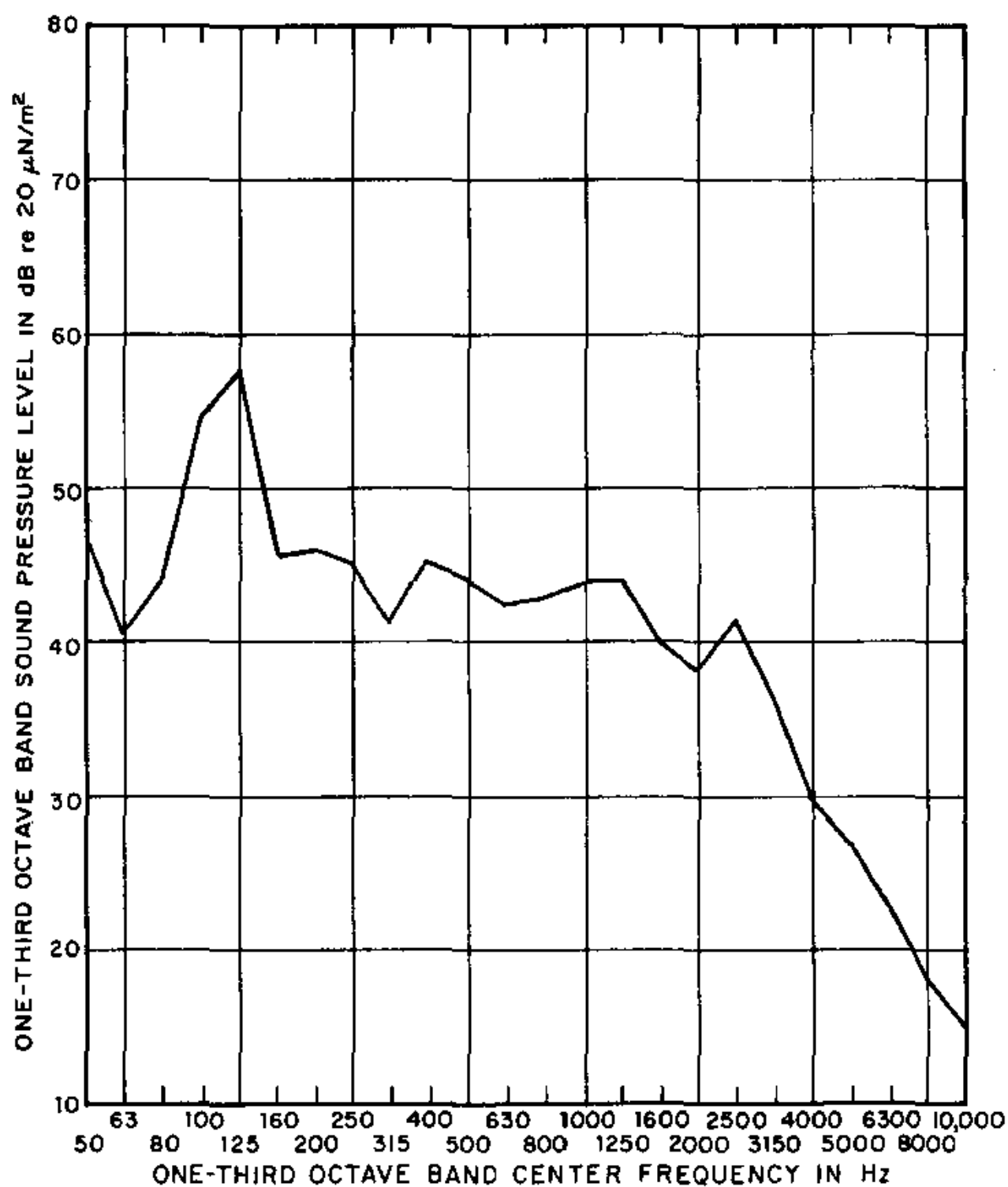


FIG. A.13 SOUND PRESSURE LEVELS FROM A DEHUMIDIFIER
(MEASURED AT 3 FT)

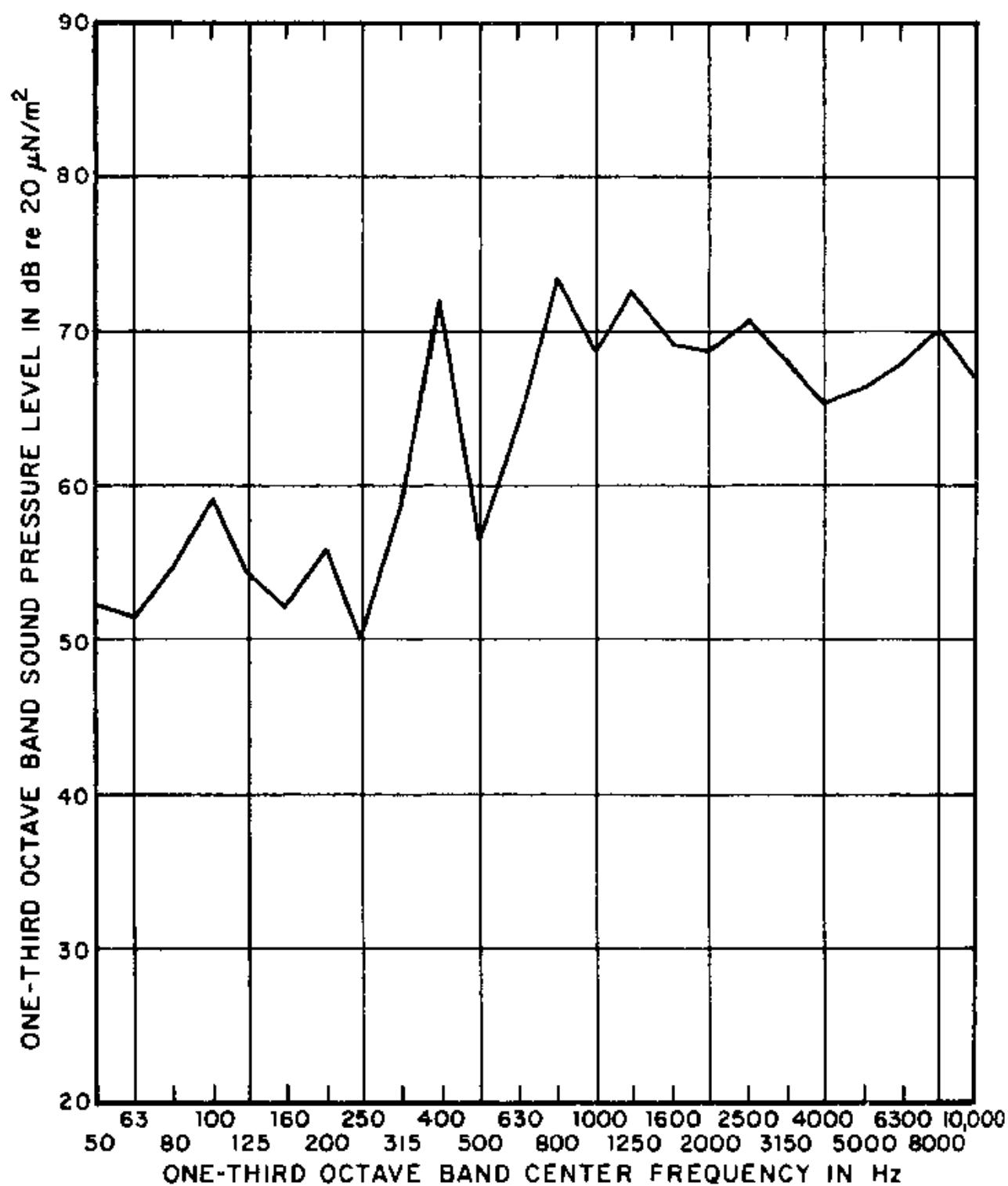


FIG. A.14 SOUND PRESSURE LEVELS FROM AN EDGER AND TRIMMER (MEASURED AT 3 FT)

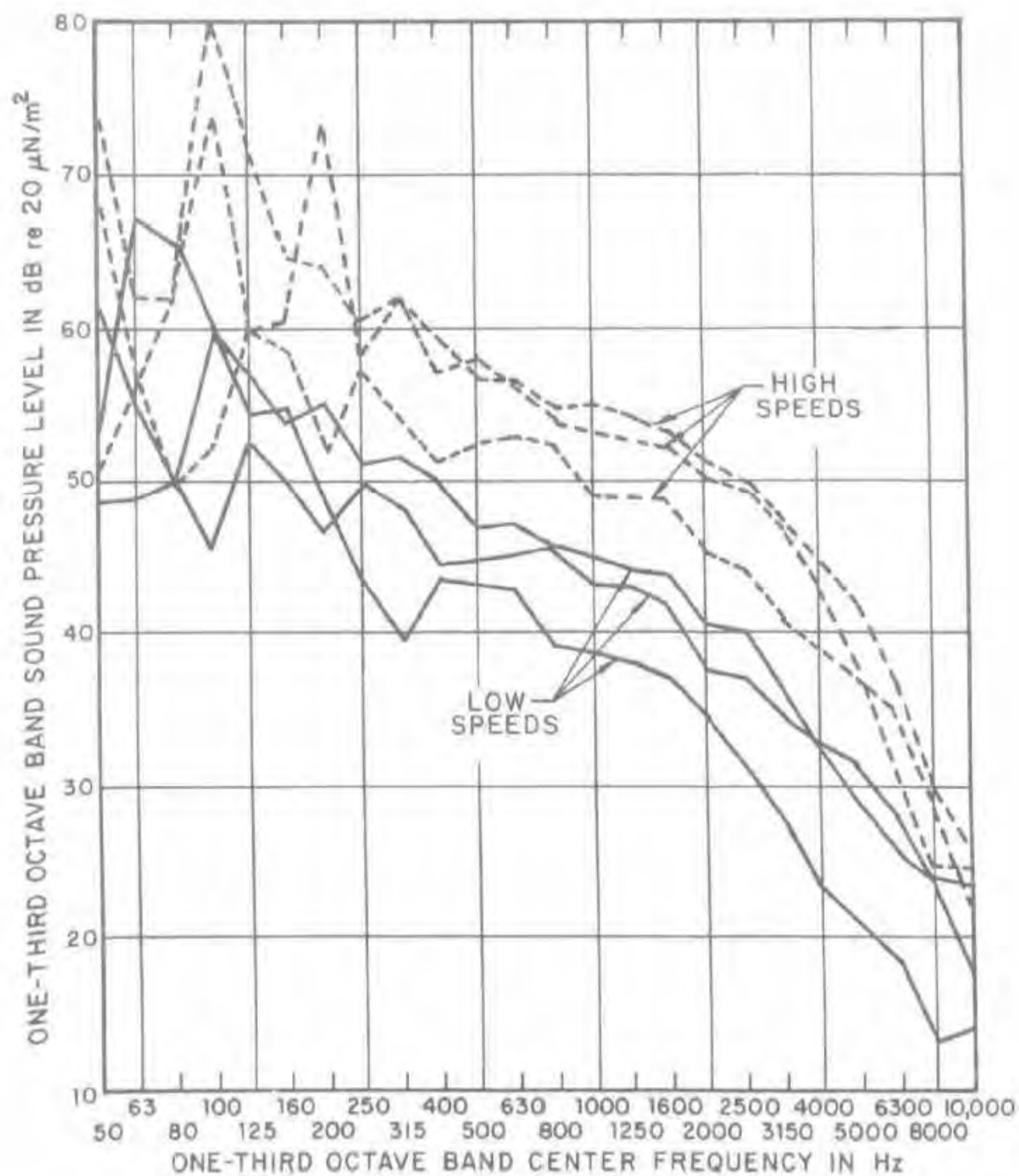


FIG. A.15 SOUND PRESSURE LEVELS OF THREE WINDOW FANS (MEASURED AT 3 FT)

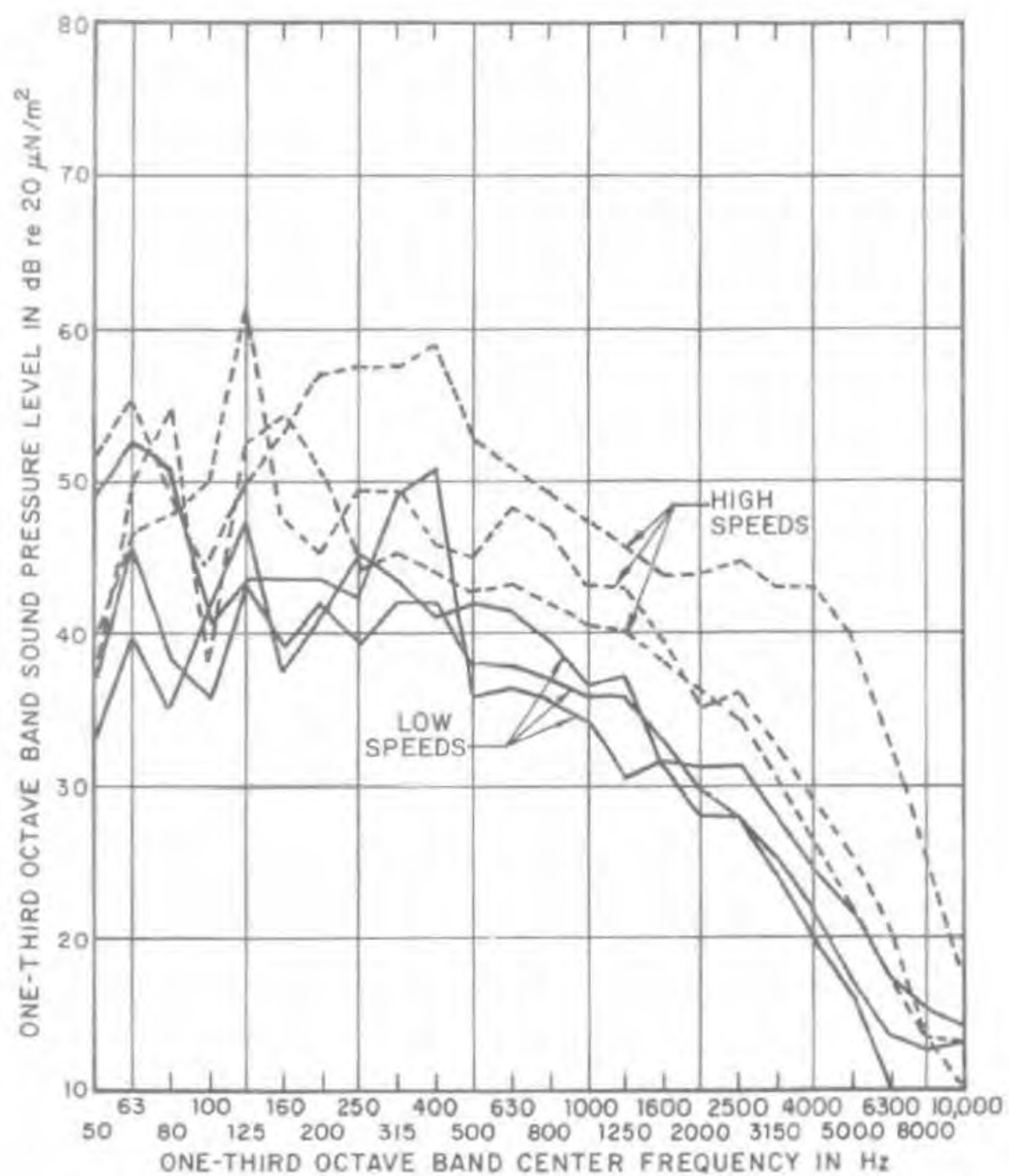


FIG. A.16 SOUND PRESSURE LEVELS OF THREE FLOOR FANS
(MEASURED AT 3 FT)

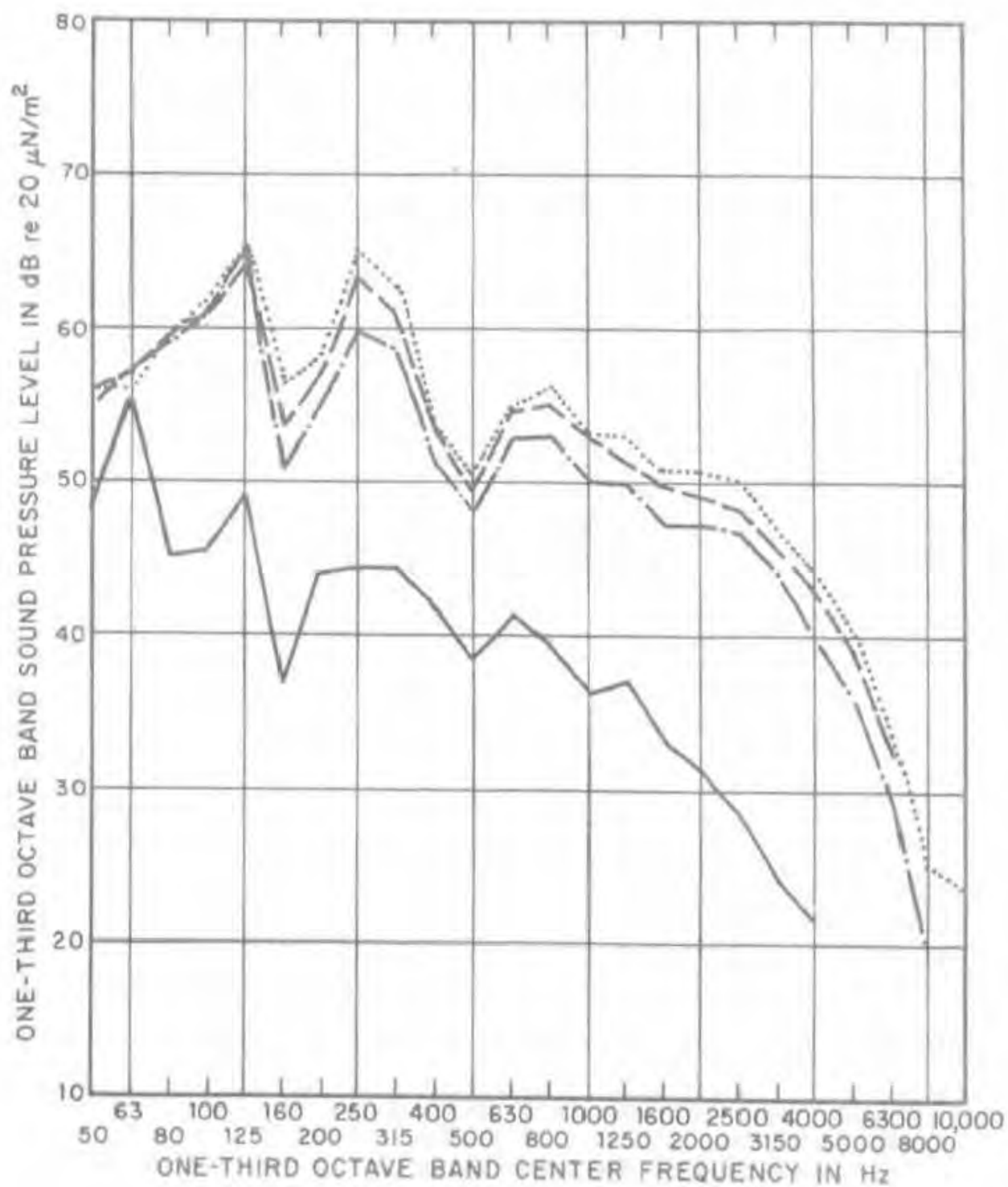


FIG. A.17 SOUND PRESSURE LEVELS FROM A STOVE HOOD EXHAUST FAN - 4 SPEEDS (MEASURED AT 3 FT)

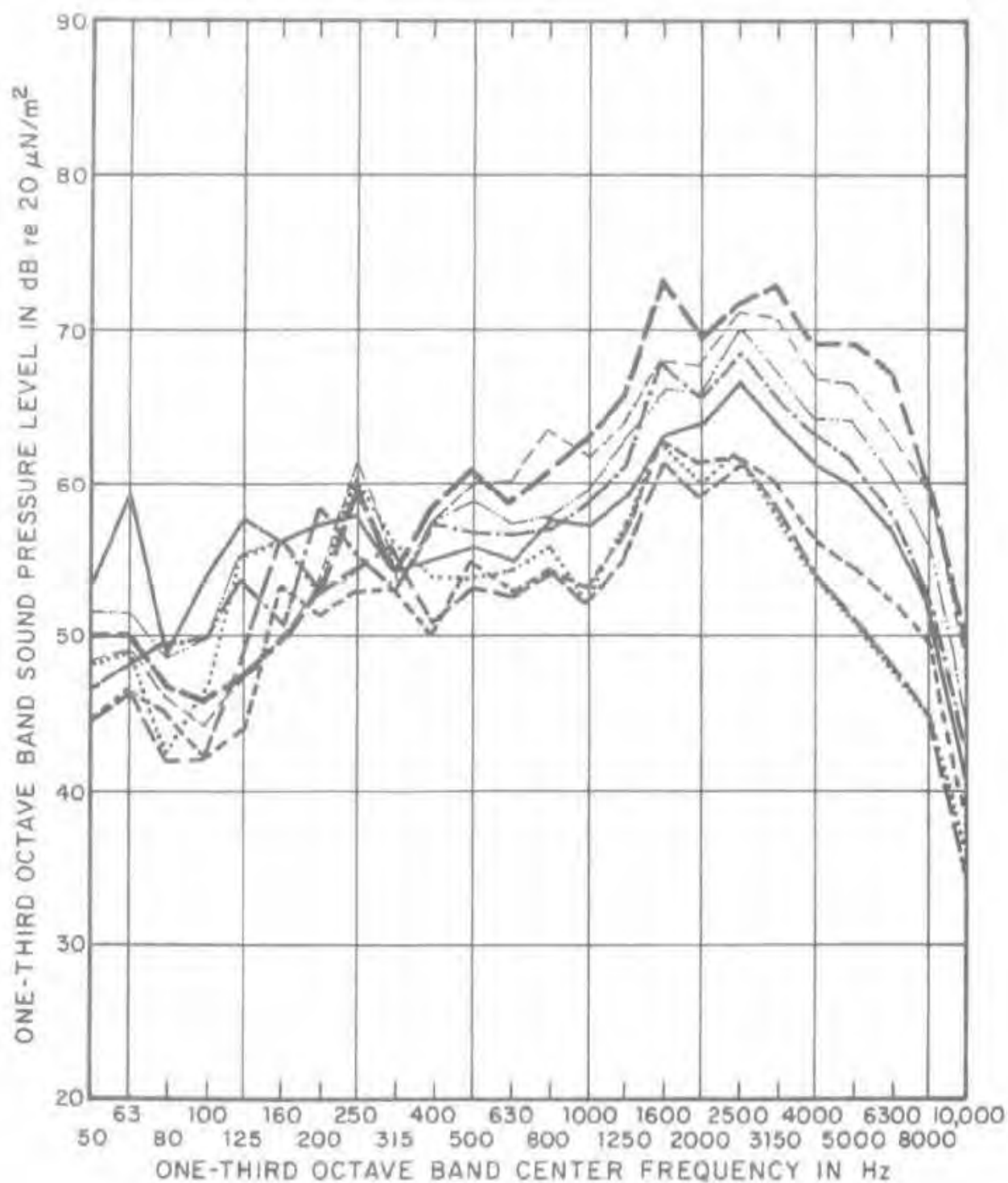


FIG. A.18 SOUND PRESSURE LEVELS FROM A FOOD BLENDER
EIGHT DIFFERENT SPEEDS (MEASURED AT 3 FT)

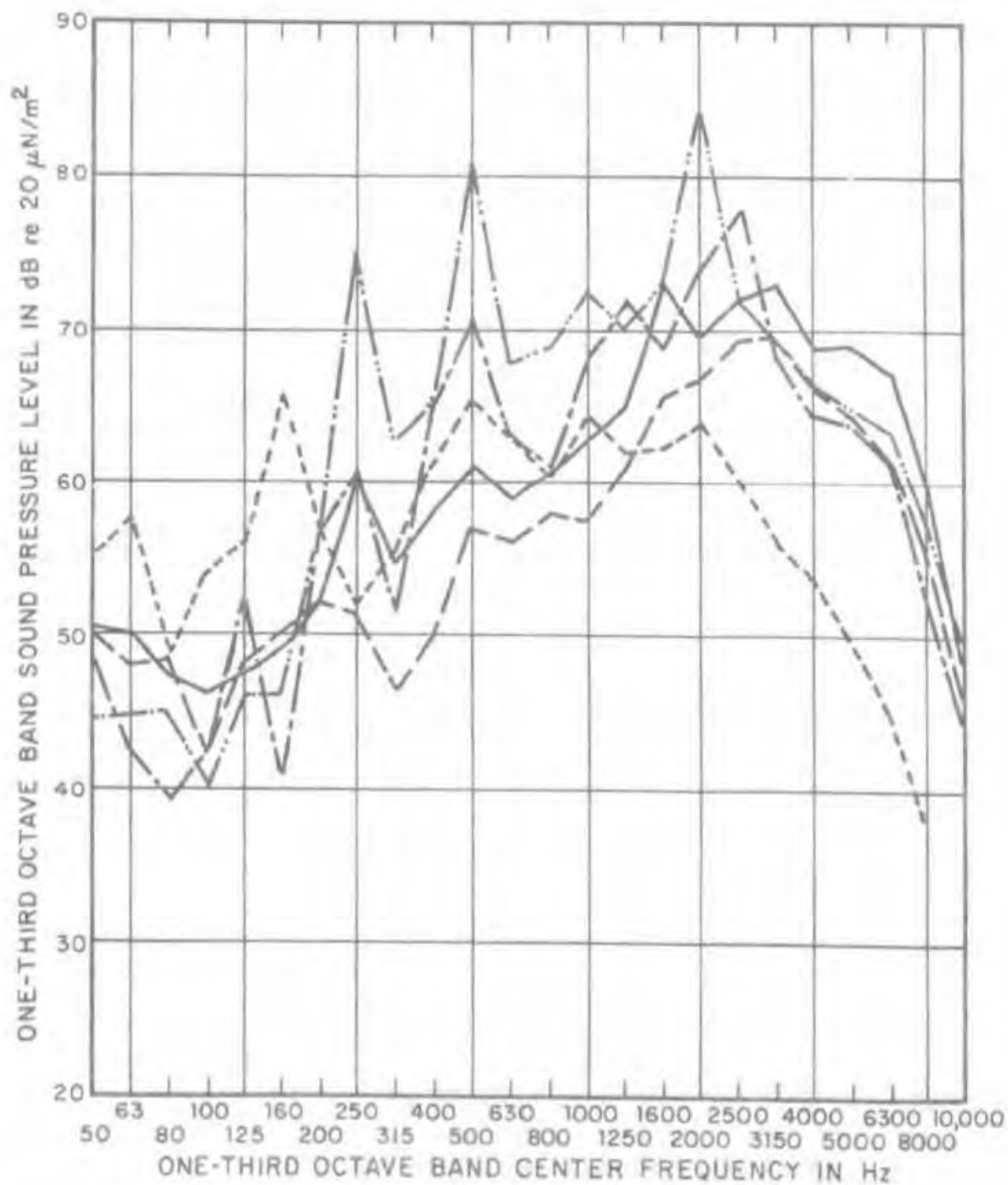


FIG. A.19 SOUND PRESSURE LEVELS FROM FIVE BLENDERS
AT MAXIMUM SPEED (MEASURED AT 3 FT)

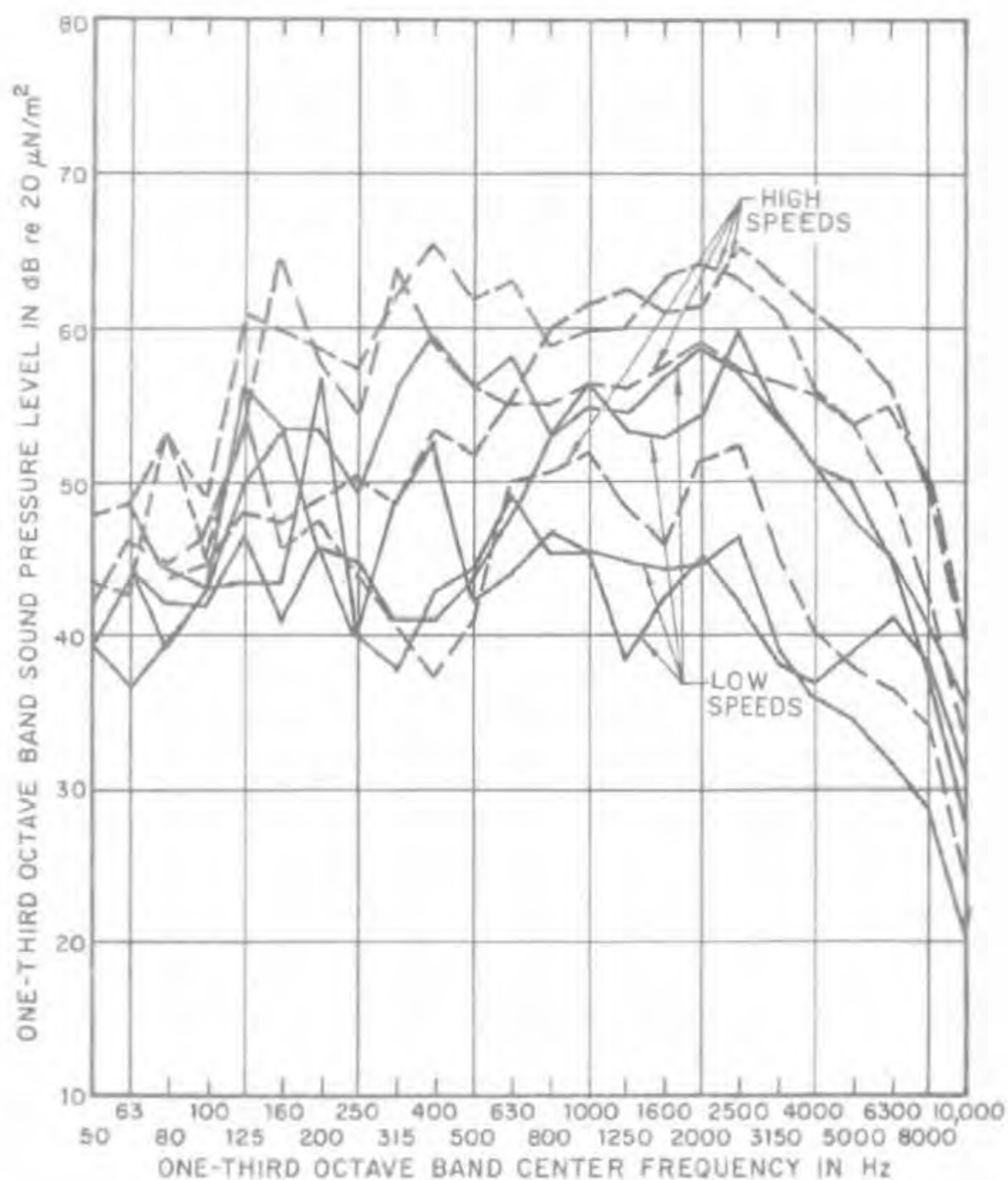


FIG. A.20 SOUND PRESSURE LEVELS FROM FOUR FOOD MIXERS AT LOW AND HIGH SPEED (MEASURED AT 3 FT)

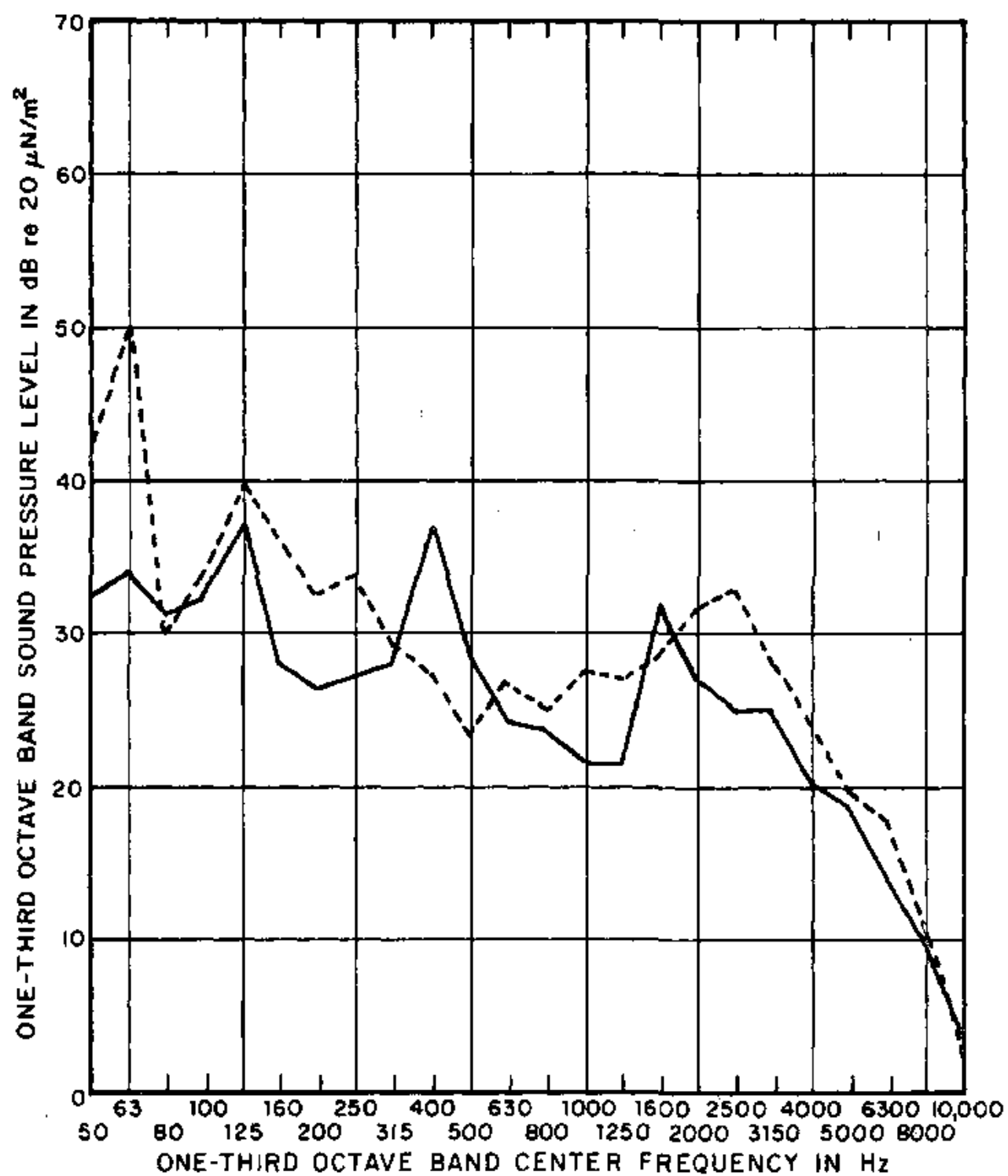


FIG. A.21 SOUND PRESSURE LEVELS FROM TWO FREEZERS
(MEASURED AT 3 FT)

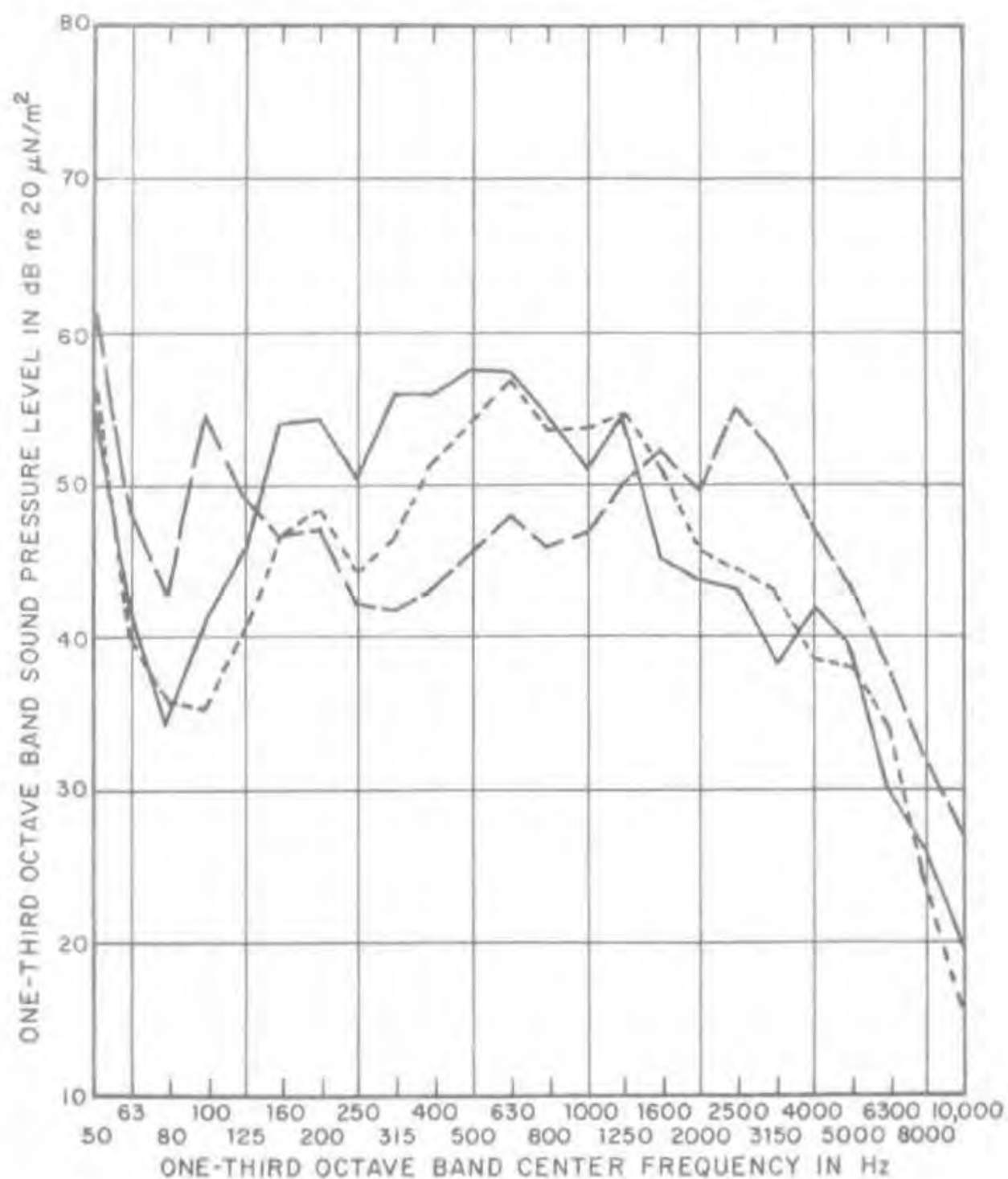


FIG. A.22 SOUND PRESSURE LEVELS FROM THREE HAIR DRYERS
(MEASURED AT 3 FT)

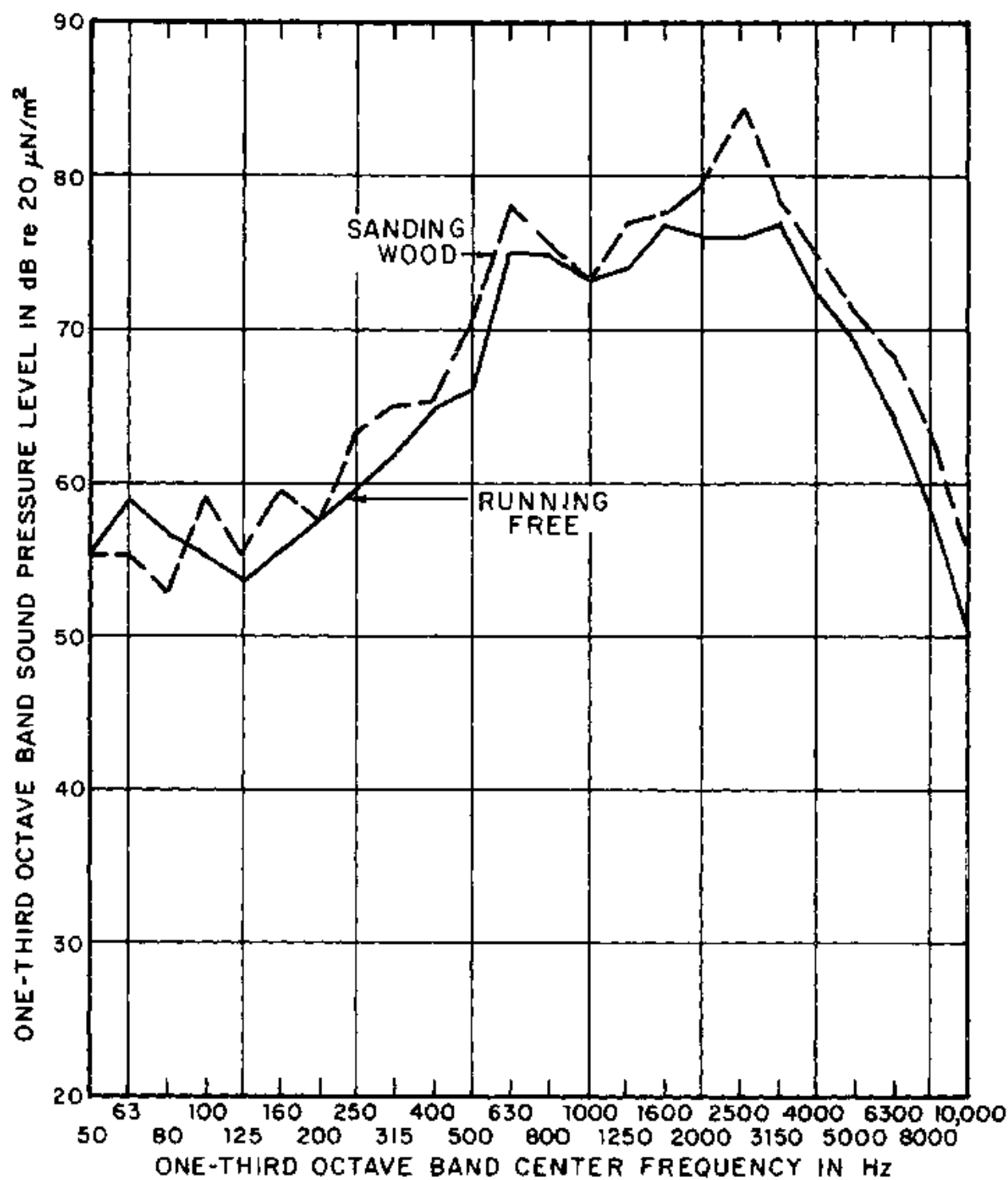


FIG. A.23 SOUND PRESSURE LEVELS FOR A BELT SANDER
 RUNNING FREE AND SANDING WOOD (MEASURED AT
 3 FT)

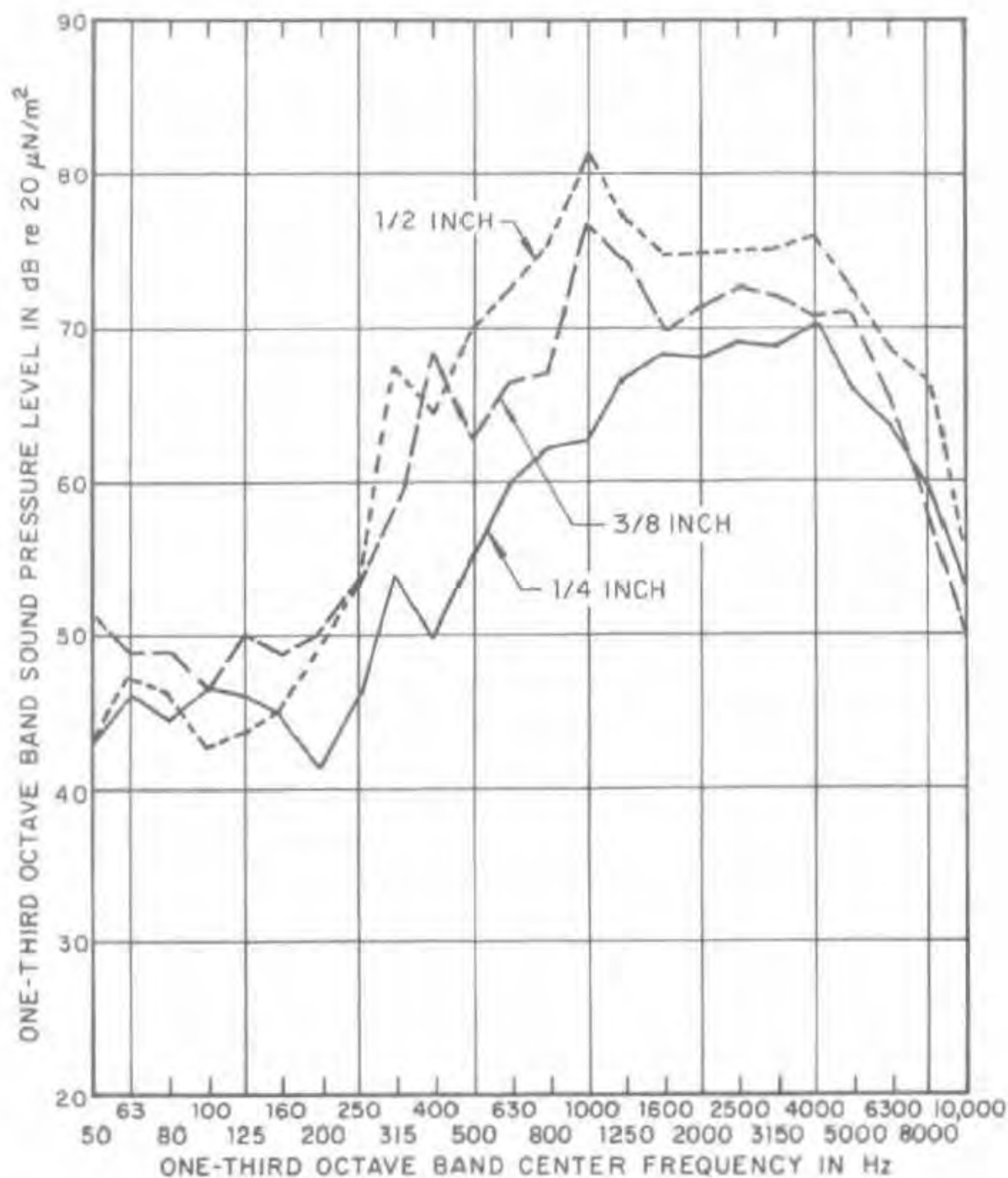


FIG. A.24 SOUND PRESSURE LEVELS FROM THREE DRILLS
(MEASURED AT 3 FT)

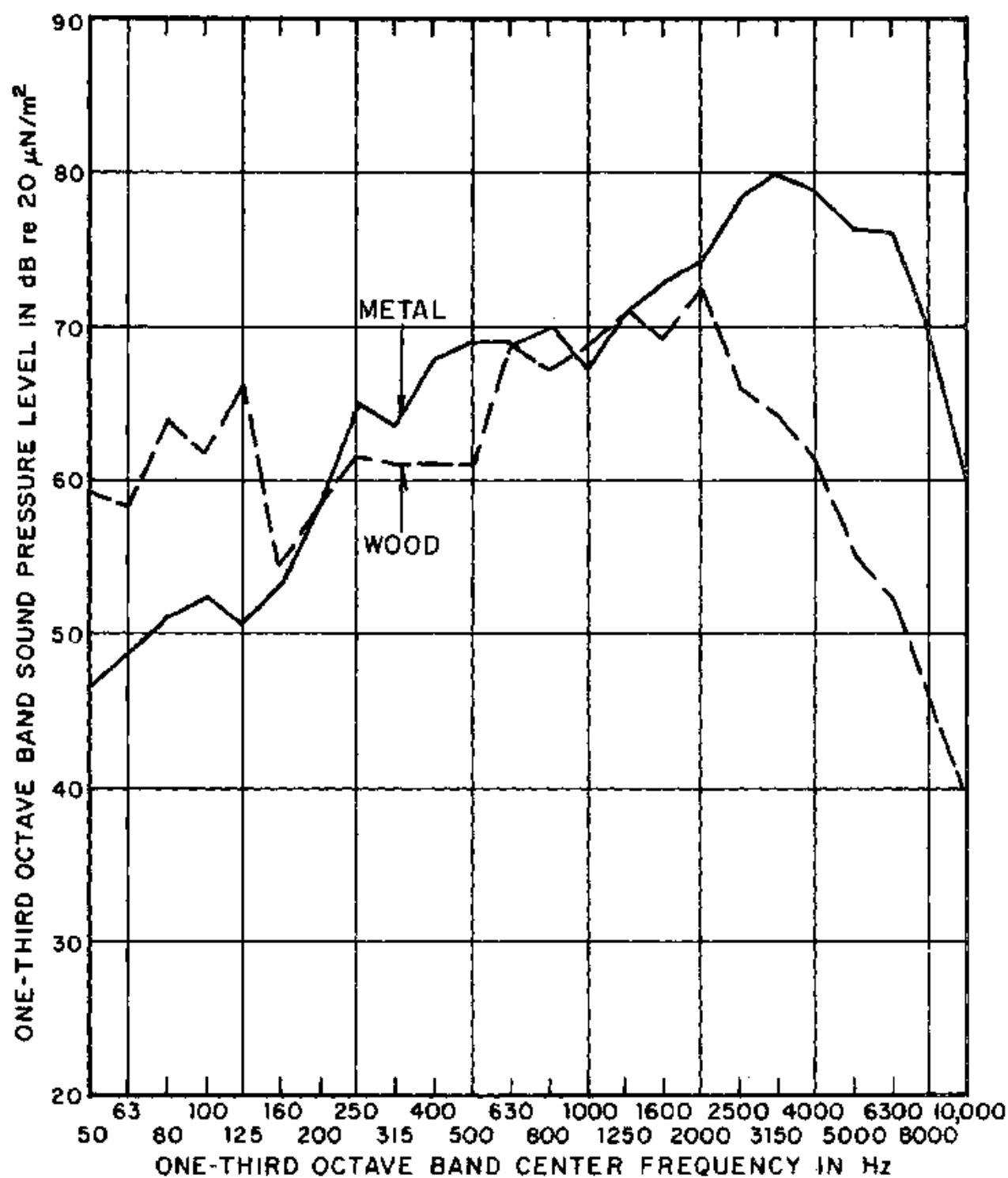


FIG. A.25 SOUND PRESSURE LEVELS FROM TWO DRILL PRESSES DRILLING THROUGH WOOD AND METAL (MEASURED AT 3 FT)

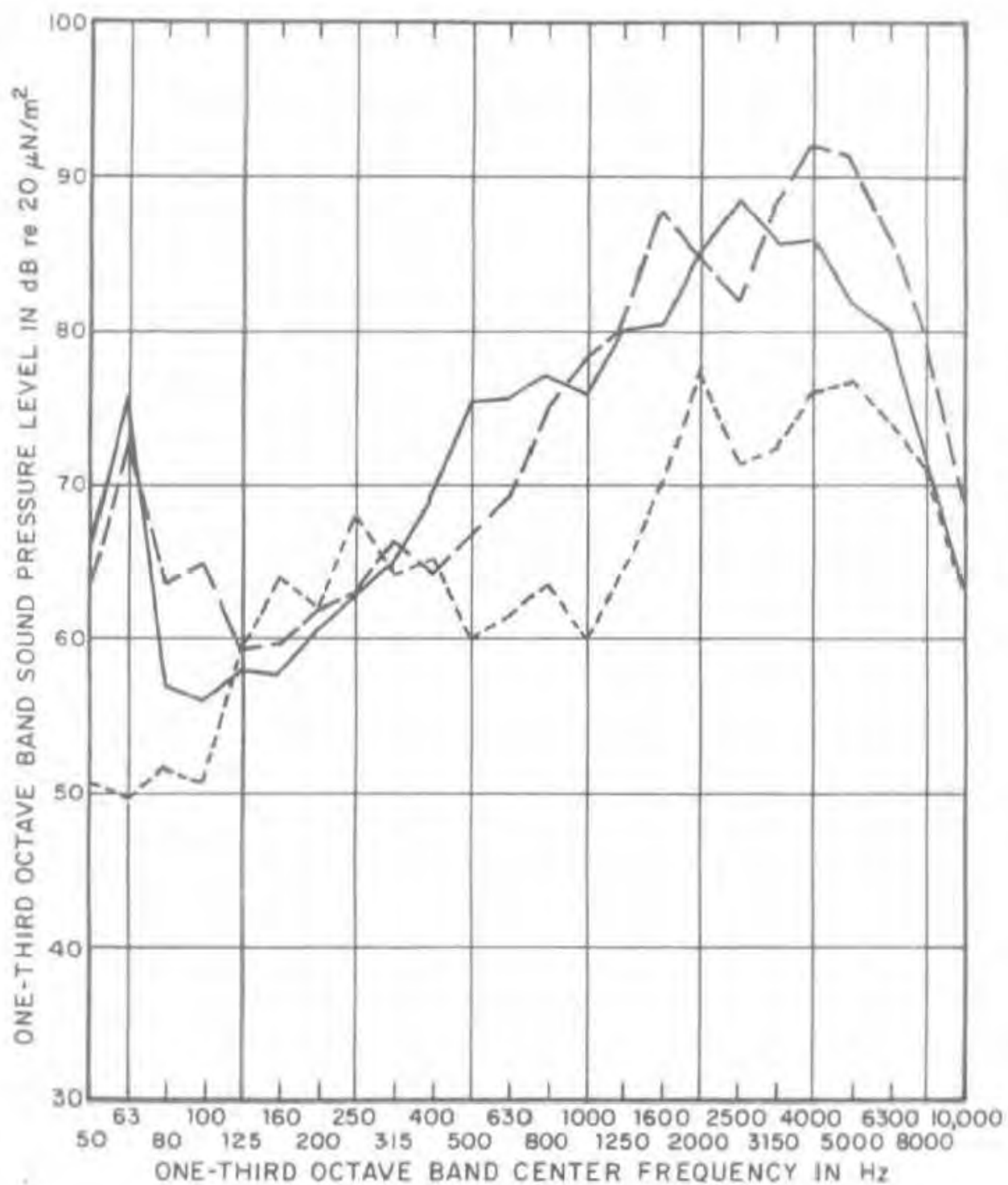


FIG. A.26 SOUND PRESSURE LEVELS FROM THREE GRINDERS GRINDING METAL STOCK (MEASURED AT 3 FT)

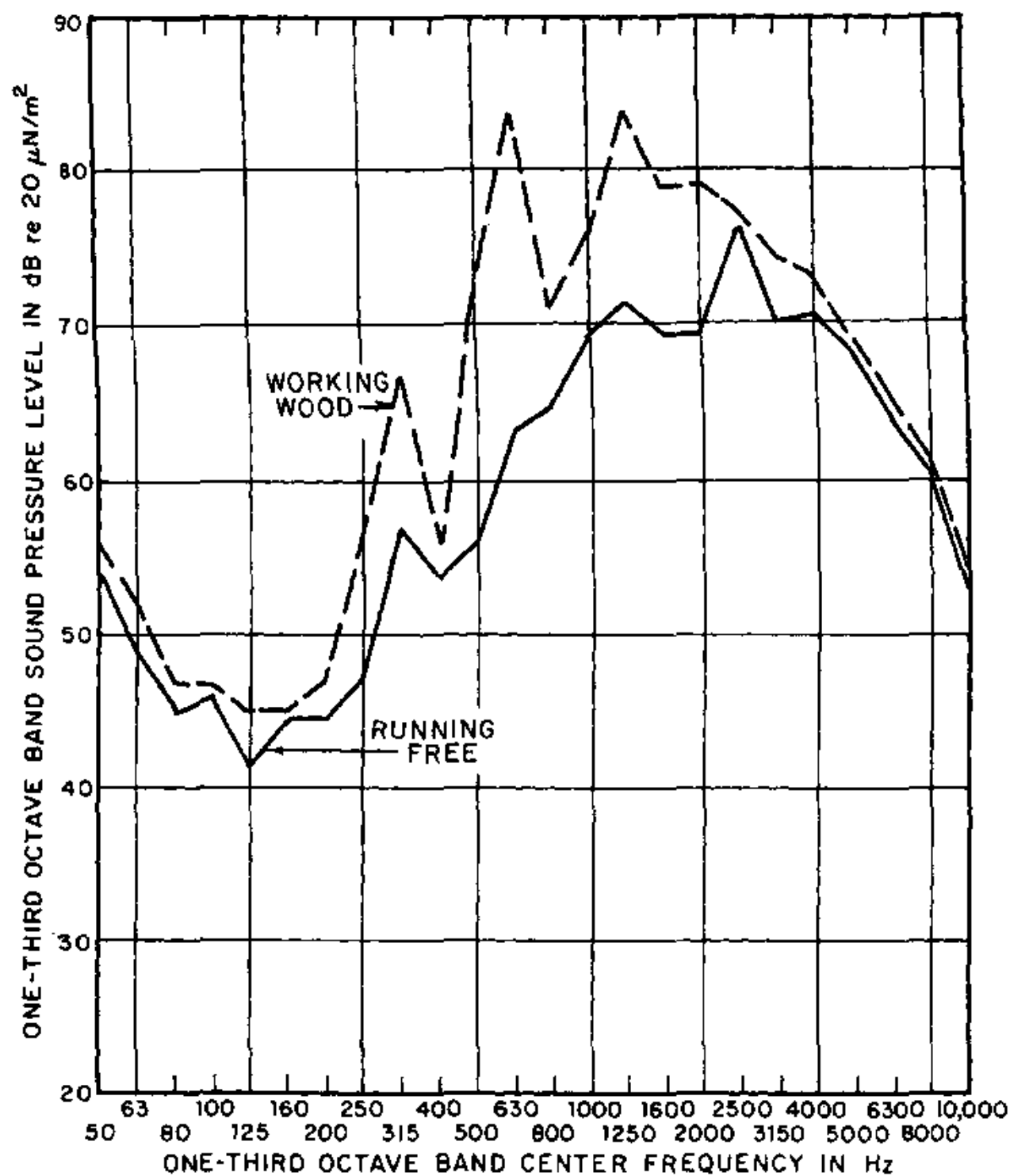


FIG. A.27 SOUND PRESSURE LEVELS FROM A ROUTER RUNNING FREE AND WORKING WOOD (MEASURED AT 3 FT)

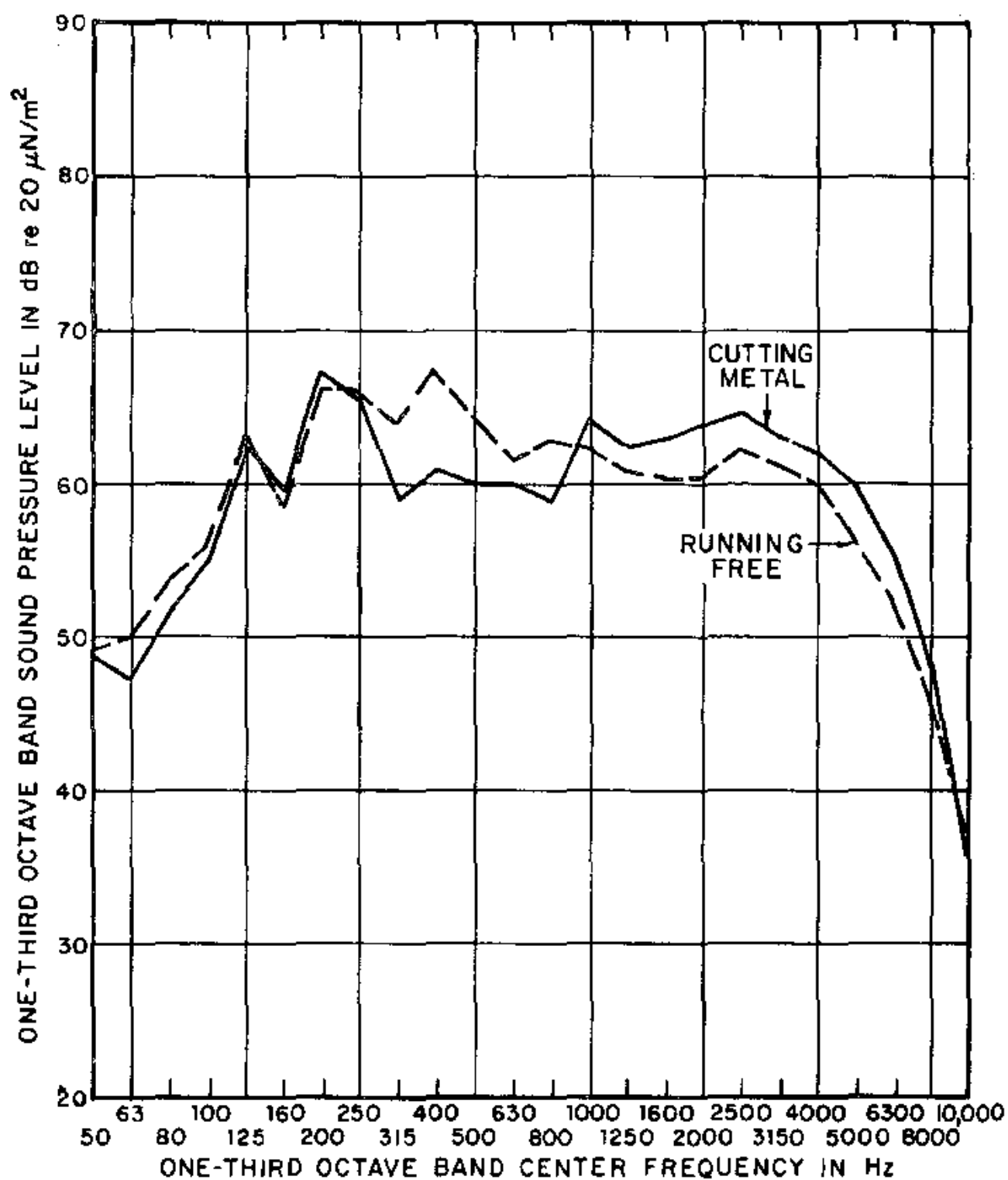


FIG. A.28 SOUND PRESSURE LEVELS FROM A SMALL METAL LATHE RUNNING FREE AND CUTTING (MEASURED AT 3 FT)

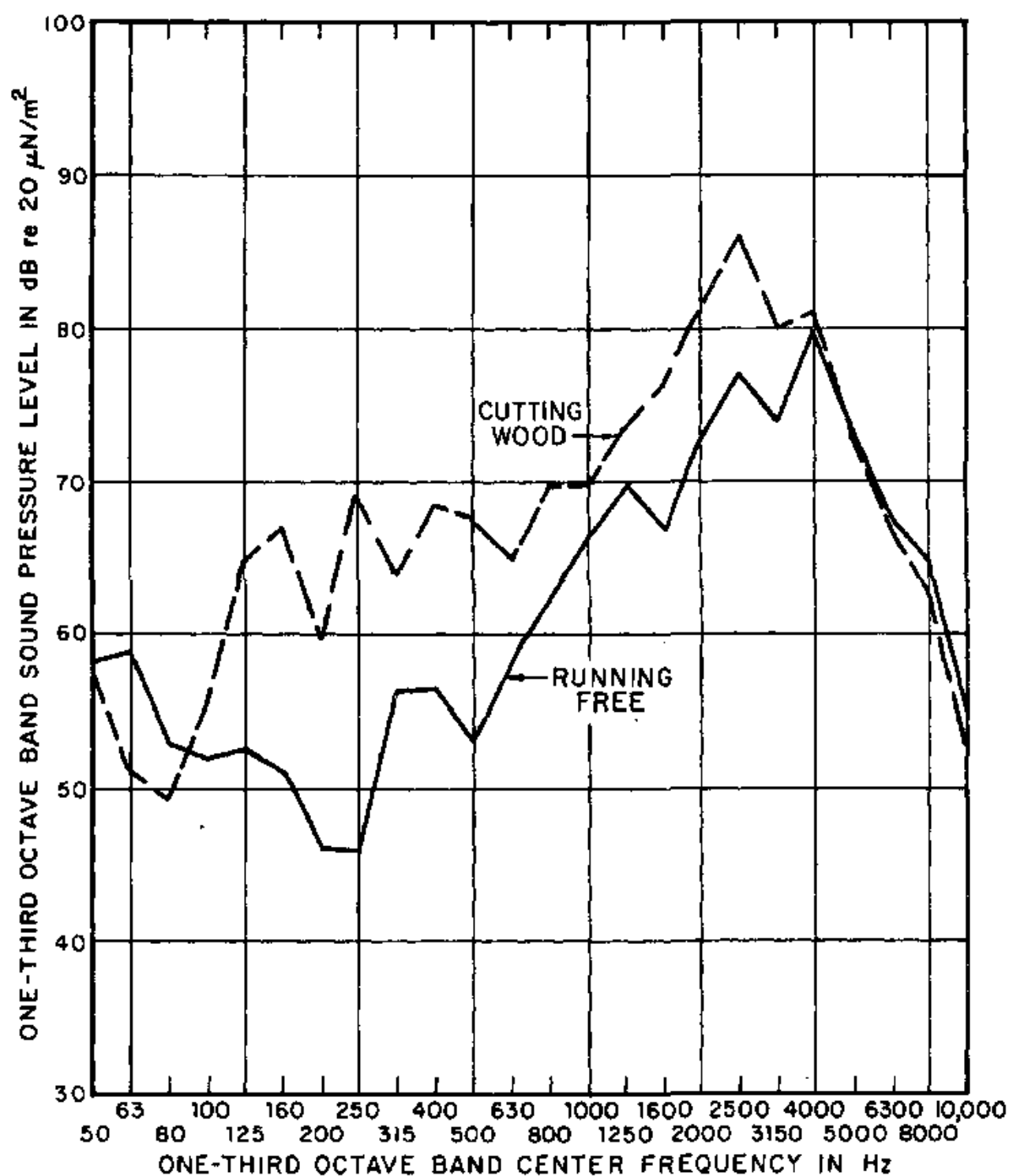


FIG. A.29 SOUND PRESSURE LEVELS FROM A SABRE SAW
 RUNNING FREE AND CUTTING WOOD (MEASURED AT
 3 FT)

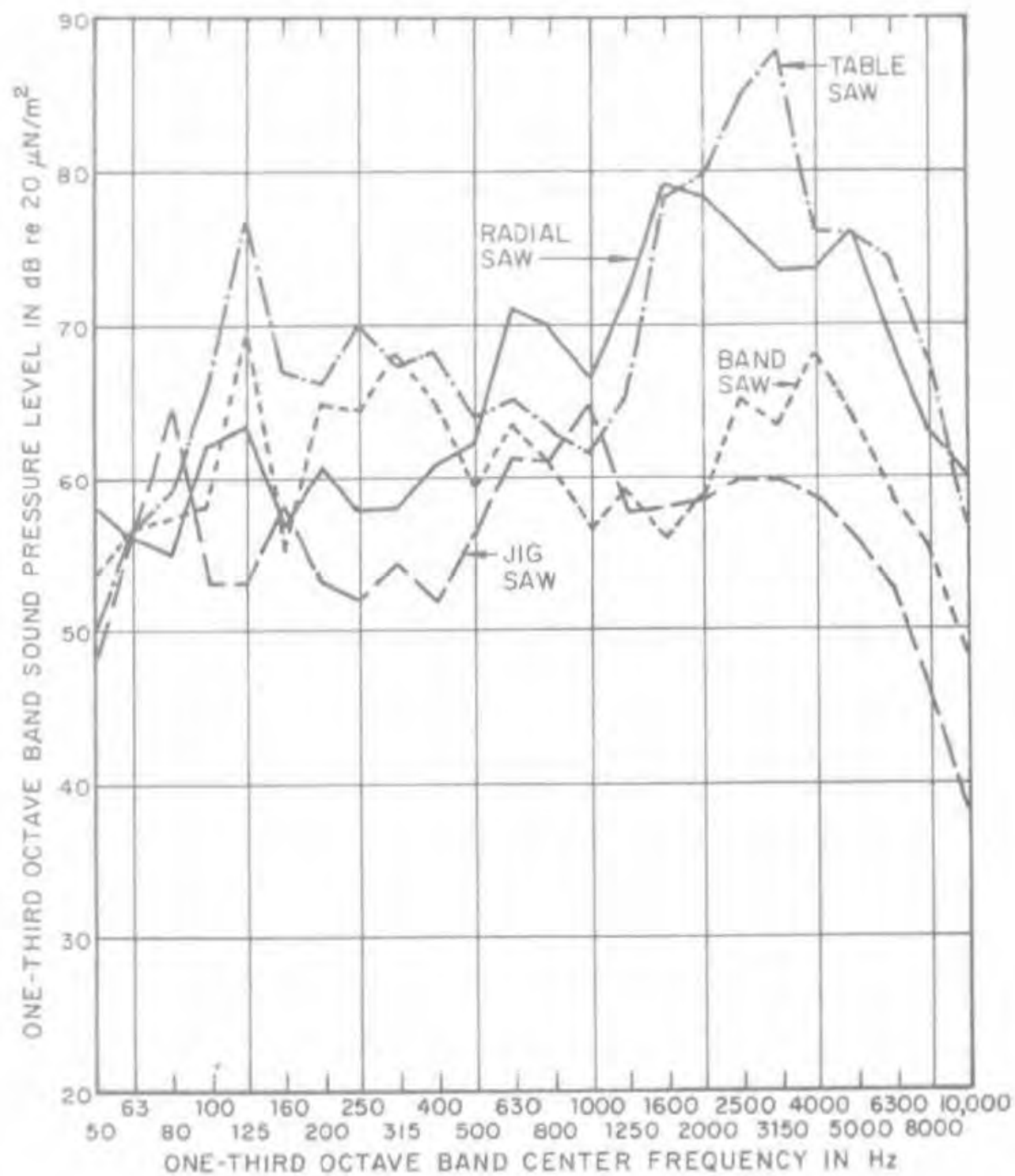


FIG. A.30 SOUND PRESSURE LEVELS FROM FOUR DIFFERENT SAWS CUTTING WOOD (MEASURED AT 3 FT)

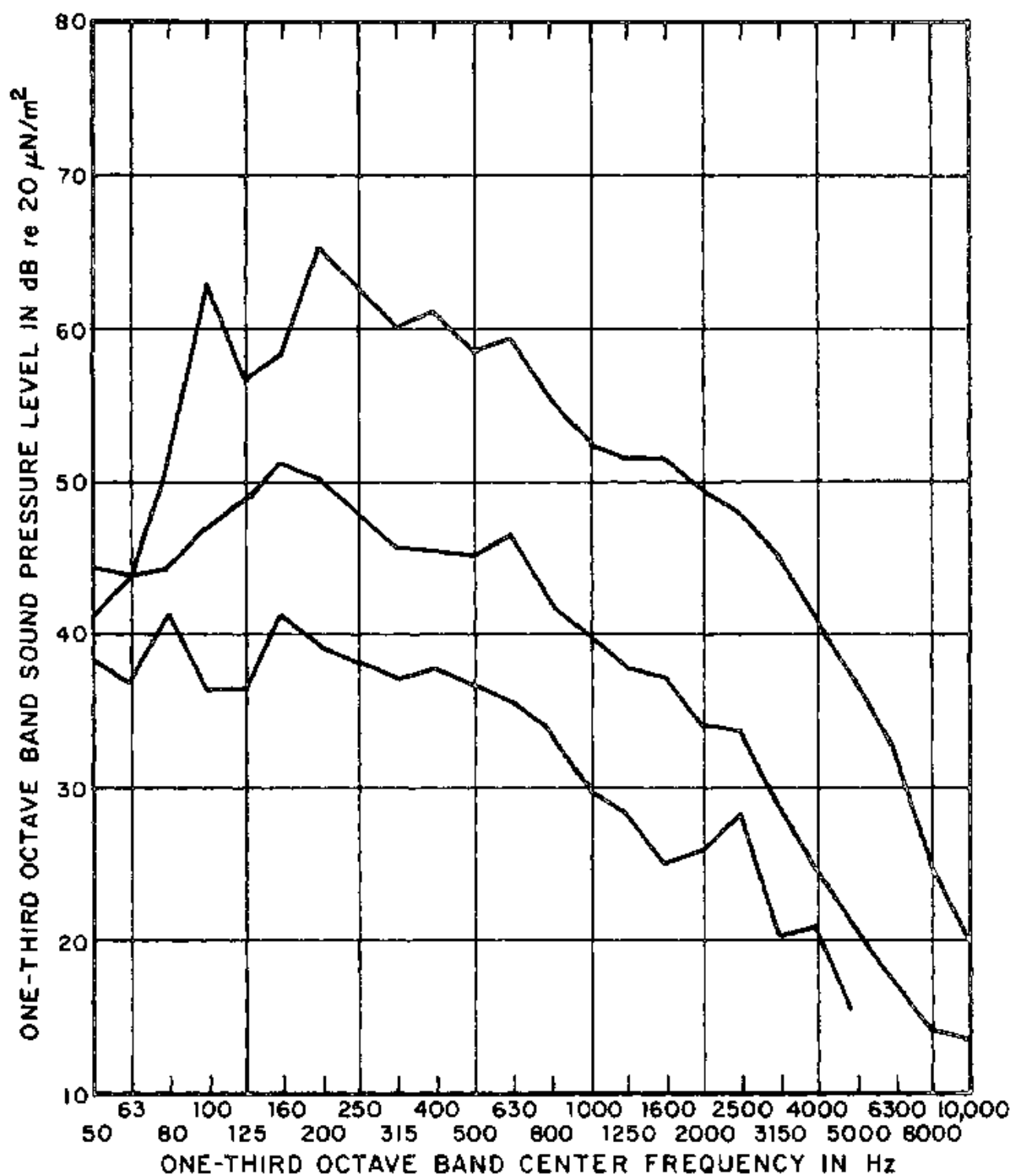


FIG. A.31 SOUND PRESSURE LEVELS FROM A ROOM DEHUMIDIFIER FOR THREE SETTINGS (MEASURED AT 3 FT)

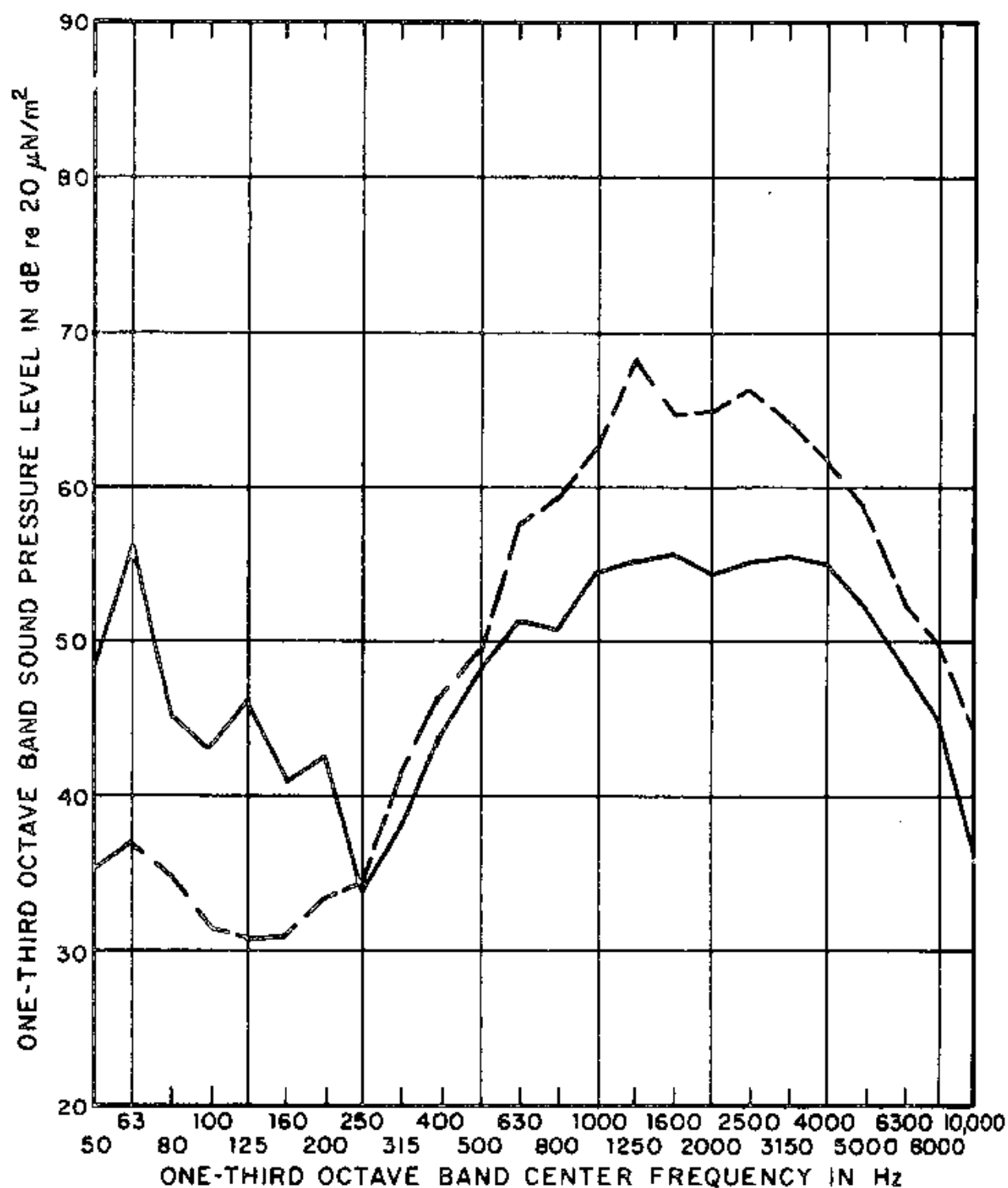


FIG. A.32 SOUND PRESSURE LEVELS FROM TWO ELECTRIC KNIVES (MEASURED AT 3 FT)

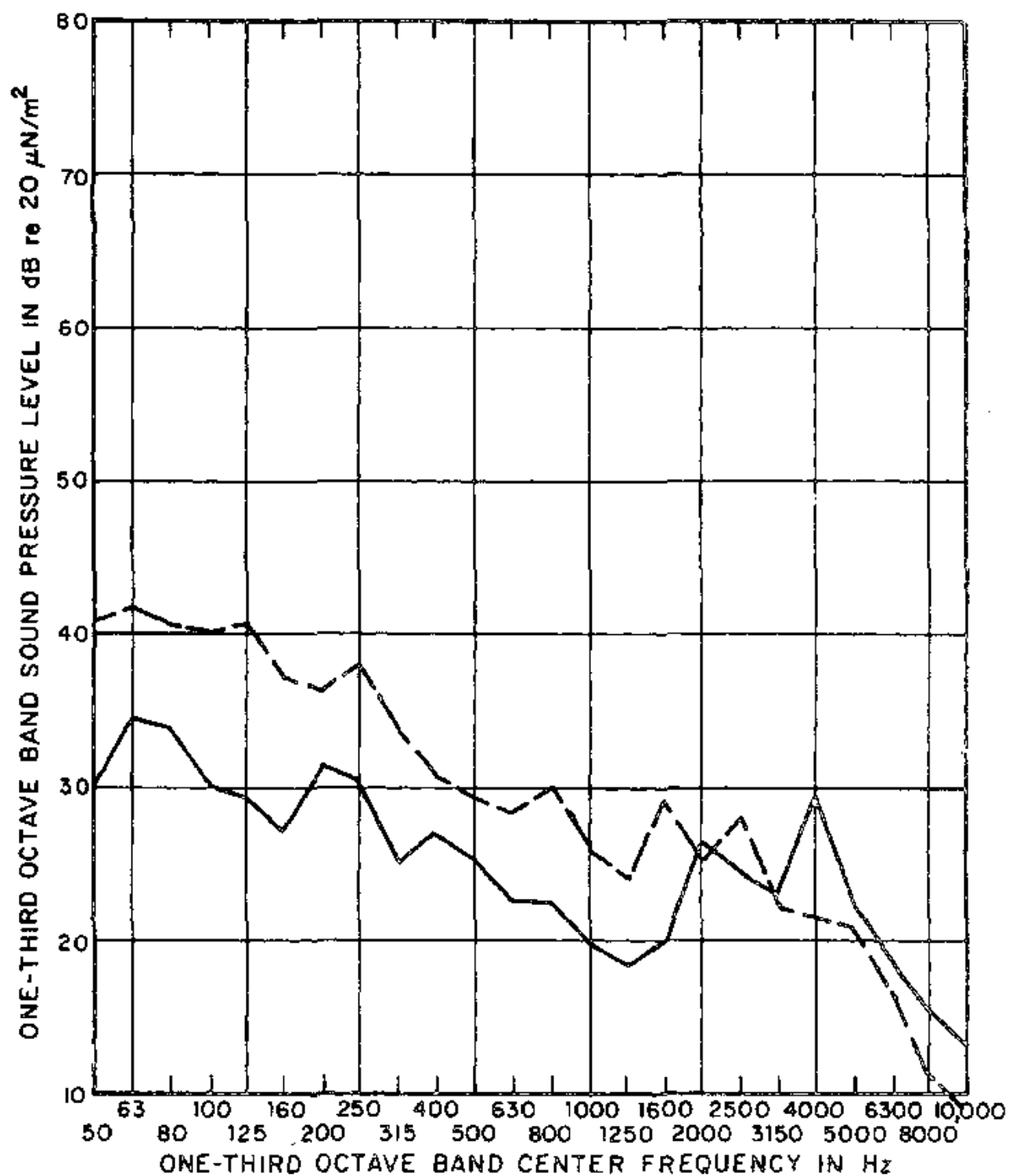


FIG. A.33 SOUND PRESSURE LEVELS FROM TWO REFRIGERATORS
(MEASURED AT 3 FT)

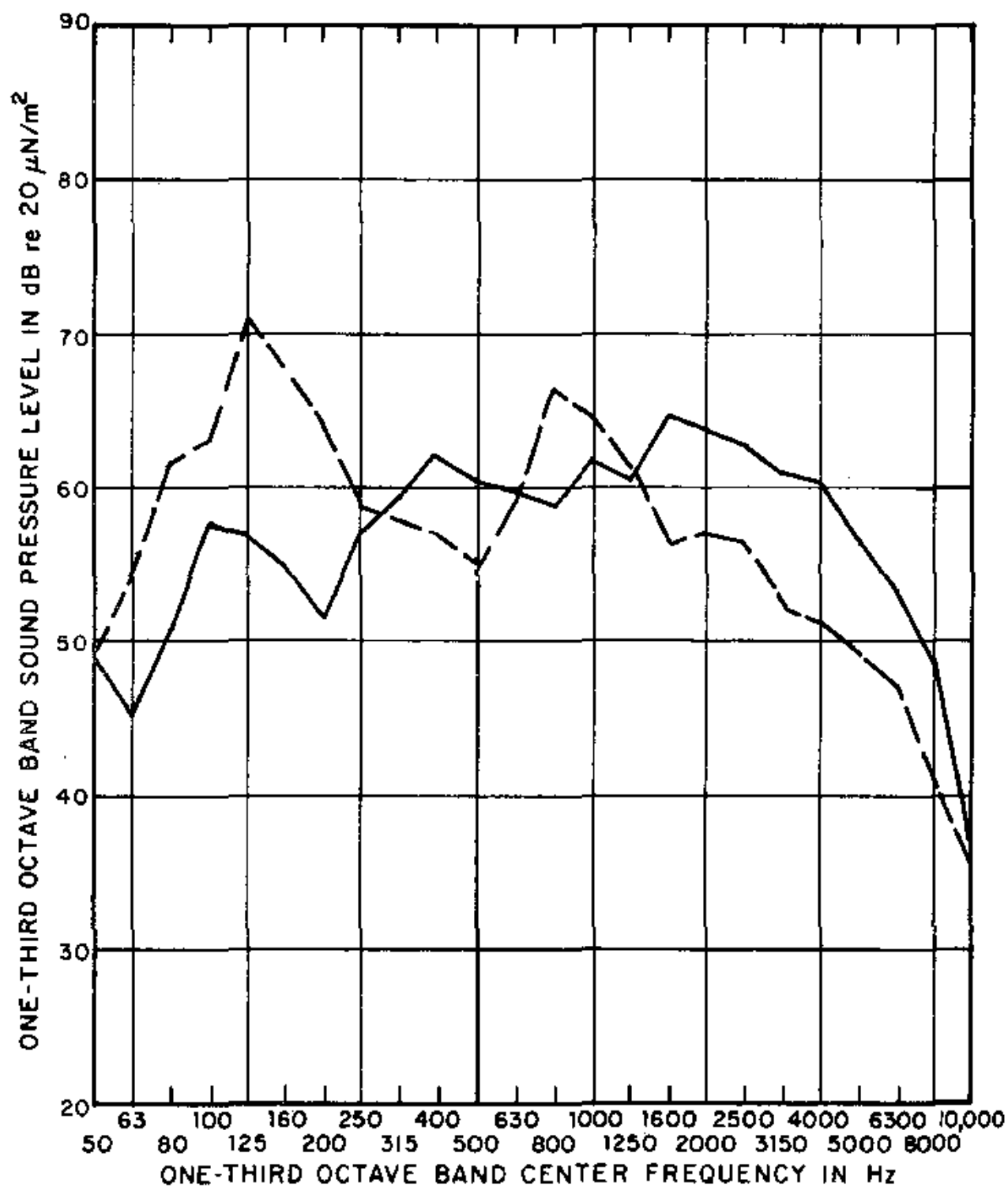


FIG. A.34 SOUND PRESSURE LEVELS FROM TWO SEWING MACHINES (MEASURED AT 3 FT)

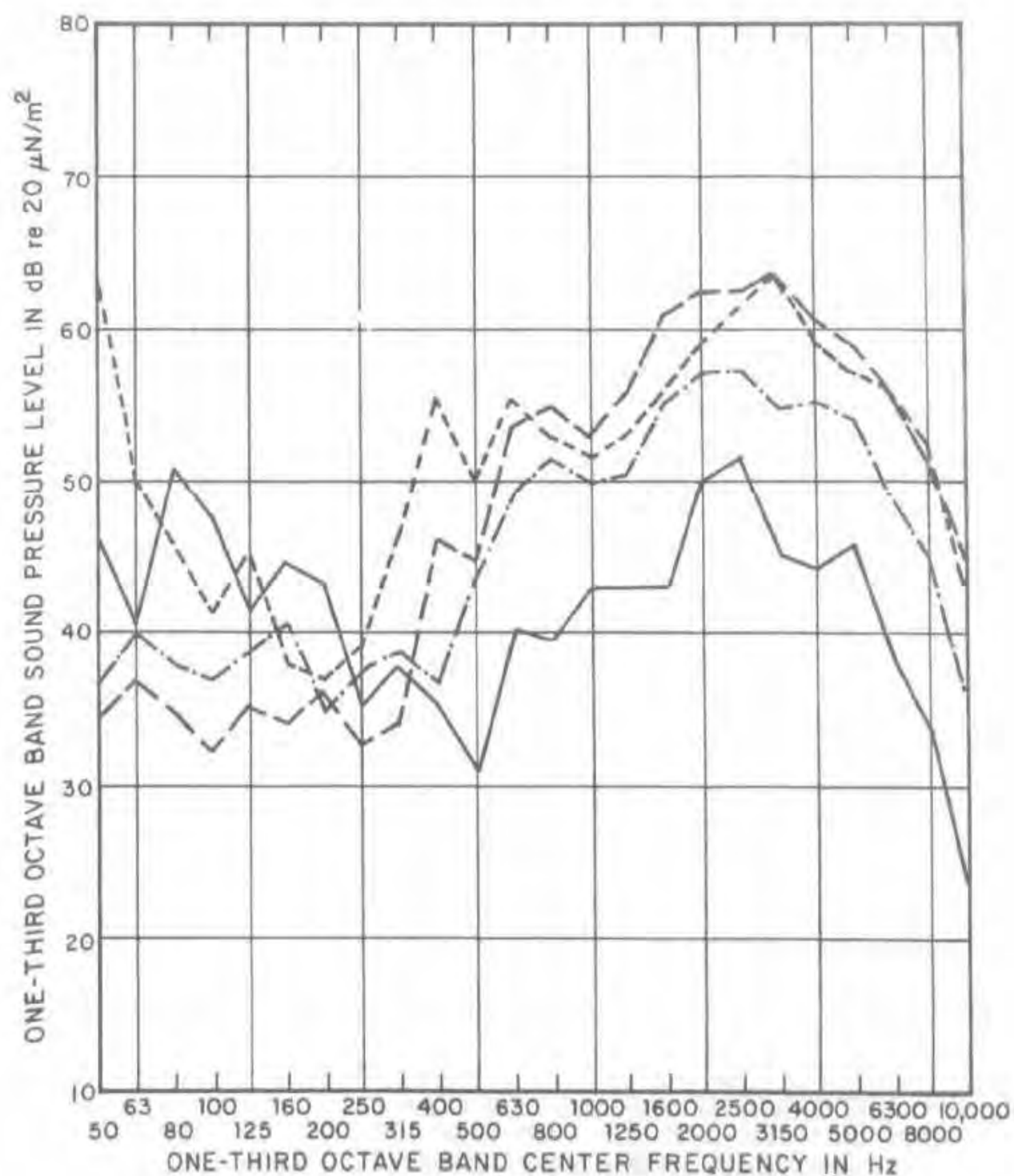


FIG. A.35 SOUND PRESSURE LEVELS FROM FOUR MEN'S ELECTRIC SHAVERS (MEASURED AT 3 FT)

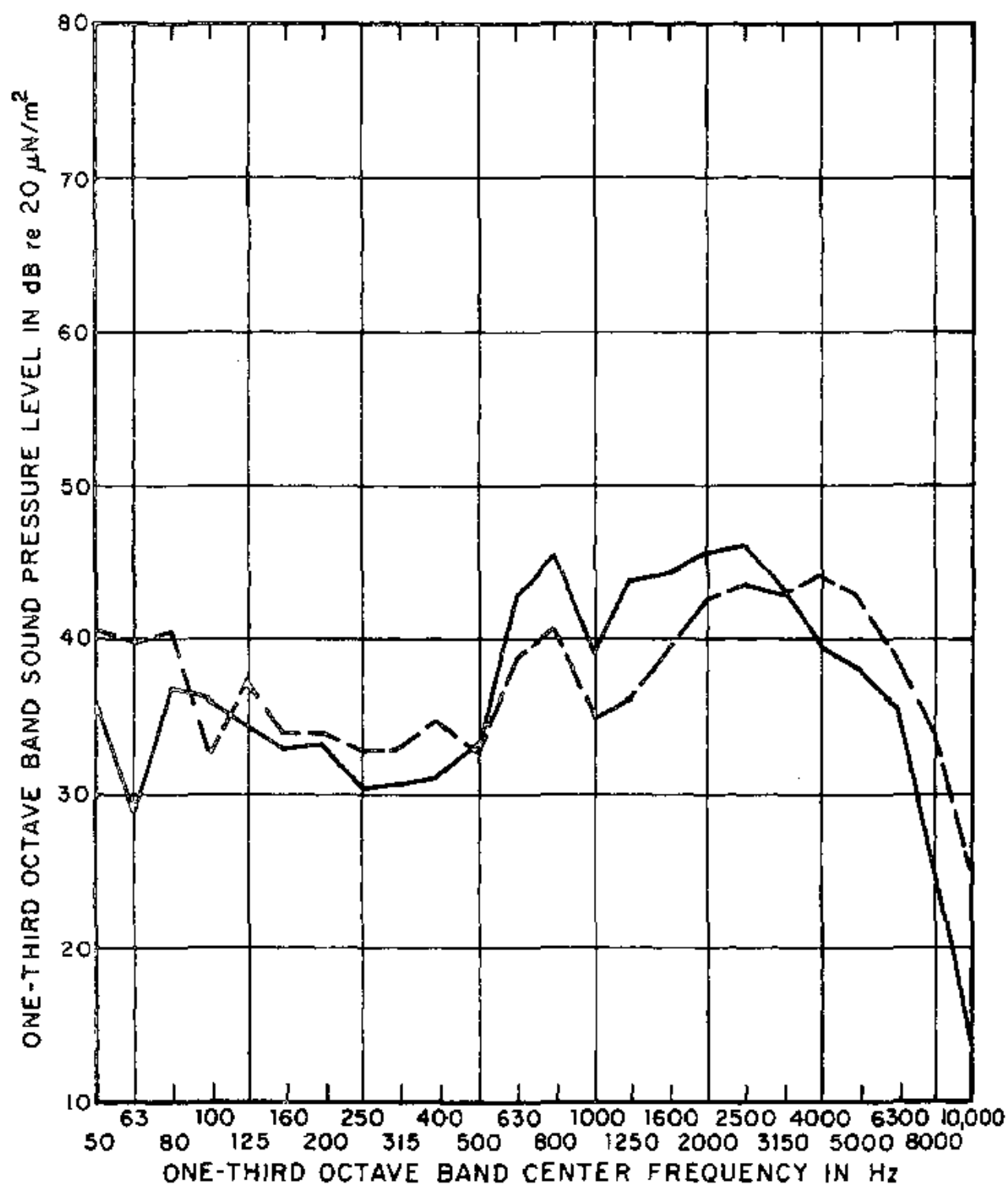


FIG. A.36 SOUND PRESSURE LEVELS FROM TWO WOMEN'S ELECTRIC SHAVERS (MEASURED AT 3 FT)

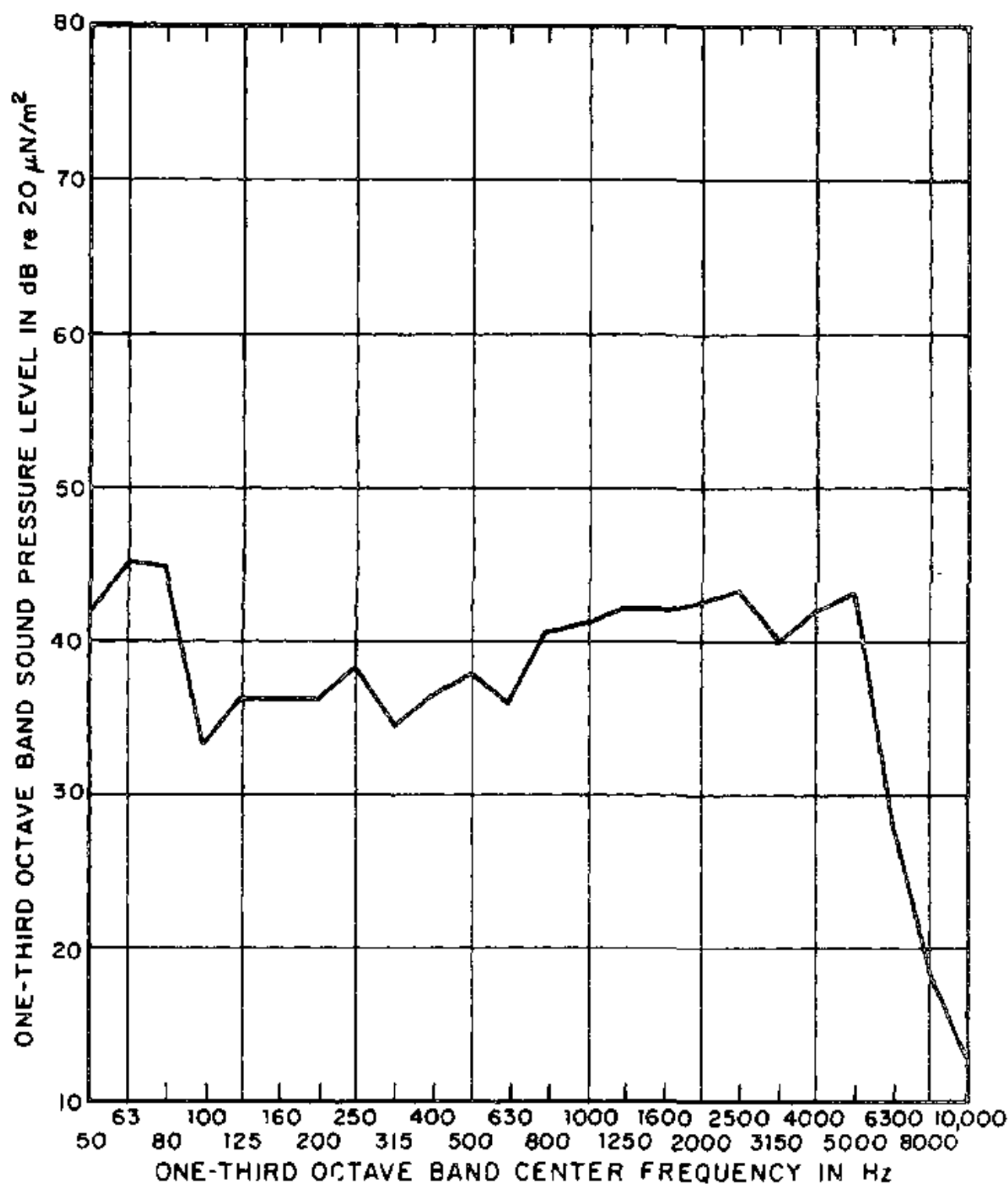


FIG. A.37 SOUND PRESSURE LEVELS FROM AN ELECTRIC TOOTHBRUSH (MEASURED AT 3 FT)

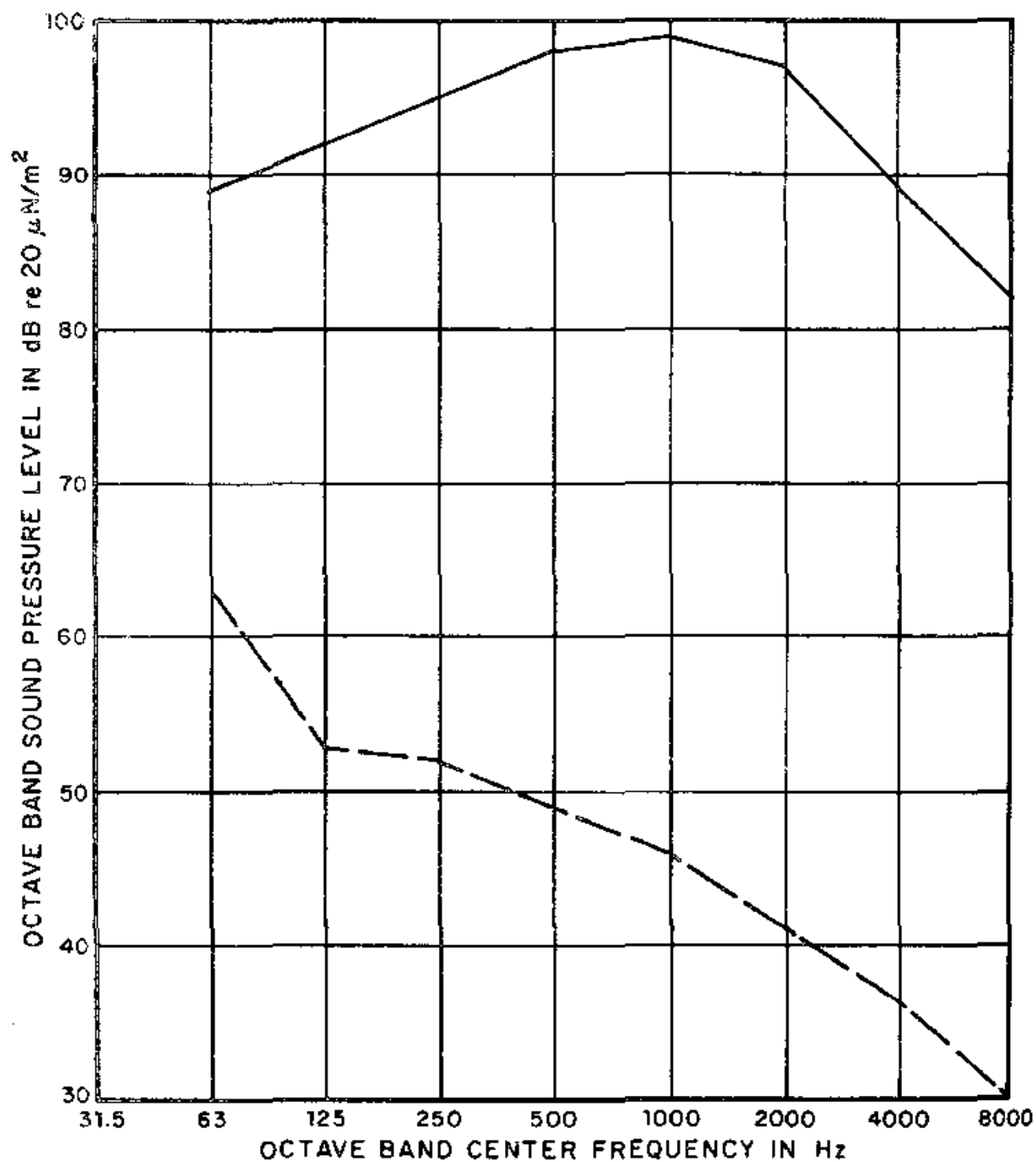


FIG. A.38 RANGE OF SOUND PRESSURE LEVELS FROM DIFFERENT SIZES OF MOTORS (MEASURED AT 3 FT)

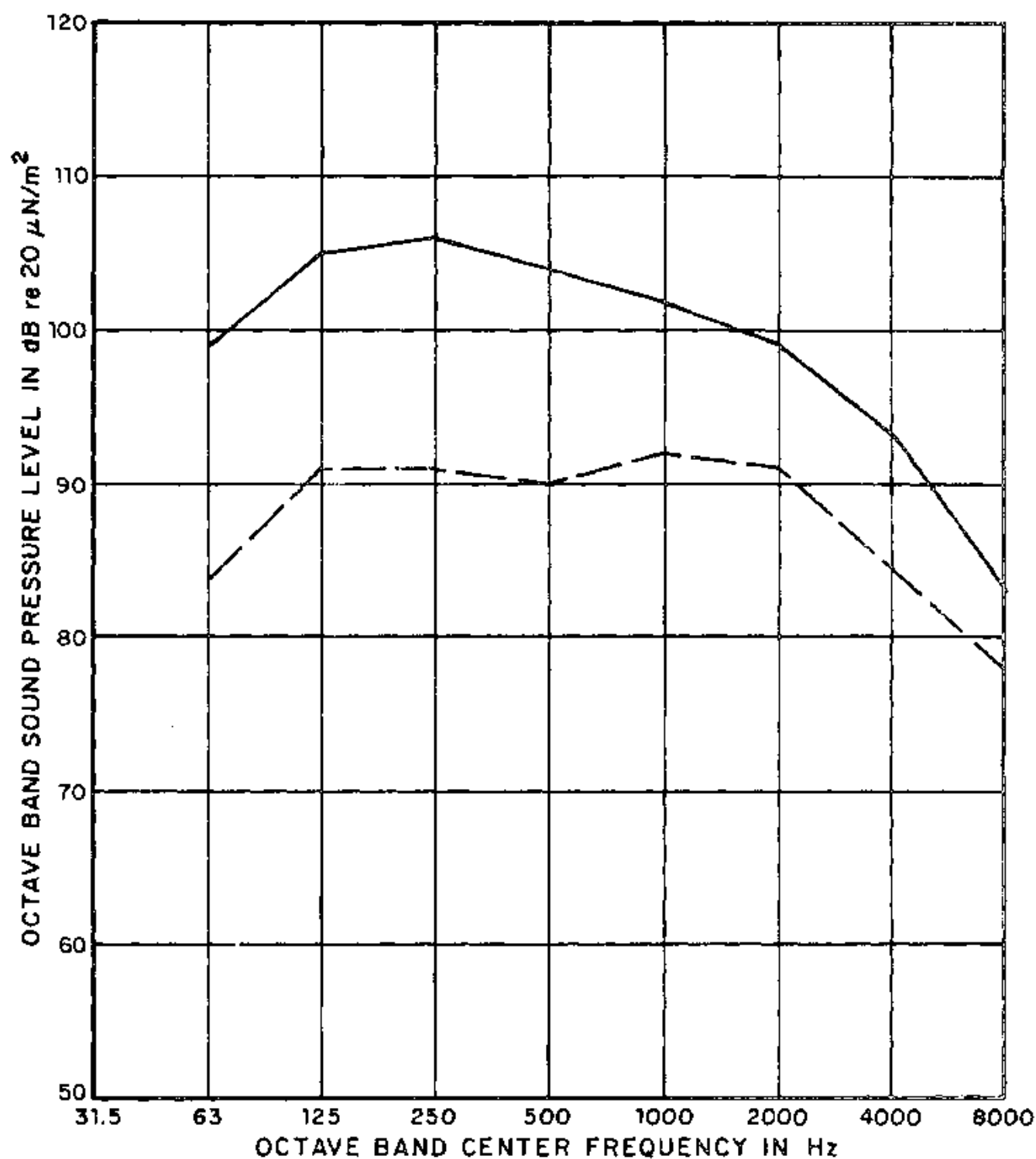


FIG. A.39 RANGE OF SOUND PRESSURE LEVELS FROM INTERNAL COMBUSTION ENGINES (MEASURED AT 3 FT)

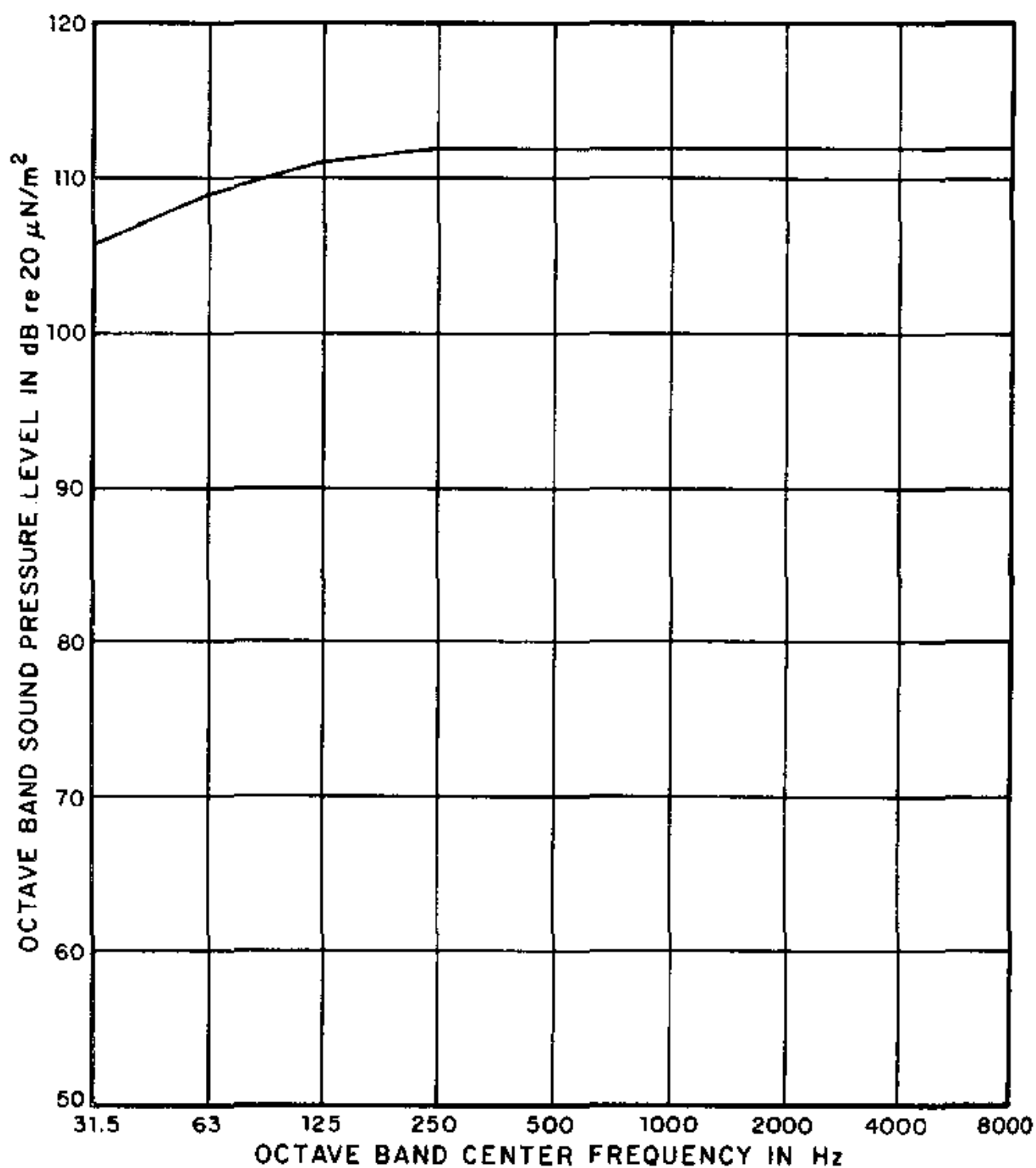


FIG. A.40 TYPICAL SOUND PRESSURE LEVELS FROM GAS TURBINES (MEASURED AT 3 FT)

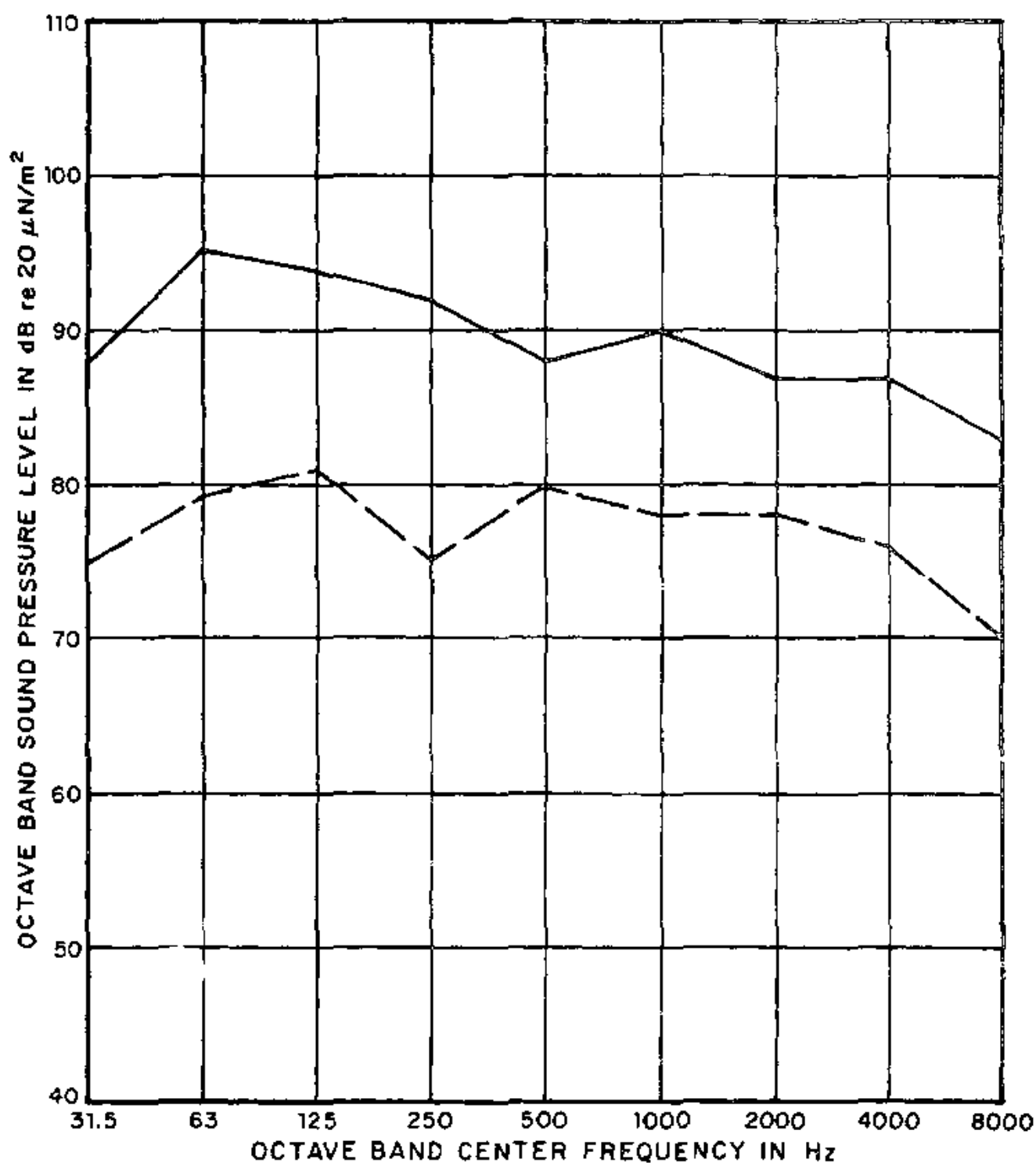


FIG. A.41 RANGE OF SOUND PRESSURE LEVELS FROM STEAM TURBINES (MEASURED AT 3 FT)

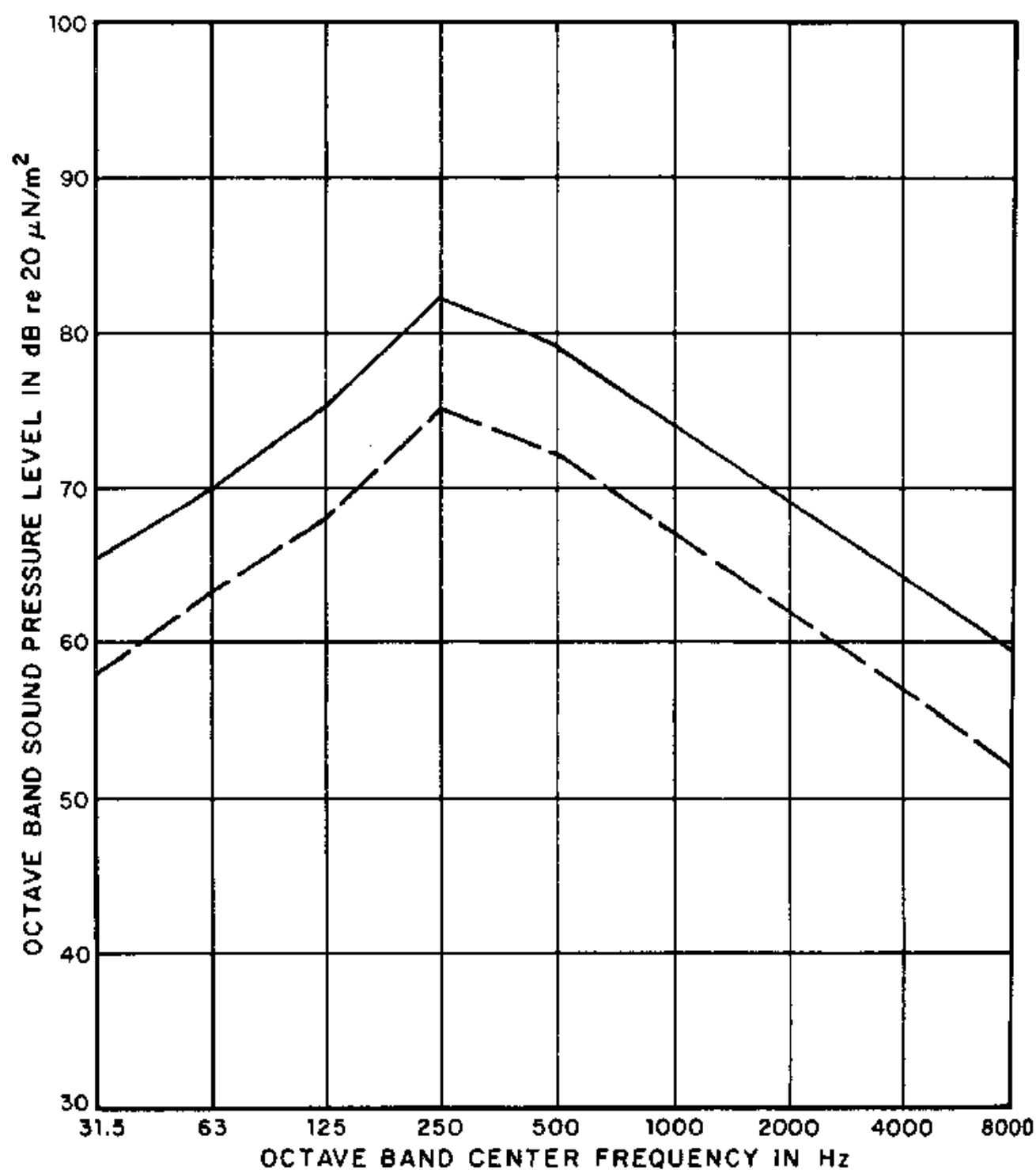


FIG. A.42 RANGE OF SOUND PRESSURE LEVELS FROM TRANSFORMERS (MEASURED AT 3 FT)

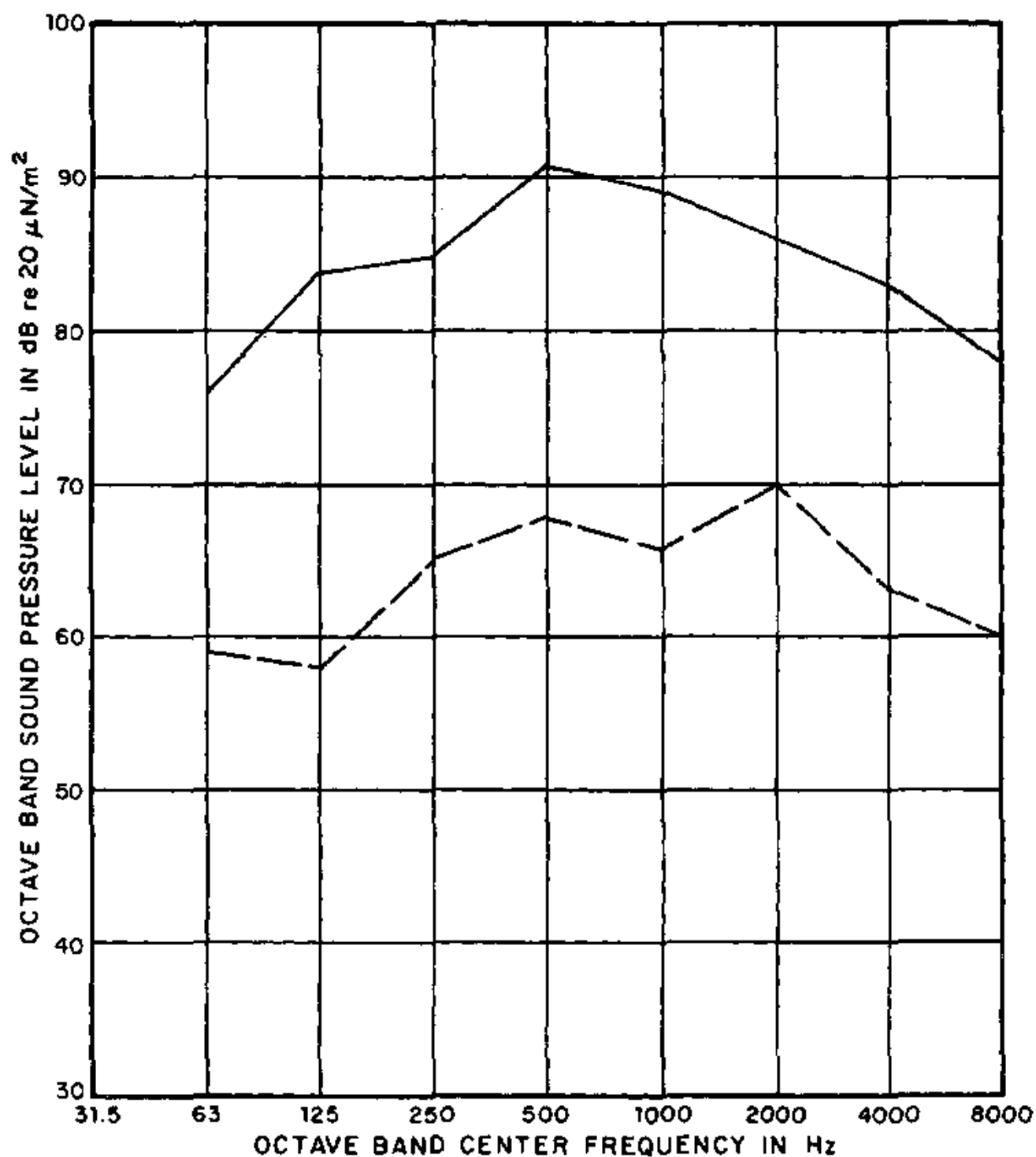


FIG. A.43 RANGE OF SOUND PRESSURE LEVELS FROM PUMPS
(MEASURED AT 3 FT)

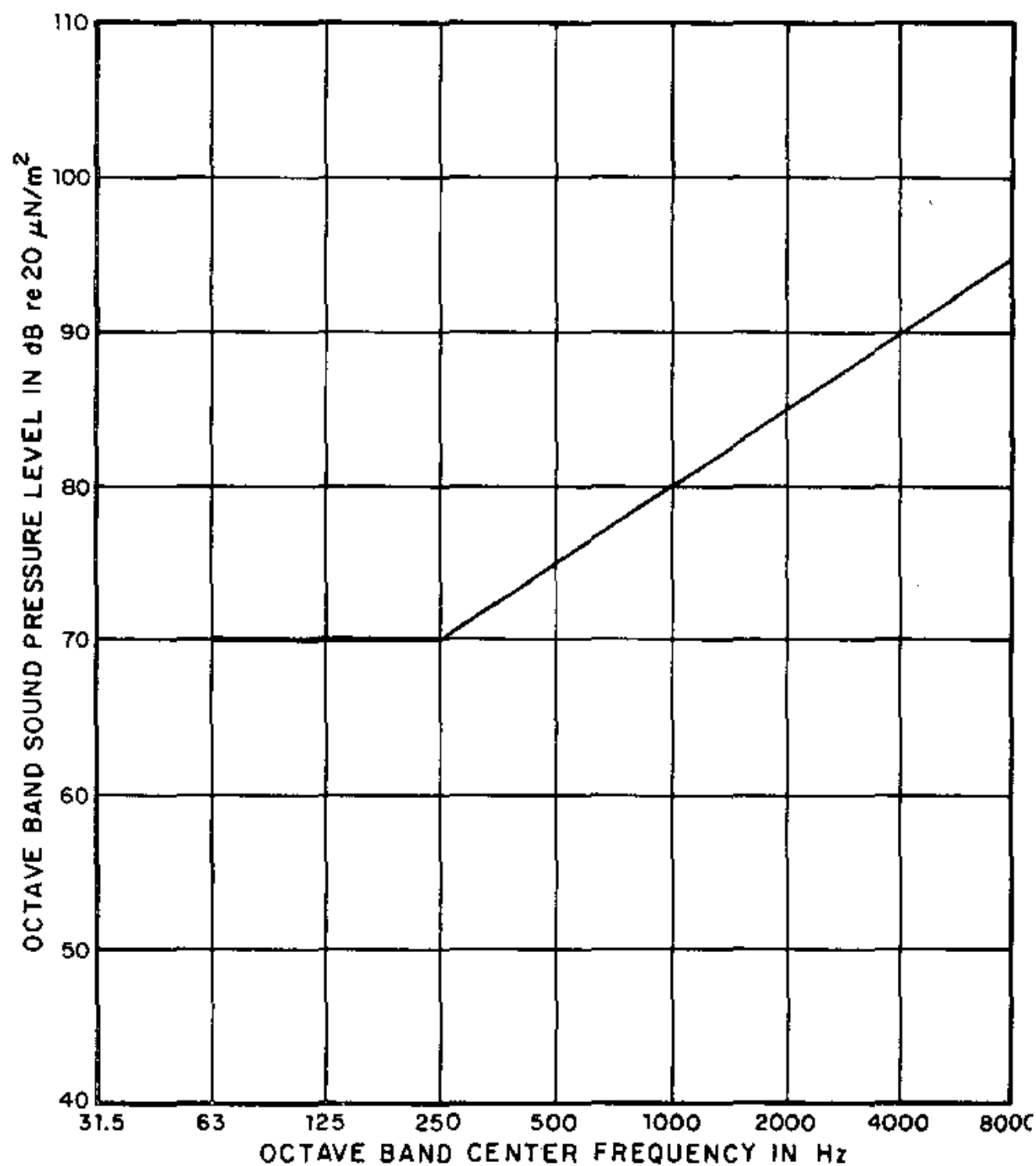


FIG. A.44 TYPICAL SOUND PRESSURE LEVEL FROM STEAM VALVE
(MEASURED AT 3 FT)

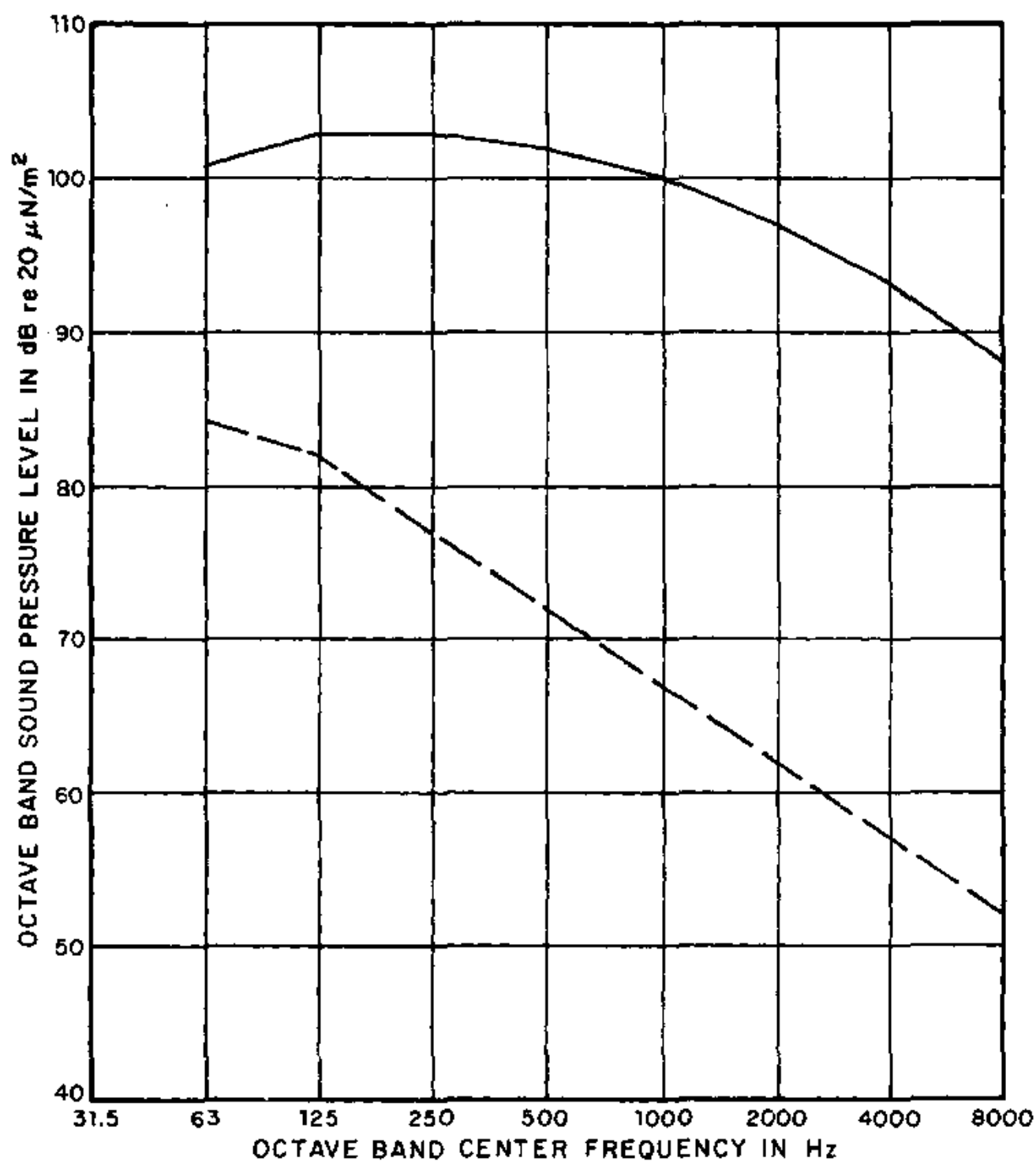


FIG. A.45 RANGE OF SOUND PRESSURE LEVELS FROM FANS
(MEASURED AT 3 FT)

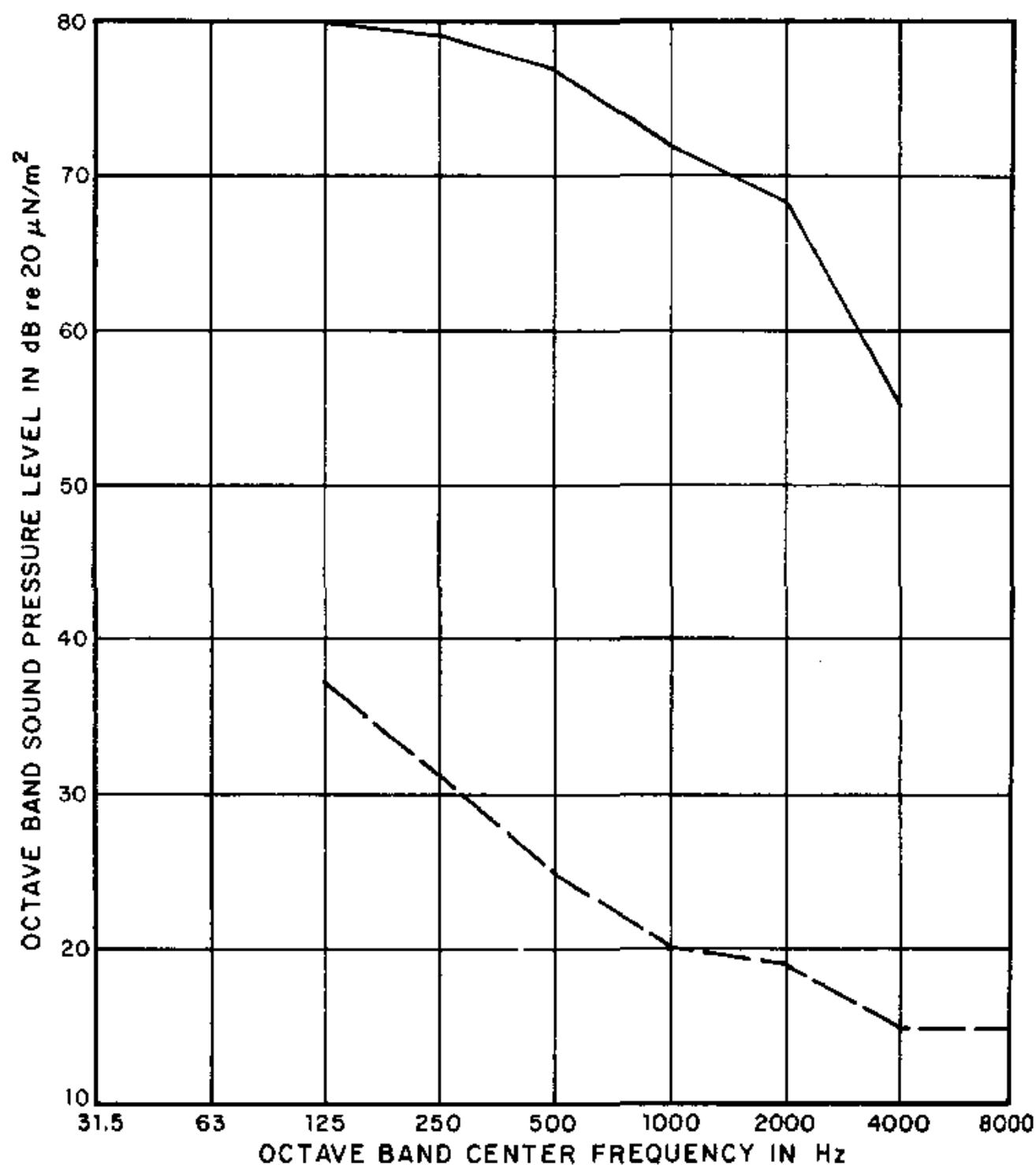


FIG. A.46 RANGE OF SOUND PRESSURE LEVELS FROM AIR CONTROL UNITS AND MIXING BOXES (MEASURED AT 3 FT)

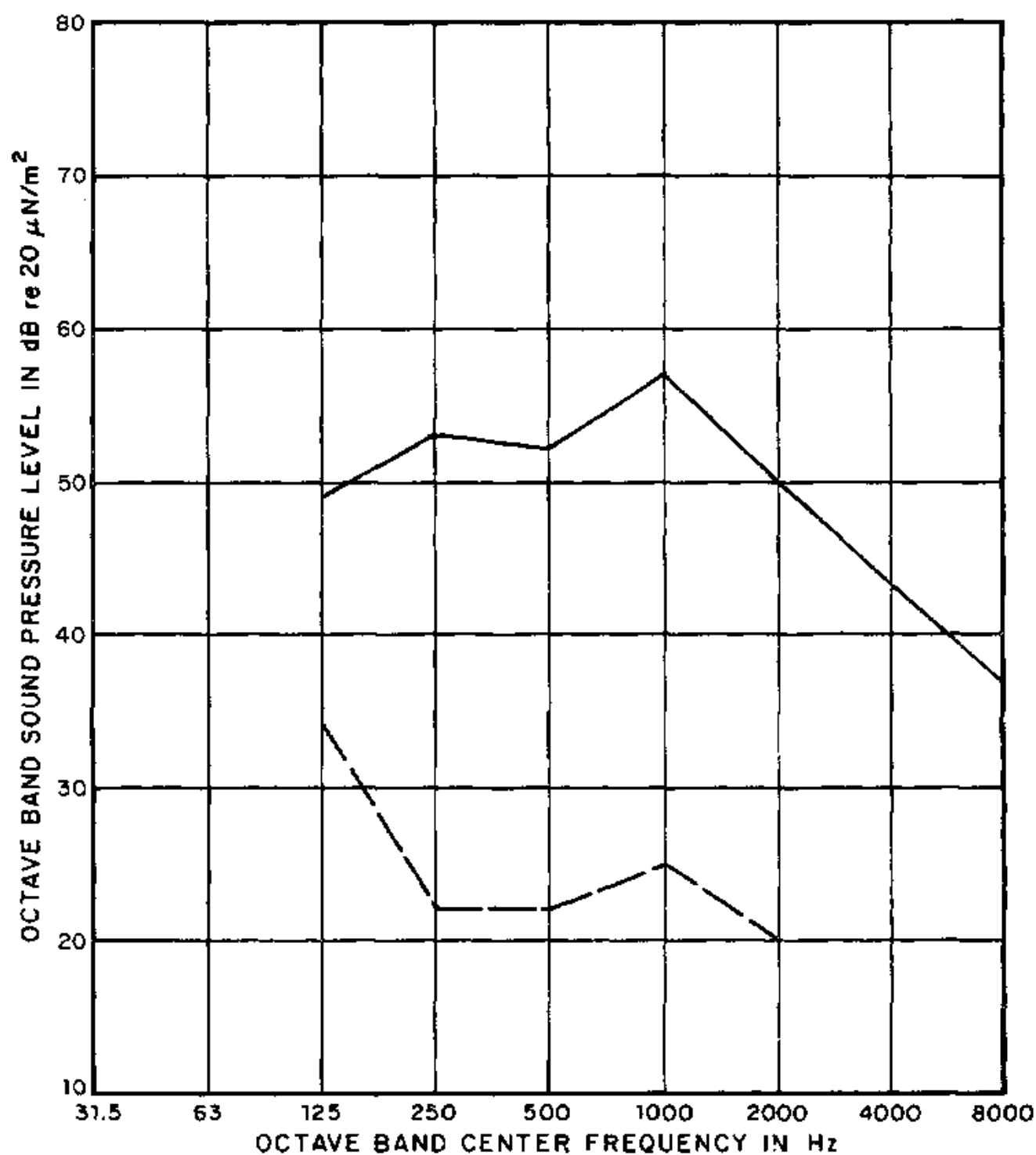


FIG. A.47 RANGE OF SOUND PRESSURE LEVELS FROM DIFFUSERS, GRILLS, REGISTERS, AND LOUVERS (MEASURED AT 3 FT)

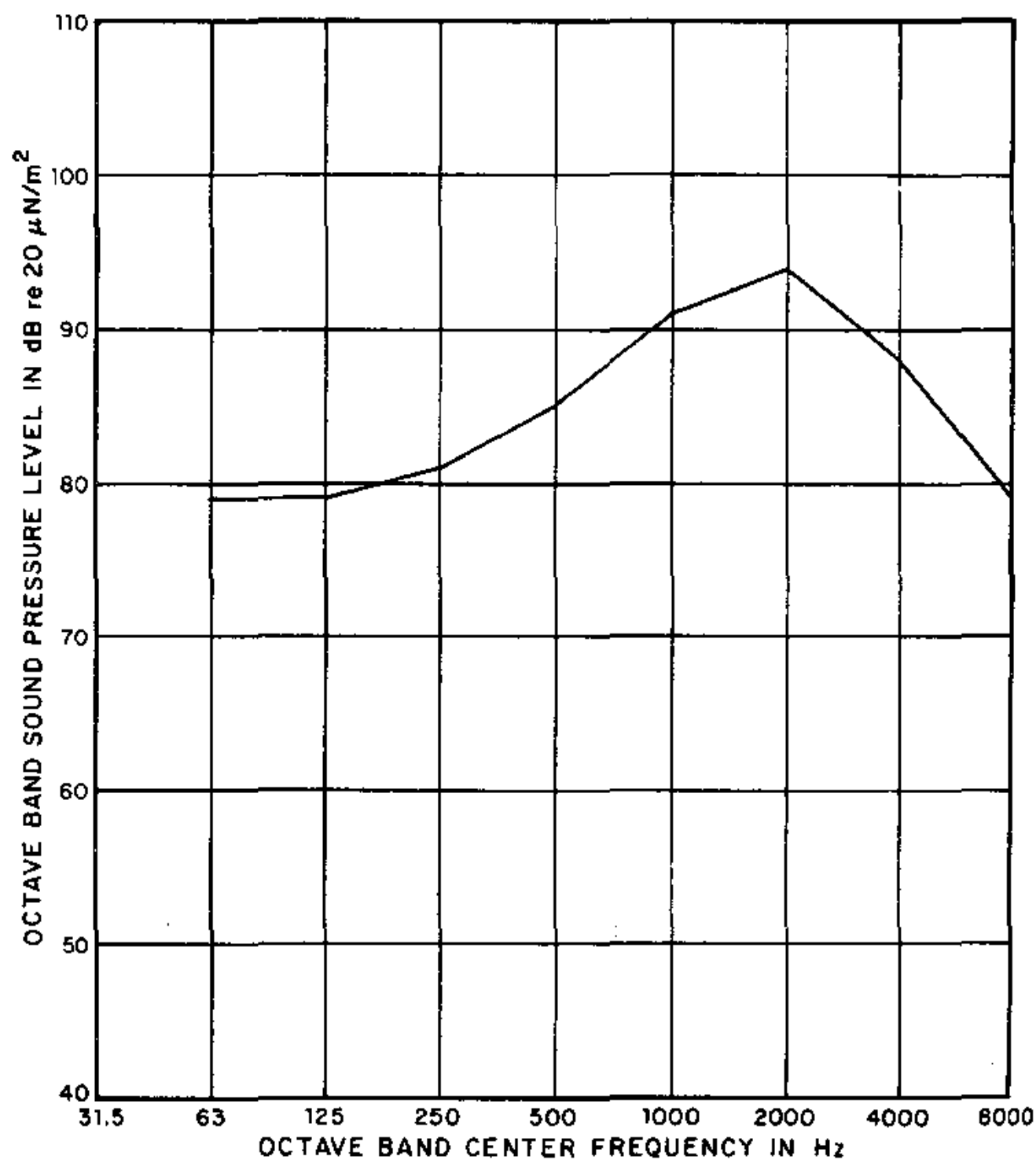


FIG. A.48 TYPICAL SOUND PRESSURE LEVELS FROM RECIPROCATING AIR COMPRESSORS (MEASURED AT 3 FT)

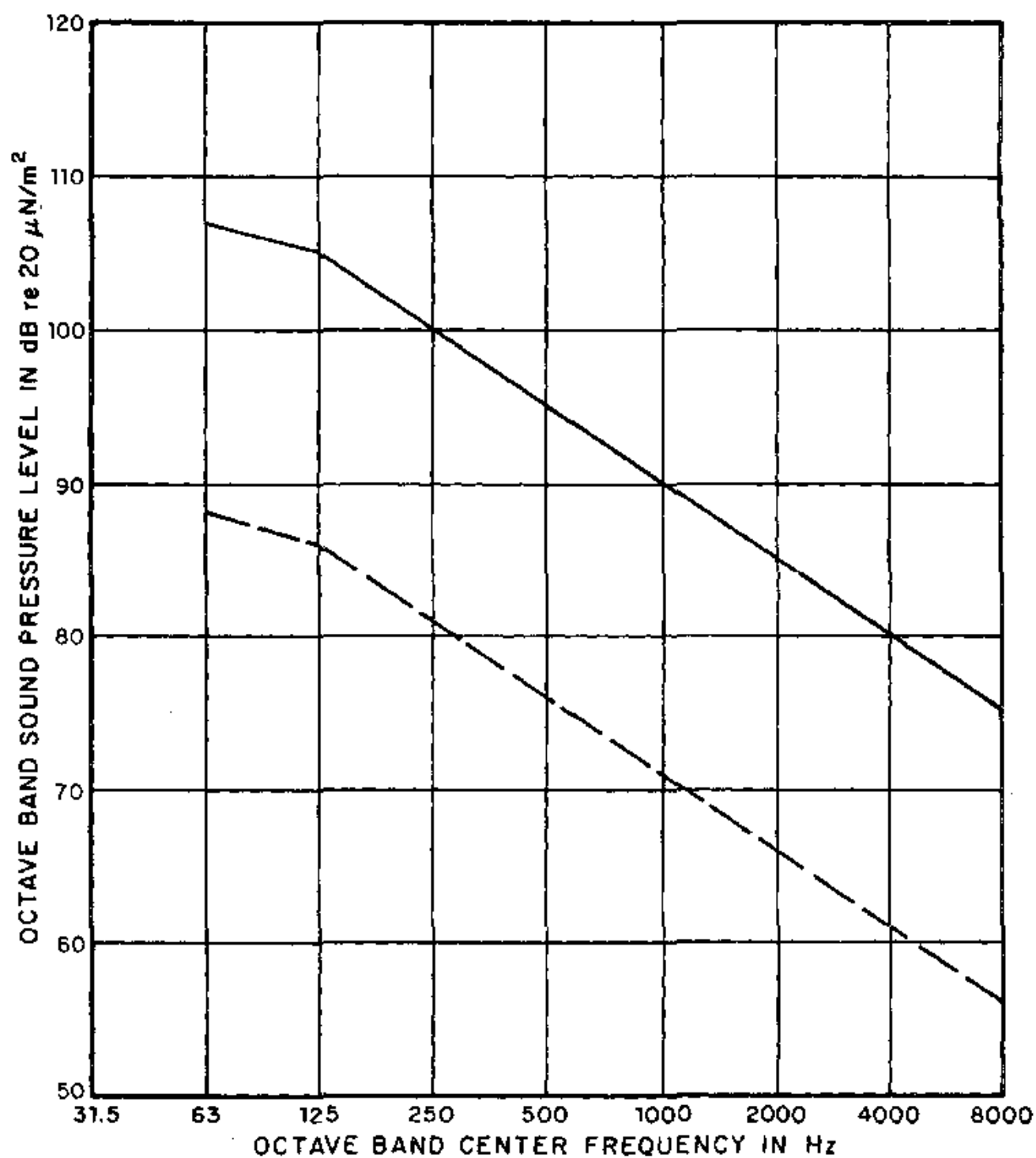


FIG. A.49 RANGE OF SOUND PRESSURE LEVELS FOR CENTRAL STATION AIRCONDITIONING UNITS (MEASURED AT 3 FT)

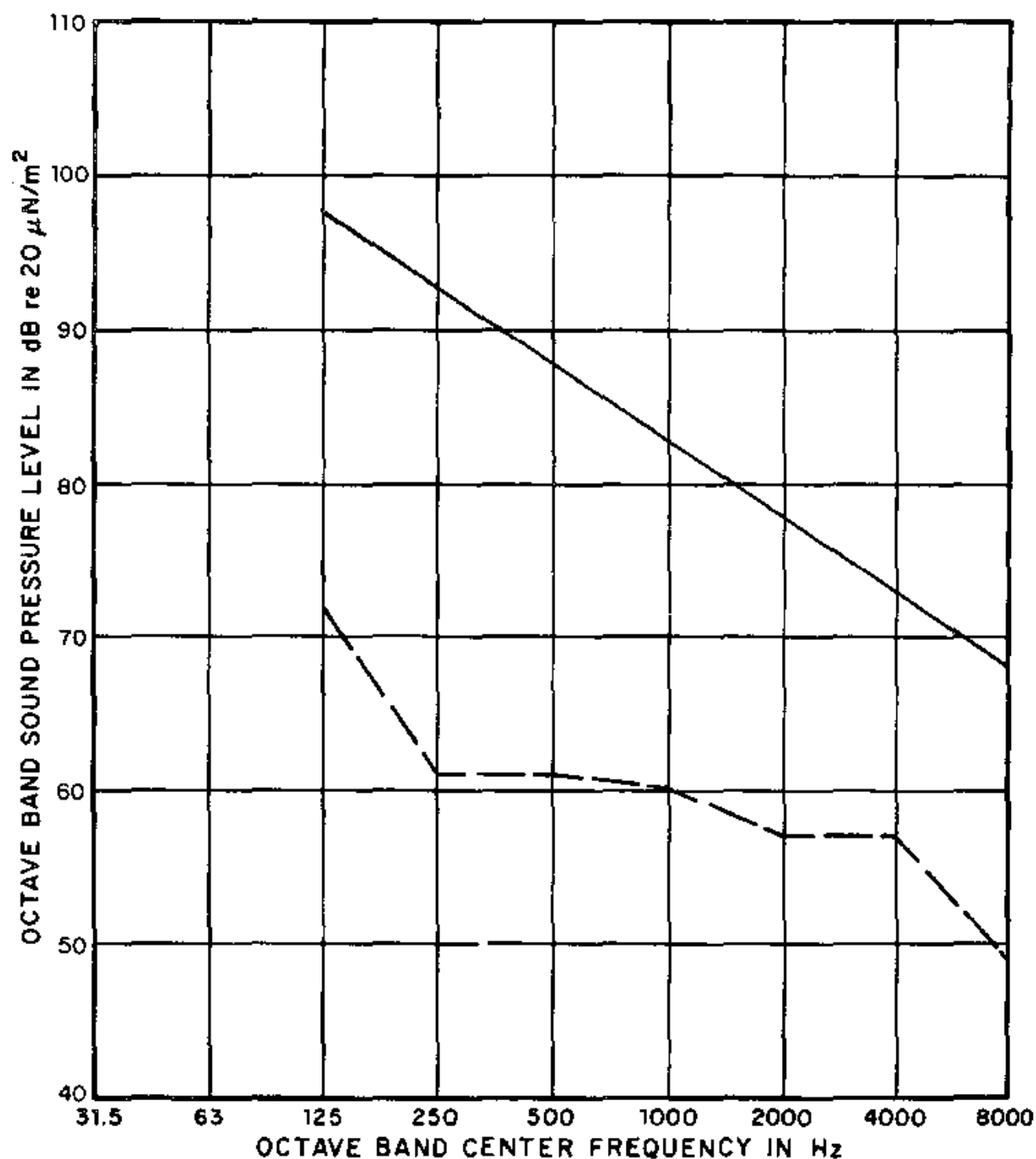


FIG. A.50 SOUND PRESSURE LEVELS FROM UNITARY ROOFTOP AIRCONDITIONING UNITS (MEASURED AT 3 FT)

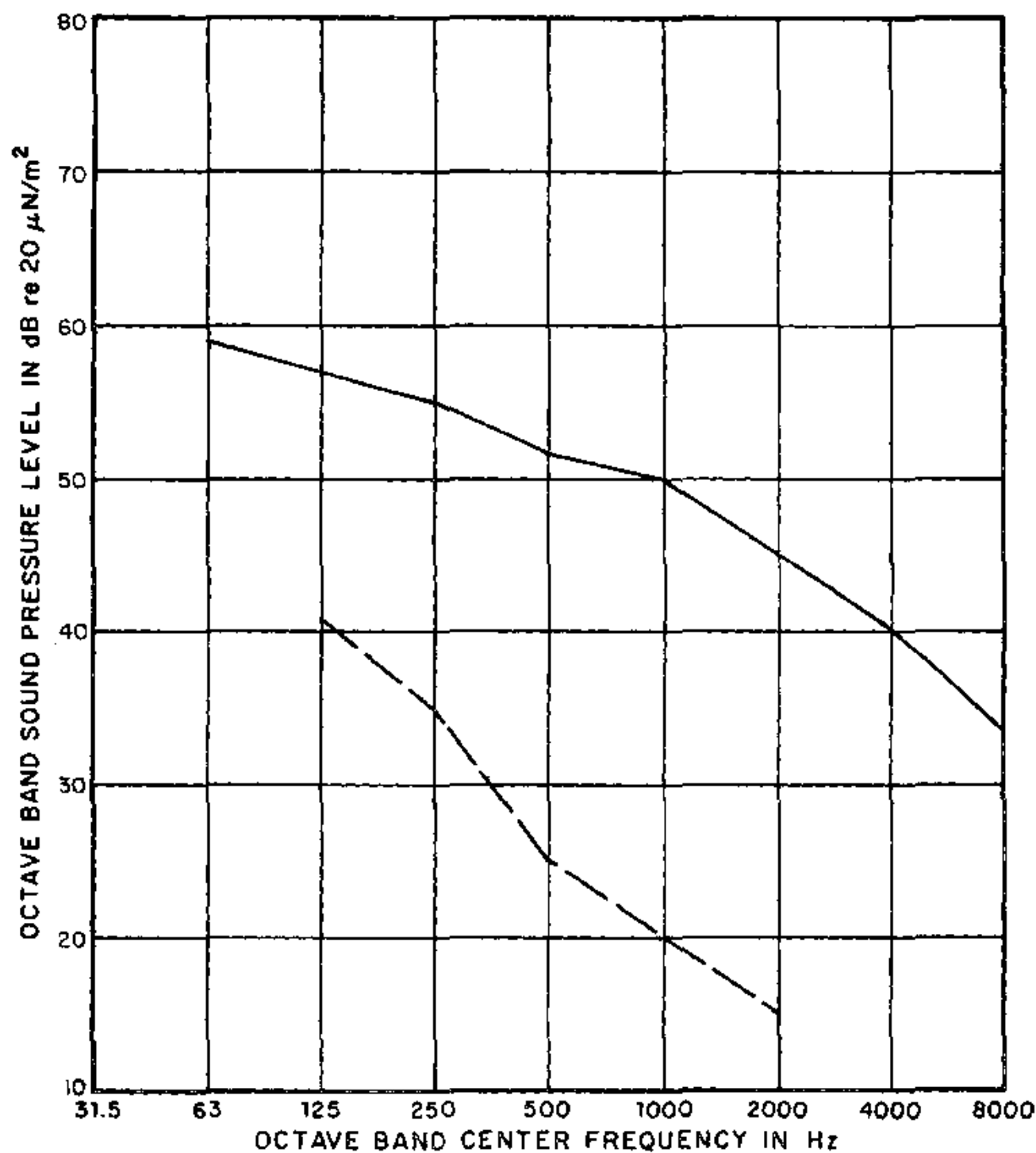


FIG. A.51 RANGE OF SOUND PRESSURE LEVELS FROM FAN COIL UNITS (MEASURED AT 3 FT)

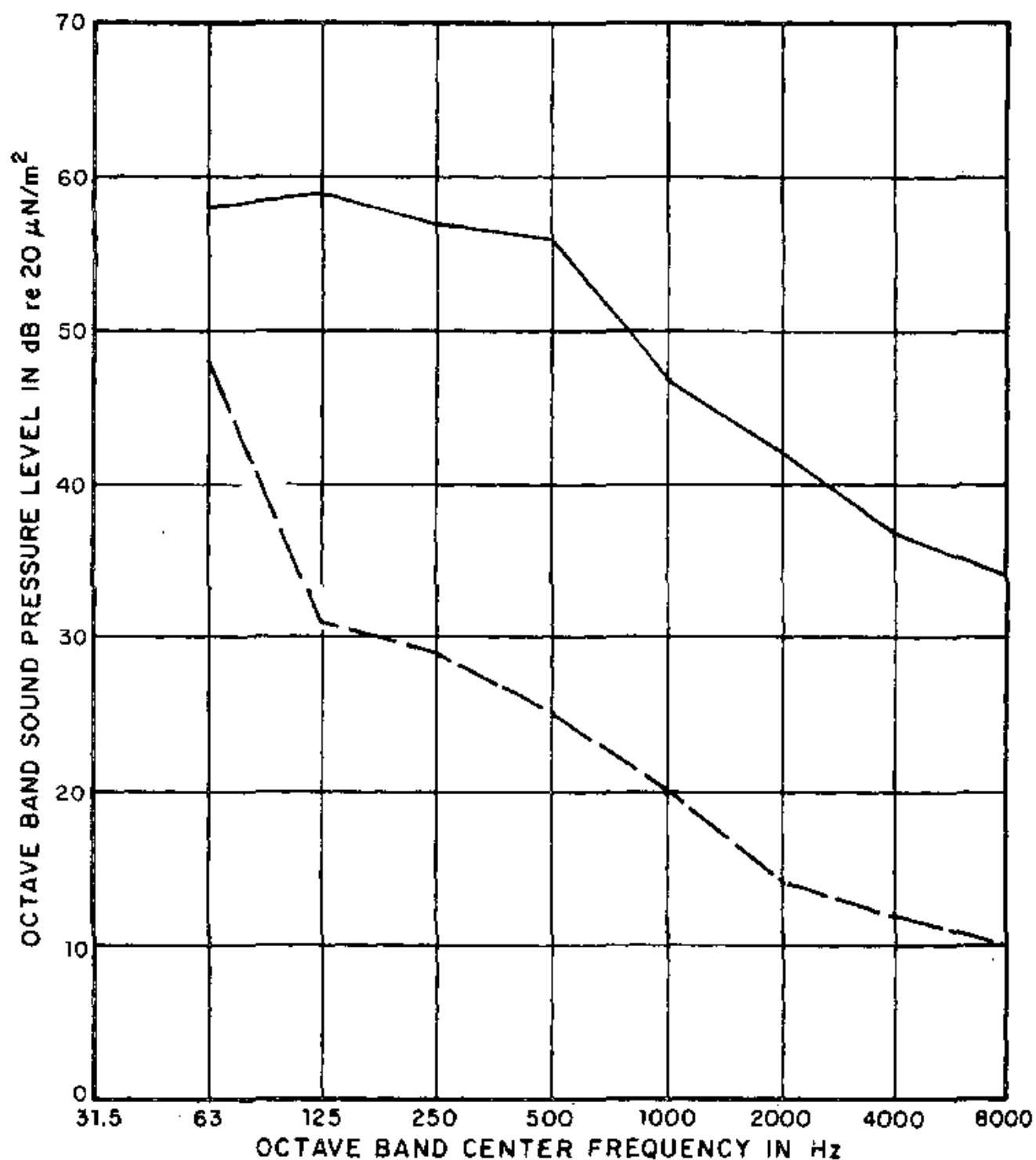


FIG. A.52 RANGE OF SOUND PRESSURE LEVELS FROM INDUCTION UNITS (MEASURED AT 3 FT)

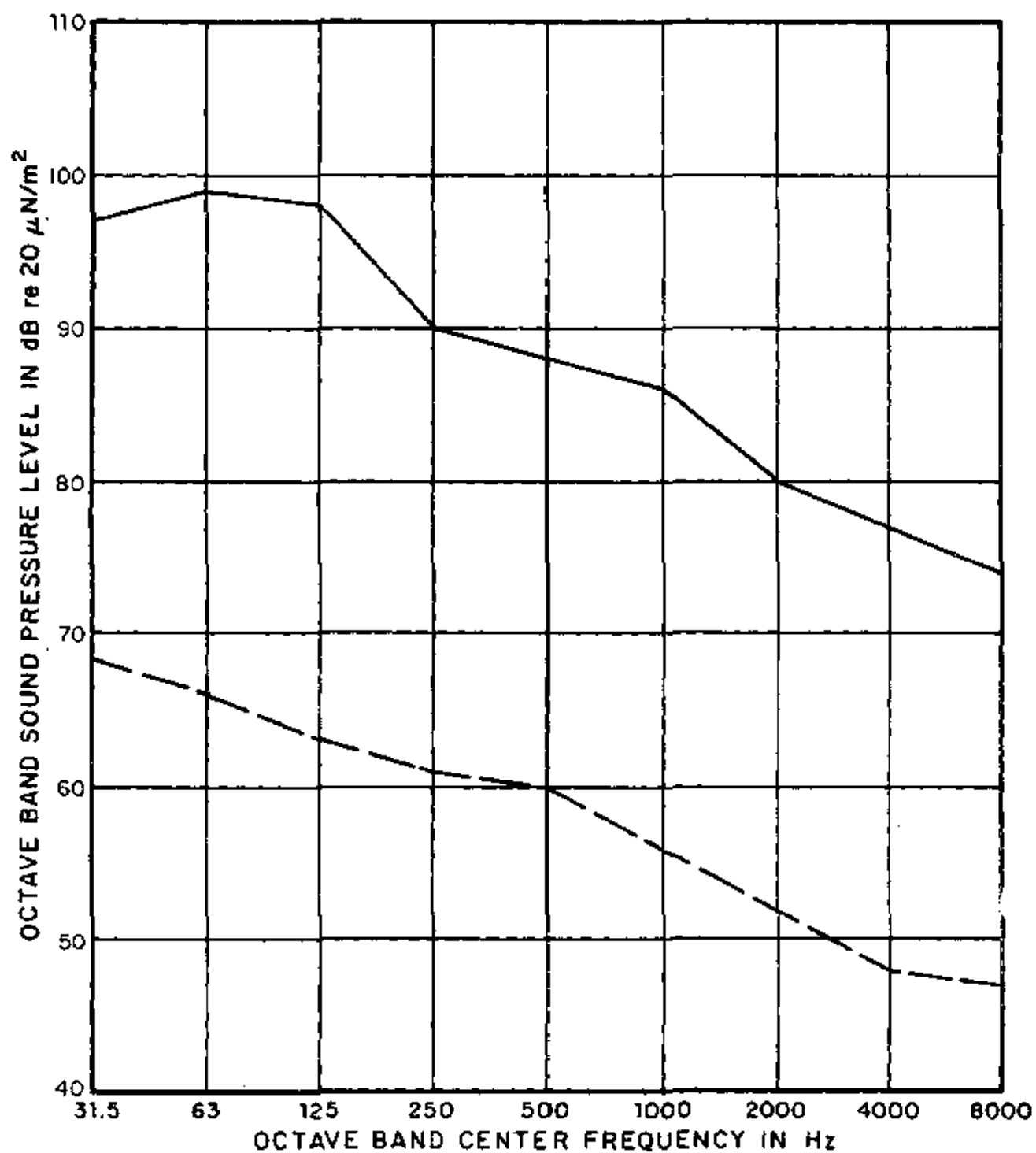


FIG. A.53 RANGE OF SOUND PRESSURE LEVELS FROM BOILERS
(MEASURED AT 3 FT)

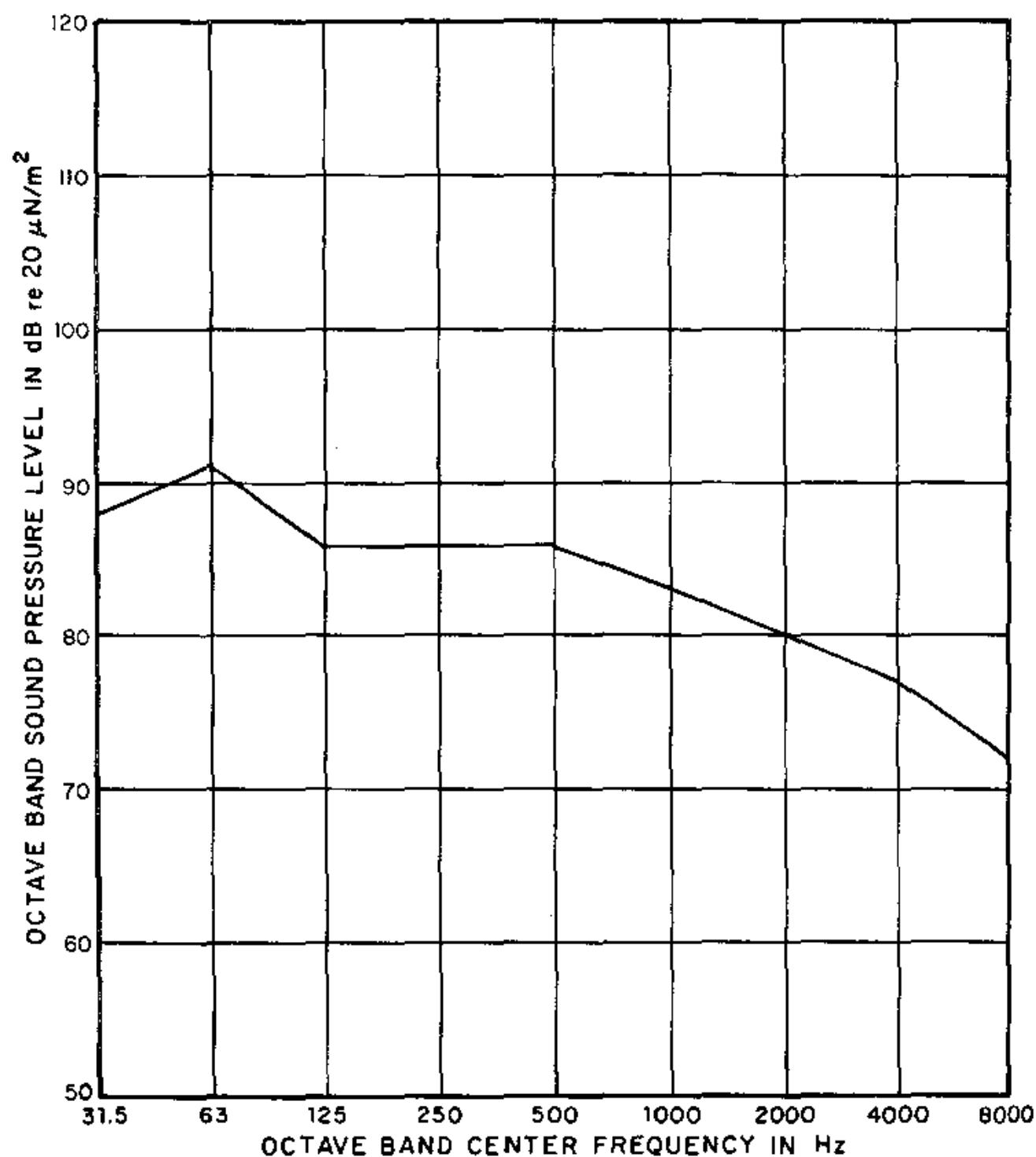


FIG. A.54 TYPICAL SOUND PRESSURE LEVELS FROM
ABSORPTION/CYCLE REFRIGERATION MACHINES
(MEASURED AT 3 FT)

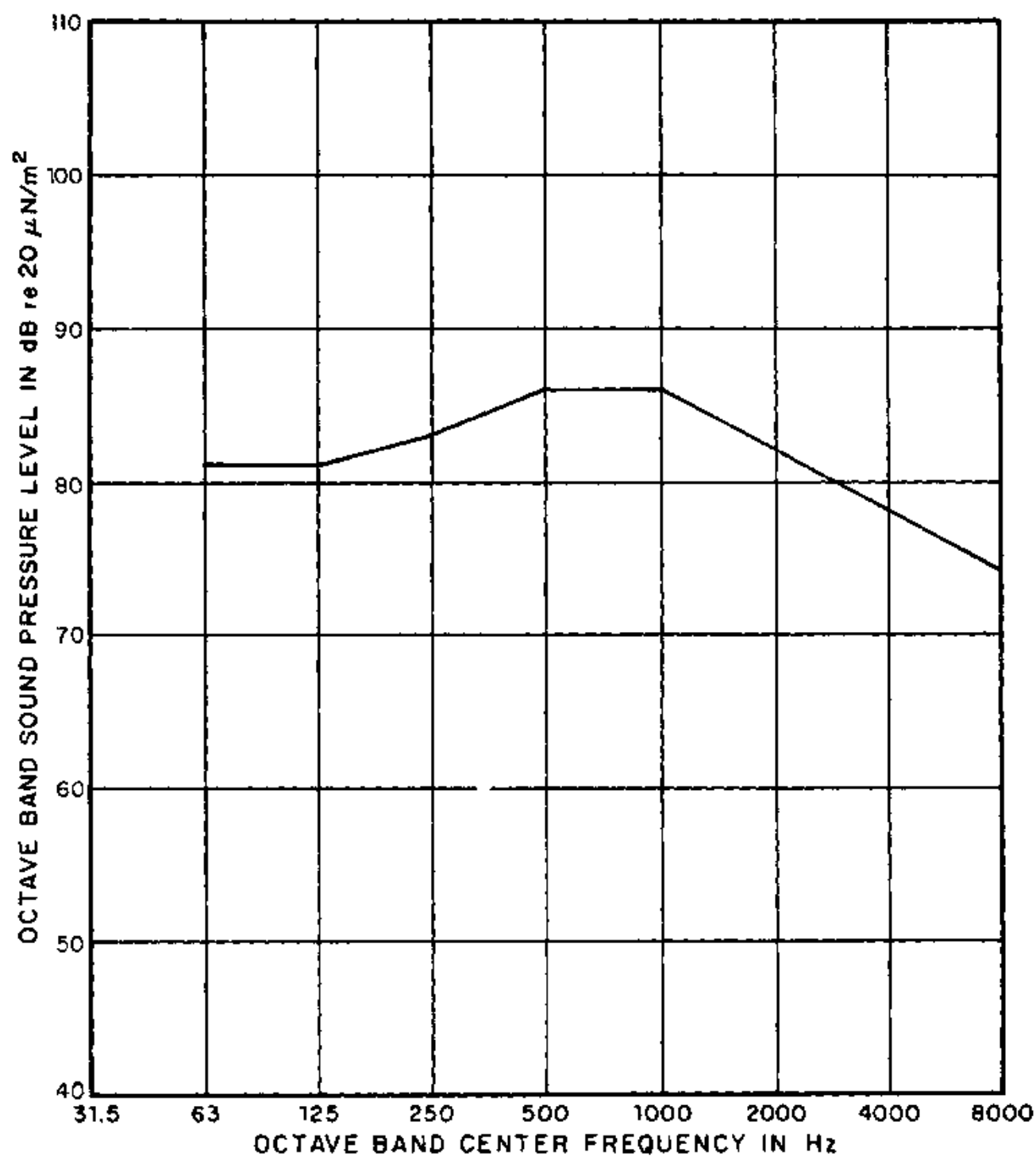


FIG. A.55 TYPICAL SOUND PRESSURE LEVELS FROM CHILLER WITH RECIPROCATING COMPRESSOR (MEASURED AT 3 FT)

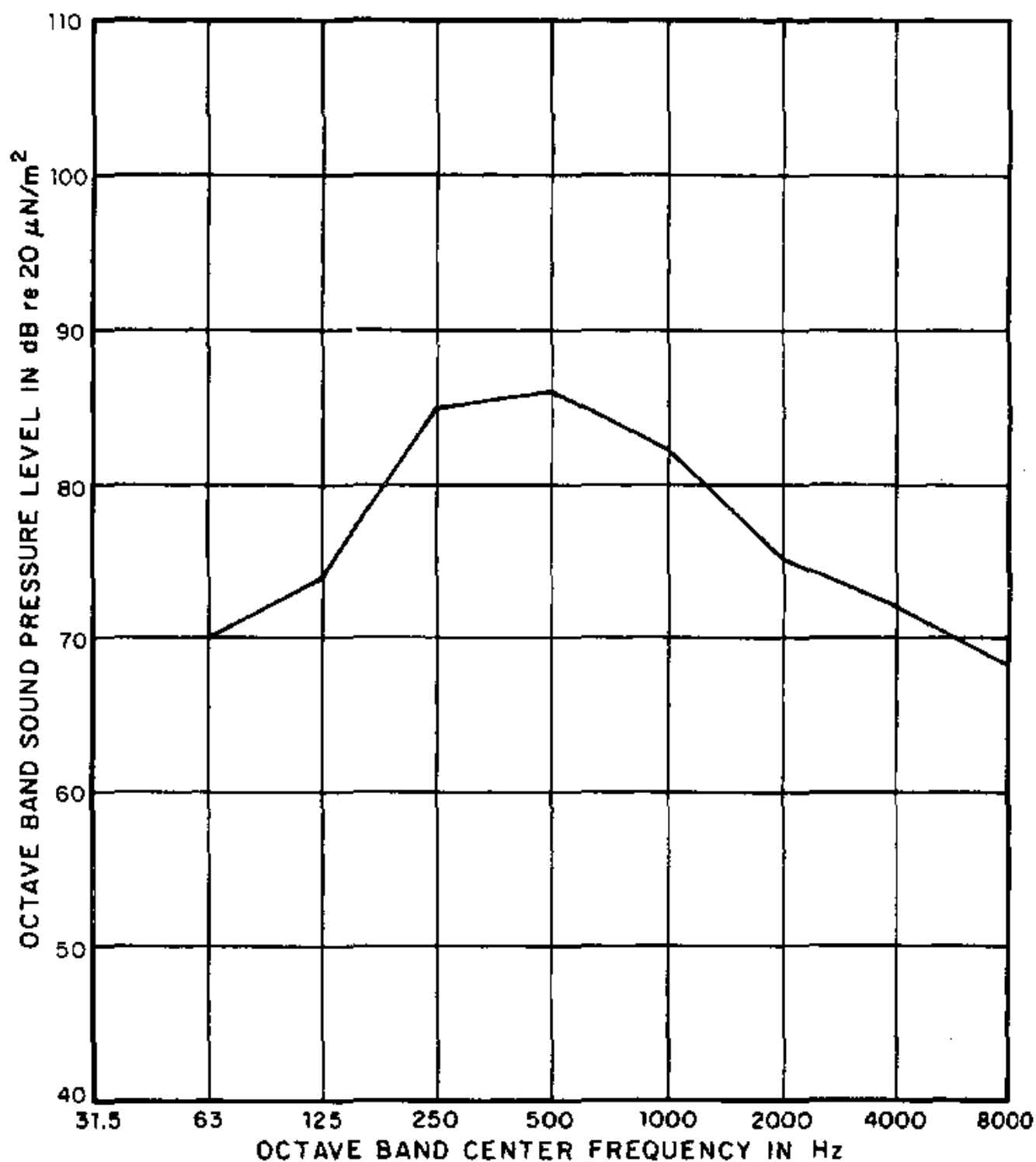


FIG. A.56 TYPICAL SOUND PRESSURE LEVELS FROM CHILLER WITH ROTARY-SCREW COMPRESSOR (MEASURED AT 3 FT)

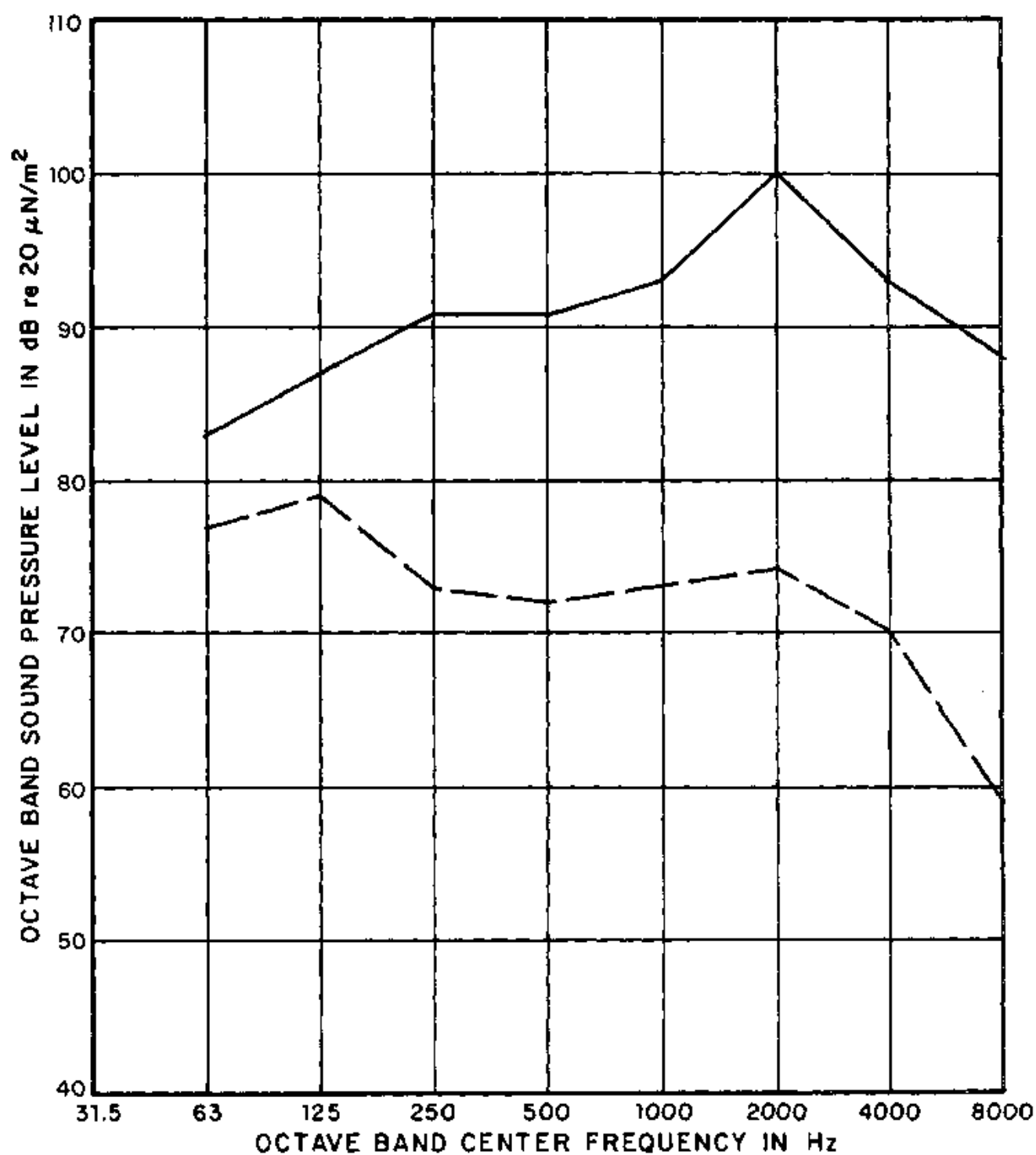


FIG. A.57 RANGE OF SOUND PRESSURE LEVELS FROM CHILLER WITH CENTRIFUGAL COMPRESSOR (MEASURED AT 3 FT)

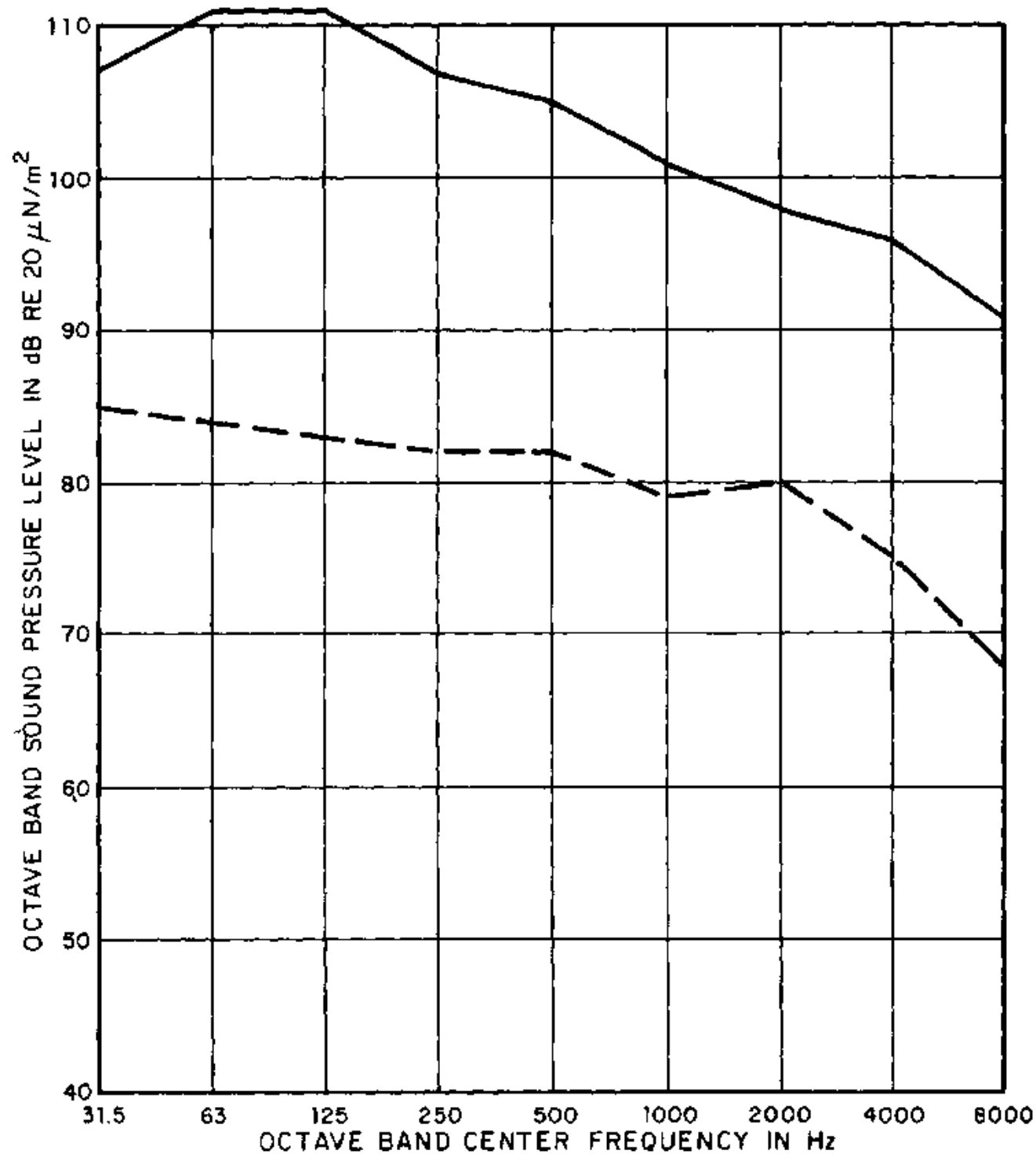


FIG. A.58 RANGE OF SOUND PRESSURE LEVELS FROM COOLING TOWERS (MEASURED AT 3 FT)

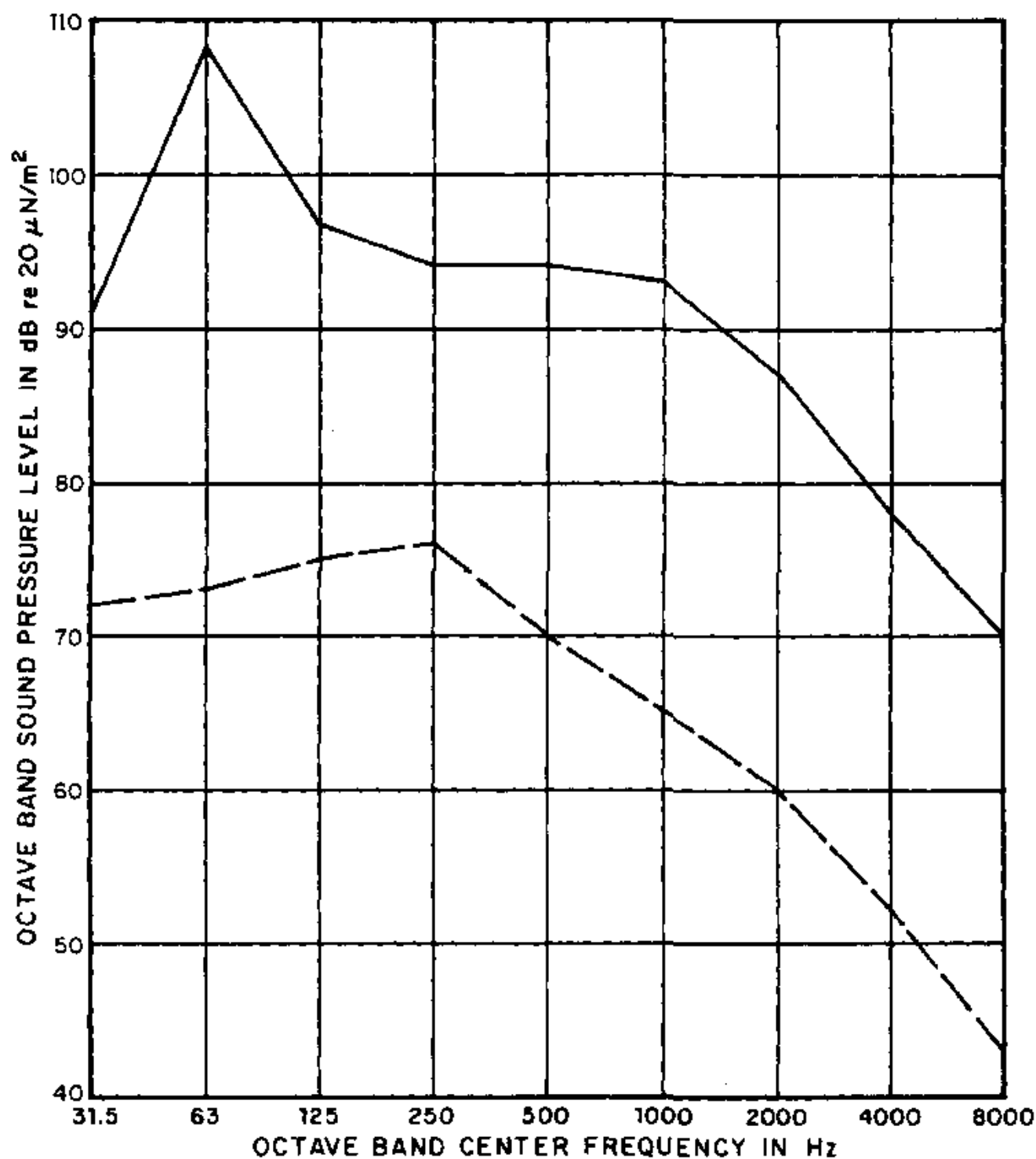


FIG. A.59 RANGE OF SOUND PRESSURE LEVELS FROM AIR-COOLED CONDENSERS (MEASURED AT 3 FT)

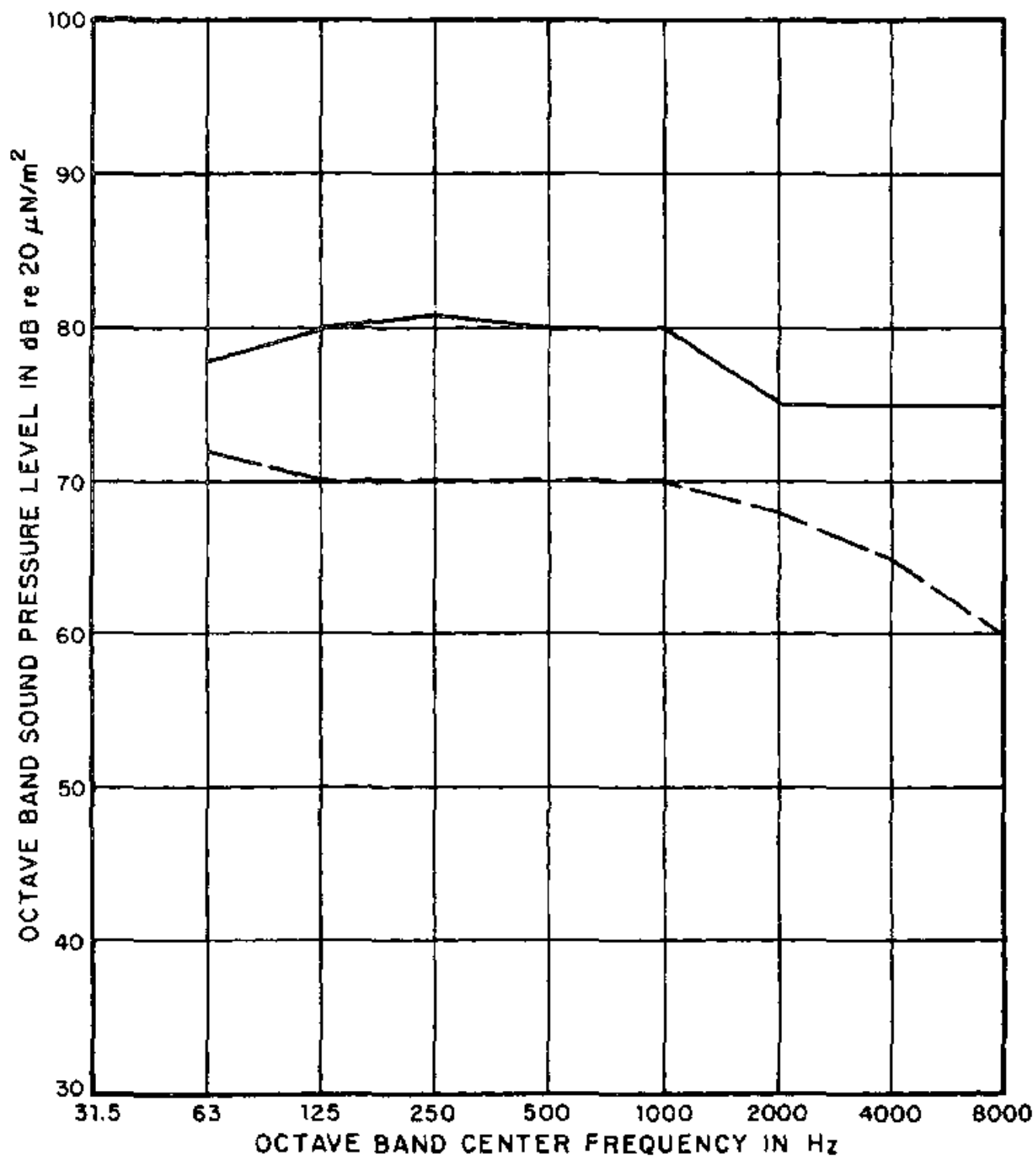


FIG. A-60 RANGE OF SOUND PRESSURE LEVELS FROM ELEVATOR ROOM (MEASURED AT 3 FT)

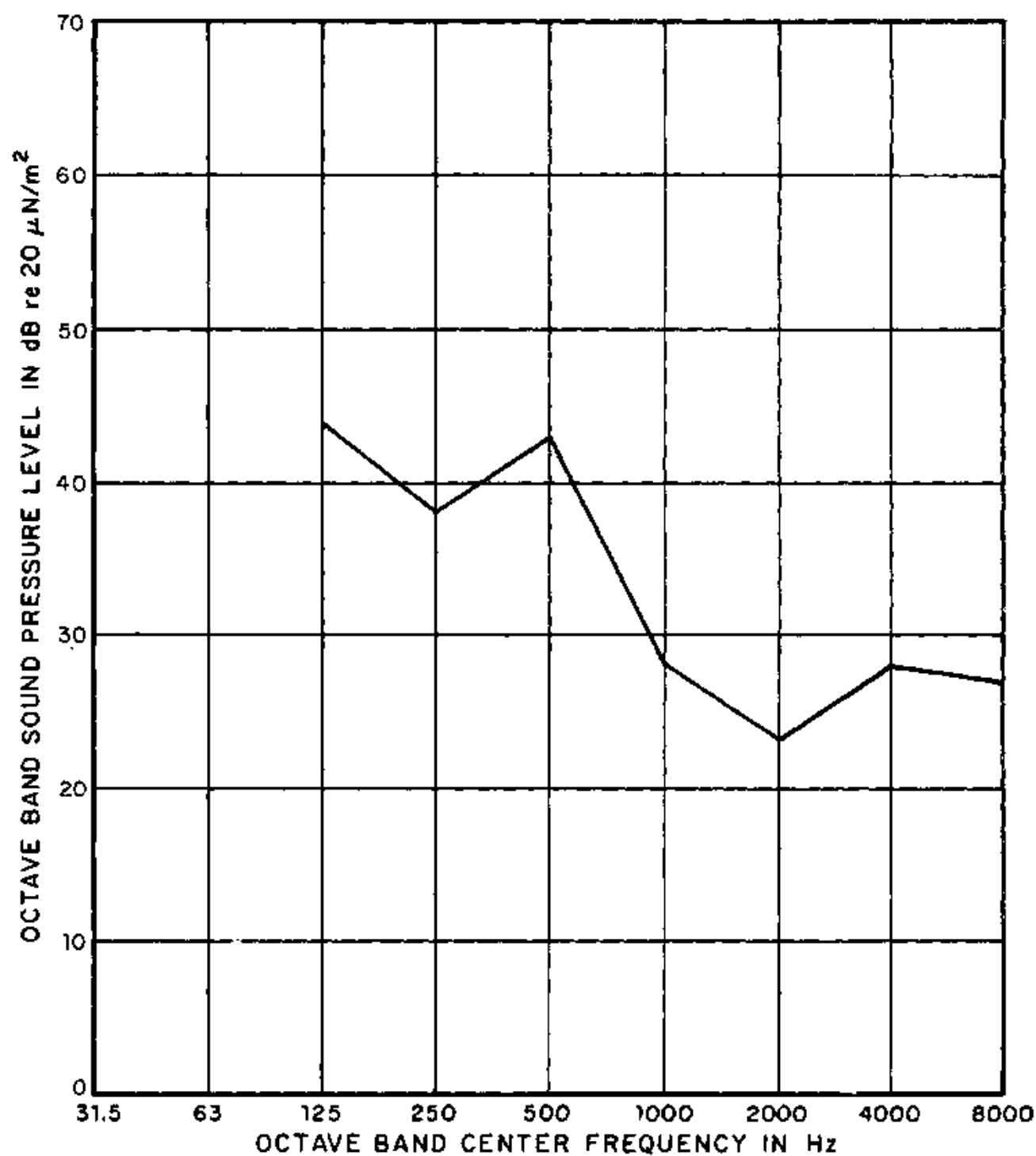


FIG. A.61 SOUND PRESSURE LEVELS FROM BALLASTS
(MEASURED AT 3 FT)

APPENDIX B - IMPACT CONSIDERATIONS

B.1 Interpretation of Impact Estimates

Sections 3.2.2 and 3.3.2 of this report have provided detailed breakdowns of the impact on people of exposure to a variety of noise sources. This section of the report is intended to permit the reader to gain an appreciation for the significance of these estimates. It therefore consists primarily of caveats.

First, it must be stressed that both the physical levels of the noise sources and the levels at which effects on people are specified are, at best, imperfect estimates. Every attempt has been made to obtain unbiased and statistically sufficient estimates. Nonetheless, the actual levels mentioned in the text cannot be regarded as exact. Variability is inherent not only in the measurement process, but also in the noise sources, the propagation paths by which their sounds are transmitted to people, and of course in the responses of people. Thus, individual instances of extreme sensitivity to noise effects are to be expected, as are cases of excessively noisy and quiet sources. In some situations the total amount of variability may be so great as to transform assessment of noise impact, *a priori*, into an imponderable issue. It is important to acknowledge that the impact estimation of Sections 3.2.2 and 3.3.2 can pertain only to the general, rather than the specific, instance.

It must also be understood that research on the effects of noise on people has been conducted for the most part under controlled and simplified conditions. The application of knowledge gained from such experimentation to heterogeneous populations living in complex environments necessarily entails

. fair amount of interpretation and approximation. Disagreement among experts on matters of detail is probably unavoidable.

Yet another important consideration to bear in mind when reading the sections on the impact of home appliance, building equipment, and construction noise on people is that these noises comprise only a fraction of most people's daily noise exposure. Since many noise effects are cumulative in nature, discussion of the impact of exposure to restricted classes of noise is both artificial and potentially misleading. It is not safe to assume, for example, that hearing damage is not a substantial risk to the public at large merely because the risk from construction noise exposure is negligible.

In short, it has been necessary to make a large number of assumptions in preparing most sections of this report. Assumptions are the coin with which conclusions are purchased. The reader must understand the assumptions before he can decide for himself whether the conclusions are worth the price.

The final caution is perhaps the most basic. Stated simply, it is that no attempt has been made in this report to address the crucial issues of social desirability and costs of noise impacts. Such issues were purposely avoided as inappropriate and far beyond the scope of the current report. Value judgments about how much noise exposure is tolerable must inevitably be made, however, if this report is to be fully useful. Administrative or legislative bodies must eventually decide how much hearing loss workers must suffer to maintain industrial productivity; how much annoyance, stress, and task interference the public must endure; how much sleep interference is too much; and so forth. The authors hope that this report will provide the data and conclusions essential for intelligent actions on these issues.

B.2 Discussion of Construction Data

Table B-1 tabulates nonresidential building construction in 1970 by the nature of metropolitan region in which eleven major categories of buildings were constructed. Construction effort in each building category is characterized both by the number of sites and the total construction cost in each region. The average cost of each type of building in each region is also presented in Table B-1. The cost estimates are necessary for accurate estimation of the number of machine-hours of equipment operation at each site. The wide variability of building costs deserves special note. Office buildings in large, high-density central cities cost an average of \$1.9 million while the same type of building costs an average of only \$.67 million in low-density central cities.

The sources of the data in Table B-1 include the following:

- Columns 1 and 2: Unpublished tabulation by U.S. Bureau of the Census of all nonresidential building permits for 1970;
- Columns 3, 4, 5 and 6: Estimates based on population ratios, construction level ratios (where known), and assumptions about probable unit costs; and
- Column 7: *Construction Review*, except for lines 2, 5, and 7, which were estimated on the basis of known ratios of large city to national construction ratios.

Two categories of nonresidential building are recognized by the Bureau of the Census but are not discussed in this report. One is "residential garages and carports", of which 150,885 were authorized in 1970, at an average cost of \$1600. Carport construction was judged to contribute negligibly to construction noise problems. The second category of buildings recognized by

TABLE B-1. GEOGRAPHIC DISTRIBUTION OF MAJOR NONRESIDENTIAL CONSTRUCTION
BY TYPE OF BUILDING (1970)

| Type of Building | Large High-Density
Central Cities | | | Large Low-Density
Central Cities | | | Other Cen-
tral Cities
(Est.) | |
|-------------------------------|--------------------------------------|--------|-----------|-------------------------------------|--------|-----------|-------------------------------------|--------|
| | Bldg. | Cost | Avg. Cost | Bldg. | Cost | Avg. Cost | Bldg. | Cost |
| Office, Bank,
Professional | 235 | \$438M | \$1863K | 815 | \$559M | \$ 686K | 1998 | \$378M |
| Hotel, Motel, etc. | 27 | 108 | 4015 | 56 | 76 | 1335 | 137 | 127 |
| Hospitals and
Institutions | 123 | 326 | 2647 | 120 | 103 | 861 | 294 | 233 |
| Schools | 67 | 73 | 1091 | 149 | 40 | 267 | 366 | 106 |
| Public Works Bldg. | 58 | 48 | 822 | 107 | 64 | 601 | 262 | 75 |
| Industrial | 362 | 92 | 253 | 800 | 93 | 116 | 1961 | 306 |
| Parking Garage | 82 | 33 | 398 | 114 | 49 | 429 | 279 | 48 |
| Religious | 81 | 21 | 255 | 160 | 24 | 149 | 392 | 40 |
| Recreational | 43 | 17 | 402 | 380 | 25 | 66 | 932 | 65 |
| Store, Mercantile
Bldg. | 533 | 84 | 159 | 1649 | 205 | 124 | 4045 | 352 |
| Service, Repair
Station | 341 | 12 | 44 | 553 | 13 | 23 | 1355 | 41 |

| Type of Building | Urban
Fringe
(Est.) | | Nonurbanized
Metropolitan
Area
(Est.) | | Outside
Metro-
politan
Area
(Est.) | | National
Total | |
|-------------------------------|---------------------------|--------|--|--------|--|--------|-------------------|---------|
| | Bldg. | Cost | Bldg. | Cost | Bldg. | Cost | Bldg. | Cost |
| Office, Bank,
Professional | 3168 | \$600M | 1424 | \$270M | 2260 | \$456M | 9900 | \$2701M |
| Hotel, Motel, etc. | 344 | 320 | 154 | 143 | 207 | 157 | 929 | 931 |
| Hospitals and
Institutions | 5590 | 468 | 265 | 210 | 411 | 272 | 1803 | 1611 |
| Schools | 687 | 197 | 309 | 88 | 465 | 102 | 2043 | 606 |
| Public Works Bldg. | 689 | 196 | 310 | 88 | 421 | 95 | 1847 | 566 |
| Industrial | 6370 | 989 | 2867 | 446 | 3706 | 391 | 16336 | 2316 |
| Parking Garage | 841 | 146 | 379 | 66 | 500 | 72 | 2195 | 414 |
| Religious | 1826 | 185 | 823 | 83 | 970 | 71 | 4252 | 423 |
| Recreational | 1395 | 99 | 628 | 44 | 998 | 51 | 4376 | 301 |
| Store, Mercantile
Bldg. | 11425 | 998 | 5148 | 449 | 7258 | 424 | 29058 | 2512 |
| Service, Repair
Station | 3220 | 97 | 1451 | 43 | 2050 | 42 | 8970 | 247 |

TABLE B-2. GEOGRAPHIC DISTRIBUTION OF RESIDENTIAL BUILDING
CONSTRUCTION BY TYPE OF BUILDING (1970)

| <u>Type of Building</u> | Large High-Density
Central Cities* | | | Large Low-Density
Central Cities | | |
|-------------------------|---------------------------------------|----------------------------------|---------------------------------|-------------------------------------|----------------------------------|---------------------------------|
| | <u>Bldg.</u> | <u>Total
Const.
Cost</u> | <u>Avg.
Const.
Cost</u> | <u>Bldg.</u> | <u>Total
Const.
Cost</u> | <u>Avg.
Const.
Cost</u> |
| Single-Unit | 5742 | \$ 86M | \$ 15.1K | 17213 | \$ 330M | \$ 19.2K |
| Two-Unit | 2044 | 46 | 22.7 | 1076 | 32 | 29.8 |
| Three- and Four-Unit | 177 | 9 | 51.2 | 277 | 13 | 46.2 |
| Five-Unit and Larger | 745 | 532 | 716.0 | 3012 | 802 | 266.0 |

| <u>Type of Building</u> | Other
Central Cities | | | Urban Fringe
(Est.) | | |
|-------------------------|-------------------------|----------------------------------|---------------------------------|------------------------|----------------------------------|---------------------------------|
| | <u>Bldg.</u> | <u>Total
Const.
Cost</u> | <u>Avg.
Const.
Cost</u> | <u>Bldg.</u> | <u>Total
Const.
Cost</u> | <u>Avg.
Const.
Cost</u> |
| Single-Unit | 85776 | \$1478M | \$ 17.0K | 241800 | \$4820M | \$ 19.9K |
| Two-Unit | 4776 | 92 | 19.3 | 6190 | 140 | 22.6 |
| Three- and Four-Unit | 3266 | 109 | 33.4 | 3542 | 127 | 35.8 |
| Five-Unit and Larger | 9496 | 1083 | 190.0 | 11470 | 2123 | 185.2 |

| <u>Type of Building</u> | Nonurbanized
Metropolitan Area
(Est.) | | | Outside
Metropolitan Area | | |
|-------------------------|---|----------------------------------|---------------------------------|------------------------------|----------------------------------|---------------------------------|
| | <u>Bldg.</u> | <u>Total
Const.
Cost</u> | <u>Avg.
Const.
Cost</u> | <u>Bldg.</u> | <u>Total
Const.
Cost</u> | <u>Avg.
Const.
Cost</u> |
| Single-Unit | 109018 | \$2171M | \$ 19.9K | 165218 | \$2720M | \$ 16.4K |
| Two-Unit | 2800 | 63 | 22.6 | 5455 | 109 | 20.0 |
| Three- and Four-Unit | 1593 | 57 | 35.8 | 2720 | 90 | 33.1 |
| Five-Unit and Larger | 5166 | 957 | 185.2 | 33.21 | 612 | 184.7 |

| National Total | | |
|-------------------------|--------------|----------------------------------|
| <u>Type of Building</u> | <u>Bldg.</u> | <u>Total
Const.
Cost</u> |
| Single-Unit | 624767 | \$11605 |
| Two-Unit | 22231 | 482 |
| Three- and Four-Unit | 11595 | 404 |
| Five-Unit and Larger | 32465 | 6109 |

*See Sec. 3.2.1.2, Table IX, for definitions of large high-density and large low-density central cities.

the Census but not discussed in the current report is "all other nonresidential buildings", of which 259,814 were authorized at an average cost of \$6,760. The latter category of construction was considered too heterogeneous in nature to permit reasonable estimation of the nature of construction noise at a "typical" site.

Table B-2 presents data on the construction effort involved in erecting residential buildings as a function of the type of metropolitan region in which the construction occurs. The data on Table B-2 were obtained from unpublished Bureau of the Census tabulations and from the Census publication *Construction Reports: Housing Authorized by Building Permits and Public Contracts, 1970*.

B.3 Estimating the Extent of Public Works Construction Noise

The public is exposed to construction noise not only from operations of erecting buildings of various sorts, but also from operations arising from public works construction. Such operations include road, highway, street, and sidewalk construction and maintenance, as well as sewerage, water works, and utilities installation and maintenance. The noise created by these construction activities is frequently prolonged and intense. Even small repair jobs on water works create considerable noise as sections of pavement are ripped up to gain access to buried pipes.

Estimation of the amount of noise created by such activities required that a number of assumptions be made about the distribution of construction noise from public works sites. The most important assumption was that federal and state public works activity could be neglected for the purposes of this study since it occurs primarily in rural regions of low population density. Attention was therefore concentrated on municipal public works activities within SMSAs.

Although summary reports contain ample information on federal and state public works activities, comparable municipal data are available only from individual municipalities. We have been able to obtain fairly complete data on municipal public works construction and maintenance for two large, high-density cities: the central city, Boston, Massachusetts, and the adjacent city of Cambridge. We have used this information, together with the figure of 42,000 miles for municipal street construction throughout the country in 1969, published by the Federal Highway Administration, to estimate total sewerage and water works activity (in terms of miles of pipe and mains laid) for the country.

In carrying out these calculations, we assumed average values of 1.0 miles each of water and of sewer main per mile of new street. We further assumed that on the average, water and sewer main additions per year would be 2% and 1.5% of existing footage, respectively, as opposed to 7.5% for the annual increase in length of municipal street systems. This gave estimated country-wide values of some 11,000 miles of water mains and 8,000 miles of sewage mains. These estimates are considered reasonable in that they are about half as great as would be obtained if the respective annual U.S. expenditure for water works and sewer construction were allocated solely to the installation of mains. Moreover, some mains would be installed concurrently with street construction and, as a consequence, not constitute separate sources of noise pollution.

Inherent in our approach to the estimation of exposure of the population to municipal construction noise is the assumption that the locus of both municipal construction and of population exposed is the street system of a municipality. We have therefore focused on the numbers of inhabitants distributed in permanent residence along the streets of a municipality as an index of the impact of

street-associated municipal construction noise. In order to facilitate the use of this approach, we developed a correlation (see Fig. B-1) between population density and the quantities, miles of street per square mile and inhabitants per mile of street for several dozen cities, towns and counties in Massachusetts and Pennsylvania for which we had data available.

Using the above correlation, together with the amounts of municipal public works construction estimated earlier, we arrived at the impact estimates presented in Table B-3. The indicated exposures of residents along streets where municipal public works construction is taking place are 10 million and 4.4 million individuals, for street and water works and sewer construction, respectively, making a total of 14.4 million individuals exposed to public works construction noise.

B.4 Propagation Loss Model For Building Construction Sites In Metropolitan Areas

Two classes of people are exposed to construction noise: the stationary population which inhabits the region around the construction site (workers and residents) and the transient population which passes by the site (drivers, passengers, and pedestrians.) Two models were constructed to estimate the extent to which site noise is attenuated for each class of observers.

Stationary Population

The entire stationary population around a construction site was assumed to be indoors with closed windows. Acoustic propagation loss was modeled by postulating a representative site geometry and applying the formula

$$H = 20 \log \frac{R}{R_0} + 20 \text{ dB}$$

TABLE B-3. ANNUAL EXPOSURE OF PERSONS IN METROPOLITAN AREAS TO
MUNICIPAL CONSTRUCTION NOISE

LENGTH OF MUNICIPAL CONSTRUCTION (MILES)

| <u>Activity</u> | <u>Large,
High-Density
Central Cities</u> | <u>Large,
Low-Density
Central Cities</u> | <u>All Other
Central Cities</u> | <u>Urban
Fringes</u> | <u>Met. Areas
Outside
Urban
Fringes</u> | <u>Total</u> |
|--|---|--|-------------------------------------|--------------------------|---|---------------|
| Street, highway | 273 | 2,150 | 6,000 | 11,800 | 21,700 | 41,923 |
| Sewerage & Water | <u>125</u> | <u>990</u> | <u>2,700</u> | <u>5,065</u> | <u>9,850</u> | <u>18,730</u> |
| | 398 | 3,140 | 8,700 | 16,865 | 31,550 | 60,653 |
| Population Density
(people/sq. mi.) | 15,160 | 4,410 | 3,710 | 3,380 | 125 | |
| Area (sq. mi.) | 1,468 | 2,389 | 6,981 | 14,707 | 179,276 | |
| Street Distribution
(miles of street/
sq. mi.) | 21 | 10.2 | 9.5 | 8.9 | 1.35 | |
| Linear Distribution
of Population
(people/mile of
street) | 720 | 430 | 390 | 380 | 93 | |

PERSONS EXPOSED TO MUNICIPAL CONSTRUCTION NOISE ($\times 10^{-3}$)

| <u>Activity</u> | <u>Large
High-Density
Central Cities</u> | <u>Large,
Low-Density
Central Cities</u> | <u>All Other
Central Cities</u> | <u>Urban
Fringes</u> | <u>Met. Areas
Outside
Urban
Fringes</u> | <u>Total</u> |
|------------------|--|--|-------------------------------------|--------------------------|---|--------------|
| Street, highway | 196 | 925 | 2,340 | 4,470 | 2,020 | 2,951 |
| Sewerage & Water | <u>90</u> | <u>425</u> | <u>1,050</u> | <u>1,920</u> | <u>920</u> | <u>4,403</u> |
| | 286 | 1,350 | 3,390 | 6,390 | 2,940 | 14,356 |

∴ About 14.5 million people exposed to municipal construction noise.

where H = total propagation loss

R = range from source to observer

R₀ = reference range at which site source level
was measured (50 ft).

Twenty dB was added to account for the loss through building walls with closed windows. The resulting transmission loss contours are shown in Figure 19 of the main text.

Transient Population

People passing by a construction site continuously vary their distance from the site. A model such as the above is not directly applicable. The peak noise level to which passersby are exposed, however, can be computed from the propagation loss at the passerby's closest point of approach (CPA) to the site. This propagation loss is computed from the formula

$$H = 20 \log \frac{R_1}{R_0} + H'$$

where H = total propagation loss

R₁ = range at CPA

R₀ = reference range at which site source level
was measured (50 ft)

H' = is a term included to account for baffling or
obstructions between source and observer

In the case of pedestrians, we assume that R₁ = 100 feet and H' is zero. H is therefore 6 dB. For drivers, we have assumed R₁ = 100 feet and H' = 15 dB to account for attenuation caused by the transmission loss of an automobile. For this case, H = 21 dB, which was rounded to 20 dB to emphasize that the figure is only an estimate.

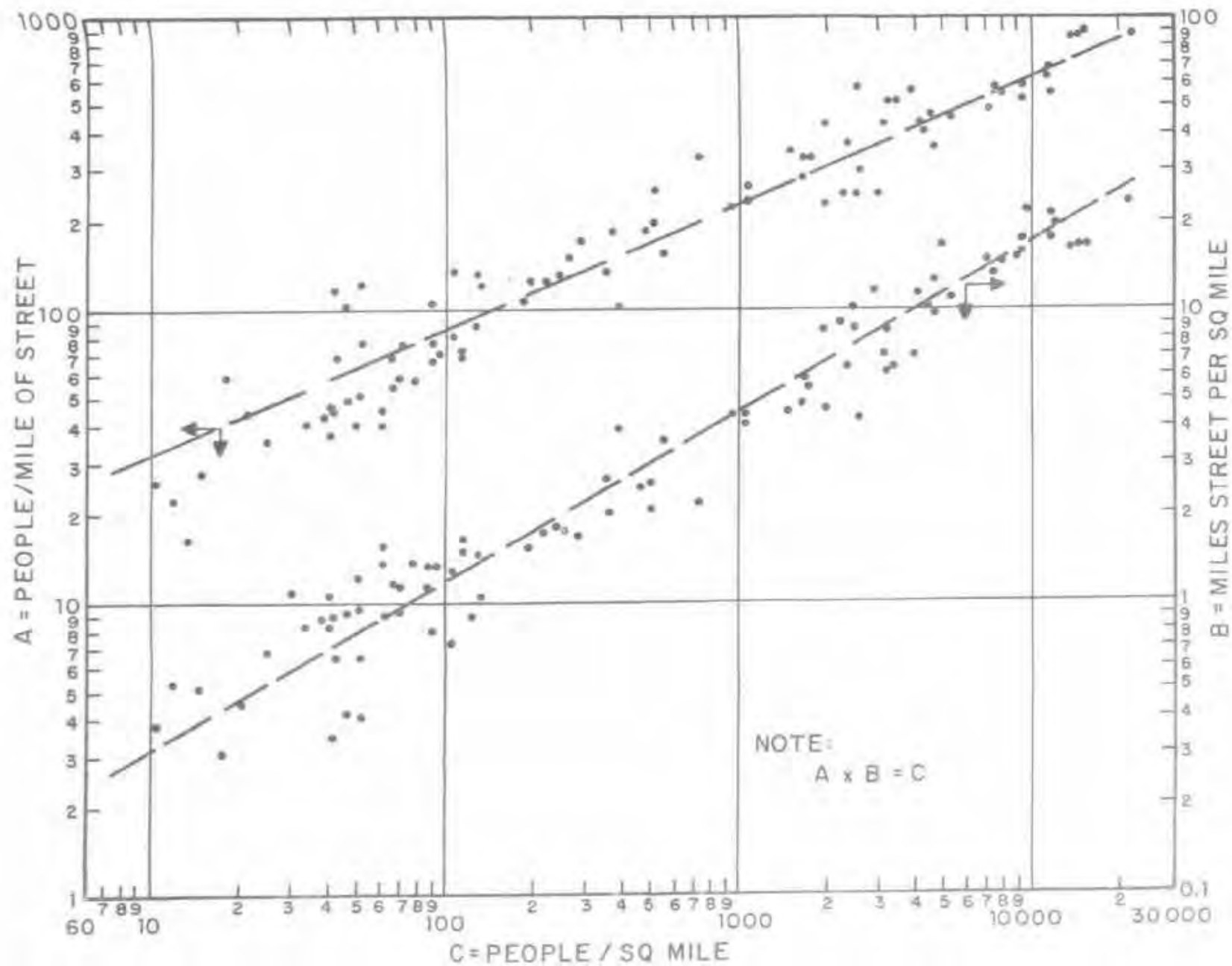


FIG.B-1 LINEAR AND AREA DISTRIBUTION OF POPULATION IN MUNICIPALITIES
(BASED ON MASSACHUSETTS AND PENNSYLVANIA DATA)

APPENDIX C - SOUND LEVEL CONSIDERATIONS
BY AMERICAN CONSTRUCTION MACHINERY MANUFACTURERS

by

H.T. Larmore
Deputy Director for Technical & Safety Services
Construction Industry Manufacturers Association
Milwaukee, Wisconsin

Presented at
The American Industrial Hygiene Association Conference
Toronto, Ontario

May 24, 1971

This presentation will attempt to place the problem of noise into its proper perspective relative to construction and construction machines - both as a potential cause of hearing loss for workers and as an air pollutant for the nearby community at construction sites.

NOISE - THE PROBLEM STATED

Unwanted sound - is not new to the construction industry. Construction sites are noisy. Likewise, it is not new to heavy machines used in the construction of buildings, highways, sewer and water systems, airports and the like. Indeed, it has been a criterion by which some machines have been operated. A skilled operator often relies upon the sound of his equipment for proper operation. Also, noise is often associated with power in the purchase of machines.

These philosophical concepts and the public demand for lower construction costs do not excuse construction machinery from being noisy, but they have contributed to the major emphasis by manufacturers over the past decade to design for greater productivity

rather than to build quieter machines. The transitory and temporary nature of construction has also allowed a lack of concern for noise. While any particular contract is underway, the workers and neighbors might well be annoyed by the noise. But relief comes when the job is completed and the big machines move on. Next job site - there are new workers; new neighbors.

During the past few decades, the public demand has been for more production with less labor and less cost. This prompted the development of today's remarkable machines with more power, automation and speed than ever before. But machine "improvements" to effect this demand generally tended to increase noise levels. Larger engines produced more noise both internally and from the exhaust. More automation was accomplished through more use of hydraulic power which also is a noise generator. Larger engines and more hydraulic power increased the heat which must be dissipated through larger quantities of air being driven by noisier fans through larger radiators. Increased speed means increased vibration frequencies which tend to concentrate in the audible hearing range.

THE CONCERN FOR NOISE

The concern for noise, only recently voiced by the public and expressed now in actual or proposed legislation at all levels of government would seem to have created a major shift from the "productive Sixties" to the "silent Seventies". Fortunately, our industry is geared to respond to our customer requirements and, hopefully, to recognize changing requirements soon enough to accommodate the necessary lead times for research and development, testing, tooling, manufacturing and distribution. Noise abatement, although recognized by manufacturers of construction

machines as a legitimate environmental concern, has been and still is difficult to define in precise engineering and machine requirements - how much - how fast - what costs and trade-offs are acceptable - cost/effectiveness ratios - all tend to remain fuzzy with even man/noise effects far from being accurately determined.

The manufacturers of construction machines, without waiting for all the answers, recognized in the late sixties the need for the basic tools for all change and/or regulation - Measurement Standards. Without such tools, base lines cannot be established or progress measured.

Through the Construction Industry Manufacturers Association (CIMA) - the necessary machinery and policies were established some four years ago to recognize needs for Performance or Safety Standards and to promote development of such Standards by nationally recognized technical and Standards writing bodies. Among these were the basic noise measurement Standards as voluntary guidelines for both industry and government authors. These were accepted for development by the Society of Automotive Engineers (SAE). They include for construction machines:

1. Noise measurement at operator station
2. Noise measurement at 50 foot radius
3. Construction job site noise measurement
4. Cumulative operator noise exposure measurement along with standardized reporting methods

Substantial progress has been made by SAE with completion and publication of some of these Standards expected in the near future.

The measurement of noise levels either at the operator's station or at a distance from the machine is no simple matter. A machine can be subjected to many operational variables. Engine at rated speed, acceleration, full power drawbar load, power take-off load, hydraulic load, idling engine, idling transmission, transport, addition of a cab, roll-over protective structures, windows open - these are some of the variables which affect noise levels. For that reason, a uniform procedure for noise measurement is most important.

There are currently under consideration at least four Federal Bills and twenty State Legislative Bills which can regulate noise on construction machinery. Consequently, there is a real need for uniformity not only in measurement methods but in noise limit levels. It can be appreciated that legislators are concerned with protecting operators and others from hearing damage and the nuisance of excessive noise. However, a mass of legislation and regulations which are nonuniform are more of a liability than an asset in reducing noise levels on construction machines. Nonuniformity with little or no lead time for making the changes is leading to stop-gap measures which have unpredictable durability and effectiveness, and which perhaps introduce unwanted trade-offs and compromises through overheating, fire hazards, maintenance interference and reduced output.

WHAT ARE MANUFACTURERS DOING ABOUT NOISE?

So - what are construction machinery manufacturers doing individually and as an industry?

Individually they are:

1. Evaluating the many noise sources peculiar to each machine.

2. Developing operator enclosures for current products.
3. Developing procedures for customizing current products off the production lines.
4. Developing quieter components and systems for quieter machines in the future.

Through CIMA they are:

1. Seeking new and updated SAE Standards and Recommended Practices for operator and exterior noise levels.
2. Organizing a cooperative effort among government, noise specialists, contractors and machinery manufacturers to accumulate the great masses of actual on-the-job noise data required by industrial hygienists in their evaluation of the man/noise effects in the construction environment.
3. Creating information on construction machine noise for use by regulatory bodies, consumers, and information media.
4. Investigating a means to express machinery noise sources in a uniform, usable and reliable manner.

THE COMPLEX ANSWERS

These individual and collective efforts are not simple nor do results come easily or cheaply. As a beginning, component noise sources are rapidly being isolated and evaluated. Oversimplification of the problem frequently leads many to believe that engine exhaust noises are the culprit and that larger mufflers would turn the trick. To be sure, this is part of the problem. However, noise reduction of the exhaust permits other machine

noises to become dominant. Larger mufflers also create a visibility problem since they usually end up directly in front of or behind the operator.

There are several other noise sources which are the same order of magnitude as exhaust noises, depending on the machine and its configuration.

These are:

1. Internal engine noises exclusive of the combustion itself.
2. Engine air inlet
3. Transmission and other gear noises.
4. Hydraulic system noises including the pump, tubes, valves, cylinders and hydraulic motors.
5. Air noise from the fan and radiator.
6. Various moving mechanical elements such as crawler tracks, or scraper elevators.

It is very likely that on a large machine today, each of these noises is individually in excess of 90 dB(A) (decibels on "A" rating scale). In the case of two equal noise source levels, the sum is about 3 dBA higher than either source alone. For four equal noise sources, the sum is about 6 dBA higher. And this in reverse acts much the same way. Suppose the total noise of a machine is 100 dBA composed of four equal noise sources. Let's say the exhaust, engine noises, gear and hydraulic noises and fan noises are these four. If by some magic the exhaust and internal engine noises could be reduced to zero, the machine would still have a noise level of 97 dBA. So, this is the

challenge to the engineers who are studying each noise source and striving for noise reduction of each component.

QUIETING CURRENT PRODUCTS

For quieting current production machines, some manufacturers are starting to use off-line, extra cost customizing. This may consist of one or more of the following: An isolation mounted cab; larger muffler; sound deadening material around noisy components; and vibration isolation of noise components. These methods are expensive and can have only minimal effect on the total problem. Also, the sound absorbing insulation causes some components to run hotter and can possibly absorb spilled petroleum products. This can be a fire hazard. One would not normally expect to replace such insulation during a machine's expected useful lifetime but durability of such materials and installation techniques are not broadly known.

FUTURE MACHINE QUIETNESS

For future machines, larger capacity cooling fans with non-resonant frequencies are being developed. These would utilize larger volumes of air at lower velocities, new radiator fin designs and more efficient shrouds.

Some gears must be changed from one form to another and perhaps made with more precision. Much noise is generated from variable gear loadings and from gear idling. Gears are designed to transmit a given power level at a required speed. Variations of these will set up vibrations which cause noise. Here again, isolation and insulation seem like possible temporary solutions but heat and flexibility can lead to premature failure and other new problems.

Hydraulic pumps, transmission lines, valves, cylinders and motors are all noise generators. Oil flowing in a smooth, uniform path should be one of the quietest methods of generating, transmitting and utilizing energy. However, each component has complicated restrictions which induce vibration. If all of the hydraulically performed functions were uniform and continuous, the noise would be minimal. But ease and flexibility of control are reasons for the many applications. Noise reduction programs for hydraulics are underway, but they will take time for development, testing and adopting.

Mechanical components such as the tracks of crawler tractors are noisy but fortunately are of lower frequencies. These types of mechanisms are just not readily quieted and do not lend themselves to encapsulation treatment. The long range, practical solution for all these problems may well dictate future machines of entirely new configurations.

NOISE STANDARDS AND REGULATIONS

Because of the many noise sources which add up to a single composite noise at an individual's ear, a unique but uniform measurement is necessary. For this purpose the SAE Standards are a very practical solution. The development of these Standards requires inputs from a broad spectrum of individuals with various areas of interest. One company cannot develop such Standards nor can just the machine manufacturers' industry. But, through CIMA, the industry is promoting and lending its support to the development of meaningful noise Standards by independent Standards writing bodies which include experts from manufacturers, government, public, users and labor.

As previously stated, these are noise measurement and reporting Standards being developed by engineers and other highly knowledgeable people in the construction field. Obviously, their efforts must be teamed with practical and effective noise limit Standards developed by the experts in the field of Industrial Hygiene. Such limits should be in keeping with the peculiar type of exposure found in the construction environment. Only when these two tasks are completed can effective and practical noise control programs and regulations be designed and implemented.

For Community Noise Control we visualize total construction job site limits geared to the particular needs of the surrounding community. This would create a natural demand for quieter machines yet still allow contractors and users to utilize their well demonstrated versatility and ingenuity to get the job done in compliance with realistic job site noise limits even with existing machines by using new job layout and operational techniques.

For control of hearing damage risk we would urge that the current Walsh-Healey noise exposure tables might be modified for construction workers to more accurately reflect their unique exposure to intermittent, variable intensity noise and the large seasonable fluctuations in noise dosages. These factors are covered in some detail in a CIMA sponsored study published by SAE, December 1969, as Technical Report - SAE Research Project R-4 and titled "A Study of Noise Induced Hearing Damage Risk, for Operators of Farm and Construction Equipment". This report is available from the Society of Automotive Engineers, Inc., Two Pennsylvania Plaza, New York, New York.

In summary, we have attempted to briefly review the background of construction machinery and the relatively recent public concern for noise.

We have outlined the complex and sophisticated industry problems involved and our concern that the public may be moving from apathy to overkill in one easy lesson.

We have indicated an industry recognition of the responsibility to help shape noise abatement legislation and regulation into reasonable and responsible instruments; also, our past and continuing active participation, through CIMA, to effectively utilize our industry expertise in major and necessary Standards activities.

We spoke of the industry efforts, both from individual manufacturers and collectively through CIMA to create quieter machines except as a stop gap, high cost measure.

We outlined the need for new noise limit criteria designed in consideration of the unique types of noise exposure and dosage for construction workers.

It is obvious that construction machine designers and industrial hygienists in both the government and private sectors are operating at the threshold of the art relative to noise. We believe there is real and urgent need for a combining of these two groups into a teamwork effort. Through such a combined grouping of expertise can come the tools and procedures to effectively reach our common noise abatement objectives - and to do so with full consideration of the total needs of our society and at costs and compromises satisfactory to the public.

APPENDIX D — NOISE CONTROL: REGULATION AND STANDARDS

D.1 Introduction

Control of the noise produced by construction activity, building equipment, and home appliances cannot be expected to proceed in an orderly fashion without supporting guidance in the form of noise criteria, noise standards, and noise limits. This section of the report presents information on the status of currently available guidance for noise control. Trends in development of criteria, standards, and limits are discussed. Where possible, future requirements for noise control guidance are anticipated.

A fundamental distinction must be made among the three basic forms of guidance necessary for systematic noise control. Noise criteria are defined as statements of the effects produced by various levels of noise exposure. Criteria are based on the effects of noise on people, as discussed in Section 3.1 of this report. Noise standards describe the properties of noise environments that are considered desirable. Standards are usually presented as long-term goals that a regulatory program may be designed to attain. Noise limits are in effect regulatory documents intended to limit public exposure to individual noise sources. The limits entail not only a knowledge of the existing noise environment, but also technological and economic constraints on noise abatement. It is intended by writers of noise limits that the noise environment should approach the goals of noise standards in a systematic fashion.

The next section will discuss the elements involved in the development and support of regulatory noise limits for construction equipment; the third section of this appendix will discuss those elements appropriate to building equipment and appliances.

D.2 Construction Equipment

The body of this report has included discussion of criteria in the estimation and evaluation of the impact of construction equipment noise. The criteria appropriate to construction equipment noise are not unique to such noise sources, of course. The selection of standards for noise exposure must take into account the characteristics of the combined impact of the many noise sources that pollute our environment, and most importantly, must be keyed to the business and recreational activities and situations in society that are to be protected from noise. Thus, the development of a set of standards for the protection of human activity from noise pollution is beyond the scope of the present project and report; indeed, the ultimate selection will be based on further legislation incorporating decisions of national policy. It is our intention here to describe the relationship between the various elements in an environmental regulatory scheme, and to identify their present state of development by scientific and engineering groups, and by State and local governments.

The third of these elements is the noise limit itself, which provides quantitative restriction of noise emissions through incorporation in legally enforceable rules, regulations, and laws. Quantitative limits must be directed at an identifiable legal entity (such as manufacturer, vendor or user), and must be accompanied by specific test and measurement procedures. Although no nationwide noise regulations for construction or other powered outdoor equipment now exist, several states are considering such noise limits, and a number of larger cities have recently enacted or proposed limits for construction equipment.

The next section of this Appendix will review the recent regulatory activities at the State and local levels that apply. Since procedures for construction equipment noise measurement are so important to the successful implementation of source limitations, the last section will discuss these in more detail.

State and Local Regulations

In the last two years, considerable activity has taken place at the State and local level with regard to reducing the noise of outdoor construction, maintenance, and repair activities.

Both the State of Illinois and the State of Hawaii enacted statutes in 1970 which grant broad regulatory powers over noise to specific state agencies. At this time neither the Illinois Pollution Control Board nor the Hawaii Dept. of Health have adopted any rules or regulations to control construction noise. The Illinois Institute for Environmental Quality has initiated a study of noise sources (including construction and other outdoor powered equipment) that could be covered by State regulations, and proposed limits for such equipment are being studied.

In the State of California, a report to the 1971 Legislature on the Subject of Noise was prepared by the State Dept. of Public Health. This report includes in its recommendations the establishment of noise emission standards for all noise-producing objects now in use as well as to be admitted in the future to California. The construction noise sources identified in the report include all diesel-engine powered equipment, such as generators, compressors, off-highway trucks, bulldozers, loaders, scrapers, power shovels and other excavating equipment, as well as piledrivers, riveting machines, jack hammers, elevators, cement mixers, hammers, power saws, drills, and nailers. Other State legislatures have or will consider a variety of proposed construction noise bills; a bill submitted to the New York State Legislature in 1968 would have limited construction noise as measured at the nearest multiple dwelling.

Because construction-equipment noise is especially severe in urban areas, limits have been proposed or adopted in several larger cities. New York City has proposed coverage of construction sites by permit, and limits for air-compressor and paving-breaker

equipment in a new noise code; public hearings are scheduled to begin in the City Council Committee on Environmental Protection on 9 September 1971. The City of Boston Air Pollution Control Commission has recently completed a study of community noise and, as part of its plan for noise control, will begin hearings 27 September 1971 on proposed regulations which include limitations on noise of both construction/outdoor powered equipment and on the operation of a construction site. The latter limits, in brief, apply at any nearby area open to the public except public ways, or at a 1000-ft radius from the site, whichever is nearer.

The City of Chicago adopted a comprehensive noise ordinance, effective 1 July 1971. Section 17-4.8 provides that "No person shall sell or lease,...any powered equipment or powered hand tool that produces a maximum noise level exceeding the following noise limits at a distance of 50 ft, under test procedures established by...this chapter." and there follows a table of limits in dB(A) for four categories of equipment. Two categories "Construction and Industrial Machinery" (#1) and "Commercial Service Machinery" (#3) cover the bulk of construction equipment.

"Construction and Industrial Machinery" includes powered outdoor equipment, mobile or stationary, associated with construction sites or industrial operations. Such equipment includes crawler-tractors, dozers, rotary drills, and augers, loaders, power shovels, cranes, derricks, motor graders, paving machines, off-highway trucks, ditchers, trenchers, compactors, scrapers, wagons, compressors, pavement breakers, pneumatic-powered equipment, etc. Specifically excluded are pile drivers.

"Commercial Service Machinery" includes powered equipment of 20 hp or less intended for infrequent service in residential areas, typically requiring commercial or skilled operators. Such equipment includes chain saws, light pavement breakers, log chippers, powered hand tools, etc.

The limits that apply to these categories are keyed to the date of manufacture of the equipment and provide a timetable for noise reduction as follows:

| Manufactured after | Construction and Industrial Machinery | Commercial Service Machinery |
|--------------------|---------------------------------------|------------------------------|
| 1 Jan. 1972 | 94 dB(A) | 88 dB(A) |
| 1 Jan. 1973 | 88 dB(A) | 84 dB(A) |
| 1 Jan. 1975 | 86 dB(A) | -- |
| 1 Jan. 1978 | -- | -- |
| 1 Jan. 1980 | 80 dB(A) | 80 dB(A) |

The application of the limits to equipment for lease is most appropriate in the case of construction machinery; such equipment is usually leased rather than sold. Since the limits only apply to equipment manufactured after 1 January 1972, it is too early to look for compiled results, but several contractors in the Chicago area are now asking for "quieted" equipment that will meet these limits, and intend to use such equipment, insofar as possible, to reduce or eliminate community noise complaints. This provides very desirable pressure in the market place for such "quiet" equipment, encouraging manufacturers to offer noise control packages on their construction equipment before the required date.

Measurement Procedures

Since quantitative limits must be applied to the noise source, most test codes and recommended practices for measurement apply to the operation of an individual item of construction equipment. The following noise measurement procedures are of this form:

SAE Standard J952a Sound Levels for Engine Powered Equipment*

Scope: For engine powered equipment including mobile construction and industrial machinery, but not covering machinery designed for operation on highways, or within factories and building areas.

Test Type: Outdoor free-field measurement on level ground. Measurement distance 50 ft. Equipment operation at speed and load producing maximum sound level.

Data: A-weighted sound level.

City of Chicago Environmental Control Ordinance, Article IV[†] Test Procedures for Noise Emitted by Engine-Powered Equipment and Powered Hand Tools

Scope: For engine-powered equipment, including construction and industrial machinery (not including pile drivers) agricultural tractors and equipment, powered commercial equipment of 20 hp or less, and powered equipment for use in residential areas.

*Society of Automotive Engineers, Inc., NYC, N.Y. 10001

[†]Sec. 17-4.26 and corresponding section of DEC Code of Recommended Practice. Chicago Department of Environmental Control, Chicago, Ill. 60610.

Test Type: Outdoor free-field measurement on level surface. Measurement distance 50 ft. Both stationary test and acceleration test (for rubber-tired mobile equipment) at load and speed producing maximum sound level. Pneumatic equipment operated as specified in CAGI-PNEUROP Test Code.

Data: A-weighted sound level.

ANSI S1.19/193 (Proposed) Test-Site Measurement of Noise Emitted
by Engine Powered Equipment*

Scope: For determining maximum noise emitted by construction and industrial machinery, transportation and recreation vehicles, and other engine-powered equipment.

Test Type: Outdoor free-field on reflecting ground. Measurement distance 15 meters (50 ft). Moving and stationary tests for construction equipment (Sec. 4.4).

Data: A-weighted sound level

*CAGI-PNEUROP[†] Test Code for the Measurement of Sound from
Pneumatic Equipment*

Scope: Applies to compressors, percussive and nonpercussive pneumatic equipment. Specifies procedures and operating conditions, not always including process noise.

*American National Standards Institute, NYC, N.Y. 10018

†Compressed Air and Gas Institute, NYC, N.Y. 10017

Test Type: Indoor or outdoor, measurements in direct field at five positions at 1 meter from equipment. Secondary measurement at 7 meters distance. Non-percussive tools measured running free and with "quiet" work process.

Data: A-weighted and Octave-band sound pressure levels for each measurement point.

The procedures adopted by the City of Chicago are based on the SAE J952 standard and the revisions now under consideration by the SAE Agricultural and Construction Machinery Sound Level Subcommittee. Substantially the same measurement procedures have been proposed by the City of Boston Air Pollution Control Commission in their *Test Procedure for Measurement of Noise from Powered Devices*.

While SAE J952a contained specific noise limits, there are being separated in a later revision now under consideration, and the test procedure will appear separately. This procedure recommends an additional 2 dB tolerance for such noise measurements; this provision has been deliberately omitted in both the Chicago and Boston test procedures, and left to administrative decision. This is more appropriate, and not unlike the enforcement measurement procedures for vehicular speed limits.

Another approach to construction equipment noise measurement is to apply the measurement to the combined operators of all construction equipment at a single test site. At the request of CIMA (Construction Industry Manufacturers' Association) the SAE is developing such a test procedure.

*SAE Recommended Practice (Proposed) Construction Site Sound
Level Measurements*

Scope: For sites where construction machinery is operated.
Measures noise radiated off-site.

Test Type: Field measurement of radiated sound levels at four nearest inhabited locations to any centerpoint of construction activity. If no inhabited locations closer than 1000 ft to a centerpoint, measurements made at 4 locations spaced 90° on 1000 ft radius circle.

Data: A-weighted sound levels at each measurement point define "Construction Site Operational Sound Levels". Provision for a record of "Construction Site Baseline Sound Levels" allows limits to be expressed as change in ambient as well as absolute terms.

The combined-operations measurement procedure is presently being proposed for use by the City of Boston, and the City of Chicago plans a test of the latest SAE draft procedure as part of a feasibility study of noise limitations on construction sites. The Federal Highway Administration is considering this procedure as a basis for regulation of noise from Federal-aid highway construction.

D.3 Noise Standards for Indoor and Outdoor Equipment for Home and Office Use

The impetus for development of standards for measuring and rating the noise produced by many types of equipment has come from the manufacturers of noise sources. For example, the manufacturers of air conditioning and ventilation appliances are by far the most conscious of the impact of their equipment on the noise environment of the home and office. Within the past decade at least ten different "standard" procedures have been formulated for measuring and rating the noise of various types of air conditioning and ventilating equipment. The automotive and airframe industries have been similarly conscious of the noise impact of their equipment and sophisticated noise standards exist for these sources. By contrast, only one standard has appeared to deal with the noise of rotating electrical machinery; one to deal with gas turbines; one for gear noise; one standard of a general nature, produced by official American National Standards Institute (ANSI), intended to guide noise measurement of practically any piece of machinery; and a draft procedure is under consideration by ANSI to rate the noise of all engine-powered equipment.

Such standards are of two types. Measurement standards specify the manner in which meaningful and reliable acoustical data may be obtained. Rating standards apply these acoustical data to produce ratings, usually single-numbered, that are supposed to correlate with subjective response to equipment noise, thus permitting at least rank-ordering of equipment noise on a justifiable basis.

Both sorts of standards are necessary and form the basis for yet a third class of standards (applications standards) that are used by architects, consultants, building codes, noise

ordinances and similar organizations. Factors which are considered in developing application standards include the economic, social, and political. Applications standards represent an equilibrium between the costs of reducing noise exposure and the feasible noise reduction made possible by acoustic technology.

The following summaries indicate the general nature of existing U.S. noise measurement and rating standards for domestic and office equipment.

ASHRAE 36-62 Measurement of Sound Power Radiated from Heating, Refrigerating and Air-Conditioning Equipment*

Scope: For unitary, unducted equipment, large or small, for indoor or outdoor use.

Test Type: Reverberation room, substitution method.

Data: Total radiated sound power level in octave or 1/3-octave bands.

ASHRAE 36A-63 Method of Determining Sound Power Levels of Room Air Conditioners and Other Ductless, Through-the-Wall Equipment*

Scope: For room air conditioners, window or attic fans, and other ductless wall- or ceiling-mounted equipment that radiate sound directly both to the conditioned space and the outdoors.

Test Type: Reverberation room, substitution method (2 rooms needed).

Data: Total sound power level radiated to indoors and outdoors, separately, in 1/3-octave bands.

* American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., 345 East 47th Street, New York, N.Y. 10017.

ASHRAE 36B-63 Method of Testing for Rating the Acoustic Performance of Air Control and Terminal Devices and Similar Equipment

Scope: For air control and terminal devices normally mounted in or connected to duct systems.

Test Type: Reverberation room, substitution method.

Data: Total sound power level radiated into the room served by the device, in octave bands.

AMCA 300-67 Test Code for Sound Rating Air Moving Devices*

Scope: For central station air conditioning and heating and ventilating units, for centrifugal fans, axial and propeller fans, power roof and wall ventilators, steam and hot water unit heaters (but not unit ventilators, room fan-coil units, room air induction units and air cooled refrigerant condensers).

Test Type: Reverberation room, substitution method, based on ASHRAE 36-62.

Data: Total radiated sound power level, in octave bands (including the sound radiated into the ducts, for ducted equipment).

AMCA 301-65 Method of Publishing Sound Ratings for Air Moving Devices*

Ratings for Centrifugal Fans, Axial and Propeller Fans, Power Roof and Wall Ventilators, Steam and Hot Water Unit Heaters; not yet suitable for central station A/C or H/V units.

Ratings: based on octave-band sound power levels, per AMCA 300-67:

For ducted devices, the eight octave-band sound power levels;

*Air Moving and Conditioning Association, 205 West Touhy Ave., Park Ridge, Ill. 60068

For unducted devices, the loudness in sones at a reference distance of 5 ft, as calculated from the sound power level data.

AMCA 302 "Application of Sone Loudness Ratings for Nonducted Air-Moving Devices"

Reference material covering applications of the loudness rating in sones (examples, combinations of sources, prediction of sound loudness indoors and outdoors, variation with fan speed.

AMCA 303 "Application of Sound Power Level Ratings for Ducted Air Moving Devices"

Reference material covering significance and accuracy of sound power level ratings, particularly their relation to sound as heard.

*ANSI*S1.2 - 1962 "American Standard Method for the Physical Measurement of Sound"*

Scope: For all devices, machines or apparatus.

Several test procedures are described:

Test Type: Free-field; free-field above reflecting plane; semi-reverberant field; or reverberation room. The semi-reverberant field procedure is similar to that of ASHRAE 36-62.

Data: Sound pressure levels at specific locations, or total sound power levels in octave bands (1/2-octave or 1/3-octave analysis optional); and directivity of the source.

* American National Standards Institute, 10 East 40th Street, New York, N.Y. 10016

IEEE #85 "Airborne Noise Measurements on Rotating Electric Machinery"*

Scope: For rotating electrical machinery of all sizes
Several test procedures are described:

Test Type: Free field; free field above reflecting plane; semi-reverberant field; or reverberation room. (Similar to ANSI S1.2-1962, but more detailed.)

Data: Sound levels or sound pressure levels in frequency bands (octave, 1/3-octave, or "narrow") at specified locations or total sound power level, overall or analyzed into frequency bands, and directivity of source.

ANSI S1.19/193 "Test-Site Measurement of Noise Emitted by Engine-Powered Equipment" (Draft only.)

Scope: For residential equipment (Section 4.5) [Other sections deal with automobiles, motorcycles, construction and industrial machinery and recreational equipment]

Test Type: Sound levels measured on flat test site with hard ground surface, free of large reflecting obstacles within 30 meters of equipment under test.

Data: A-weighted sound level measured at a point 50 ft from center of equipment and 4 ft above ground, for noisiest direction and noisiest operating conditions.

ARI† 443-66 "Standard for Sound Rating of Room Fan-Coil Air-Conditioners"

Scope: For room fan-coil air conditioners.

* Institute of Electrical and Electronic Engineers, 345 East 47th Street, New York, N.Y. 10017

† Air-Conditioning and Refrigeration Institute, 1815 North Fort Meyer Drive, Arlington, Virginia 22209

Test Type: Reverberation room, substitution method, in accordance with ASHRAE 36-62

Data: Octave-band sound power levels, computed from 1/3-octave band data corrected for presence of pure tones.

ARI 270-67 Standard for Sound Rating of Outdoor Unitary Equipment

Scope: Outdoor sections of factory-made equipment, such as unitary air-conditioners or heat pumps.

Test Type: Reverberation room, substitution method, in accordance with ASHRAE 36-62 or ASHRAE 36A-63.

Data: Sound power levels in 1/3-octave bands.

Rating: Single-number rating based on the 1/3-octave band sound power levels (corrected for the presence of pure tones), by a calculation like the ANSI Standard S3.4, "Computation of Loudness of Noise".

ARI 275-69 Standard for Application of Sound Rated Outdoor Unitary Equipment

Reference material (related to ARI 270-67) establishing a method for predicting annoyance due to operation of outdoor unitary equipment, and providing recommendations for application of such equipment.

Calculation of annoyance level (ANL), taking into account distance, reflections, location of equipment, shielding by barriers, location of observer, multiple units, etc.

AHAM SR-1 Room Air-Conditioner Sound Rating*

Scope: Room air conditioners

Test Type: Reverberation room, substitution method, in accordance with ASHRAE 36A-63

Data: Single number (or letter) ratings based on the 1/3-octave band sound power levels (corrected for the presence of pure tones), by a calculation like the ANSI Standard S3.4 "Computation of Loudness of Noise"; the calculations are different for the indoor side and the outdoor side of the unit, such that the two sound ratings would be the same if the sound power levels radiated indoors were all 15 dB less than the levels in corresponding frequency bands radiated to the outdoors. The outdoor calculation is the same as that of ARI 270-67. The indoor sound rating (a number) is converted to a letter rating (11=A, 12=B, 13=C, etc.) for publication purposes.

HVI†#1966-1 Sound Test Procedure

Scope: For home ventilating equipment.

Test Type: Reverberation room, substitution method, similar to ASHRAE 36-62

Data: Octave band sound power levels, calculated from 1/3-octave band sound pressure levels, are used to compute octave-band free-field sound pressure levels at a reference 5-foot distance.

Rating: The nominal free-field octave-band SPL's at 5 foot are used to calculate loudness in sones, a single number,

* Association of Home Appliance Manufacturers, 20 North Wacker Drive, Chicago, Illinois 60606

† Home Ventilating Institute

according to ANSI S3.4 - 1968, "Computation of Loudness of Noise."

ADC Test Code 1062 R1 Equipment Test Code*

Scope: For air distribution and control devices (high pressure units).

Test Type: Reverberation room, substitution method, in accordance with ASHRE 36B-63 (except that the ASHRAE test for attenuation of terminal devices is not used).

Data: Total sound power level radiated into room, in octave bands.

* * * *

In addition to these standards for measuring and rating noise from various kinds of ventilation equipment, both the Home Ventilating Institute and the Air Conditioning and Refrigeration Institute have published directories of equipment, giving noise ratings for each model tested (a large proportion of the manufactured models); and both the Air Conditioning and Refrigeration Institute and the Association of Home Appliance Manufacturers offer guidance for the writers of noise ordinances dealing with their equipment types, to indicate achievable goals and the necessary wording in terms of existing standards, to make the model ordinances enforceable.

At the present time, the existence of several different measurement and rating standards in the ventilating/air-conditioning field is something of an embarrassment, since they are not

* Air Diffusion Council, 435 North Michigan Ave., Chicago, Ill. 60611

mutually consistent nor even compatible, but are competing for general acceptance. In an attempt to deal with this situation, an ad hoc working group of ANSI is currently trying to draft a standard for both measurement and rating of equipment noise that exhibits the best features of the already existing standards and that, it is hoped, will be found acceptable by the various organizations that have pioneered in the standardization effort in the United States. It is still too early to predict whether this action will be successful.

In spite of the slightly chaotic present situation, it is clear that a great deal of careful thinking has been done about how to measure equipment noise in the United States; indeed, in this area the U. S. is somewhat in advance of the European practice.

Exhibit 3

L.A. CEQA THRESHOLDS GUIDE

Your Resource for Preparing
CEQA Analyses in Los Angeles

City of Los Angeles
2006

CITY OF LOS ANGELES

MAYOR

Antonio R. Villaraigosa

CONTROLLER

Laura N. Chick

CITY ATTORNEY

Rocky Delgadillo

CITY COUNCIL

Ed Reyes
First District

Tony Cardenas
Sixth District

Bill Rosendahl
Eleventh District

Wendy Greuel
Second District

Alex Padilla, President
Seventh District

Greig Smith
Twelfth District

Dennis P. Zine
Third District

Bernard Parks
Eighth District

Eric Garcetti
Thirteenth District

Tom LaBonge
Fourth District

Jan Perry
Ninth District

José Huizar
Fourteenth District

Jack Weiss
Fifth District

Herb J. Wesson, Jr.
Tenth District

Janice Hahn
Fifteenth District

ENVIRONMENTAL AFFAIRS COMMISSION

Misty Sanford, President
Alina Bokde, Vice President
Maria Armoudian
Joyce Perkins
M. Teresa Villegas

ENVIRONMENTAL AFFAIRS DEPARTMENT

Detrich B. Allen, General Manager
Gretchen Hardison, Director of Air Quality Division
José Gutiérrez, Environmental Supervisor
Wayne King, Environmental Specialist

Renée Brandt, Eagle Environmental

L.A. CEQA THRESHOLDS GUIDE:

Your Resource for Preparing CEQA Analyses in Los Angeles

2006

As a covered entity under Title II of the Americans with Disabilities Act, the City of Los Angeles does not discriminate on the basis of disability and, upon request, will provide reasonable accommodation to ensure equal access to its programs, services and activities.

This Thresholds Guide is intended to provide general information about CEQA. It should not be used as a substitute for professional or legal advice. The reader should refer to the CEQA Statutes and Guidelines and consult with the appropriate City departments, as necessary.

TABLE OF CONTENTS

| | | |
|---|-------|-----|
| Executive Summary | i | |
| Introduction..... | 1 | |
| Cross-Referencing Index | 13 | |
| List of Abbreviations/Acronyms..... | 32 | |
| Glossary | 37 | |
| A. Aesthetics and Visual Resources | | |
| Introduction..... | A-1 | |
| 1. Aesthetics..... | A.1-1 | |
| 2. Obstruction of Views | A.2-1 | |
| 3. Shading | A.3-1 | |
| 4. Nighttime Illumination | A.4-1 | |
| B. Air Quality | | |
| Introduction..... | B-1 | |
| 1. Construction Emissions | B.1-1 | |
| 2. Operational Emissions | B.2-1 | |
| 3. Toxic Air Contaminants..... | B.3-1 | |
| C. Biological Resources | | C-1 |
| D. Cultural Resources | | |
| 1. Paleontological Resources | D.1-1 | |
| 2. Archaeological Resources..... | D.2-1 | |
| 3. Historical Resources | D.3-1 | |
| E. Geology | | |
| 1. Geologic Hazards..... | E.1-1 | |
| 2. Sedimentation and Erosion | E.2-1 | |
| 3. Landform Alteration | E.3-1 | |
| 4. Mineral Resources | E.4-1 | |
| F. Hazards | | |
| 1. Risk of Upset/Emergency Preparedness | F.1-1 | |
| 2. Human Health Hazards | F.2-1 | |
| G. Water Resources | | |
| 1. Surface Water Hydrology | G.1-1 | |
| 2. Surface Water Quality..... | G.2-1 | |
| 3. Groundwater Level | G.3-1 | |
| 4. Groundwater Quality | G.4-1 | |

TABLE OF CONTENTS, continued

| | |
|--|-------|
| H. Land Use | |
| 1. Land Use Consistency | H.1-1 |
| 2. Land Use Compatibility | H.2-1 |
| I. Noise | |
| 1. Construction Noise | I.1-1 |
| 2. Operational Noise | I.2-1 |
| 3. Railroad Noise | I.3-1 |
| 4. Airport Noise | I.4-1 |
| J. Population and Housing | |
| 1. Population and Housing Growth..... | J.1-1 |
| 2. Population and Housing Displacement..... | J.2-1 |
| K. Public Services | |
| 1. Police Protection | K.1-1 |
| 2. Fire Protection & Emergency Medical Services..... | K.2-1 |
| 3. Public Schools..... | K.3-1 |
| 4. Recreation and Parks | K.4-1 |
| 5. Libraries | K.5-1 |
| L. Transportation | |
| Introduction..... | L-1 |
| 1. Intersection Capacity | L.1-1 |
| 2. Street Segment Capacity | L.2-1 |
| 3. Freeway Capacity | L.3-1 |
| 4. Neighborhood Intrusion Impacts | L.4-1 |
| 5. Project Access..... | L.5-1 |
| 6. Transit System Capacity | L.6-1 |
| 7. Parking | L.7-1 |
| 8. In-Street Construction Impacts | L.8-1 |
| M. Public Utilities | |
| 1. Water..... | M.1-1 |
| 2. Wastewater..... | M.2-1 |
| 3. Solid Waste | M.3-1 |
| 4. Energy | M.4-1 |

LIST OF EXHIBITS

Introduction

| | |
|---|---|
| Exhibit 1. Case Study: Operational Noise | 6 |
| Exhibit 2. Initial Study Checklist Process | 7 |
| Exhibit 3. Initial Study Determination..... | 8 |
| Exhibit 4. Impact Evaluation and Mitigation Process | 9 |

A. Visual Resources

| | |
|---|--------|
| 1. Aesthetics | |
| Exhibit A.1-1. Selected Aesthetic-Related Regulations in the Los Angeles
Municipal Code | A.1-7 |
| 2. Obstruction of Views | |
| Exhibit A.2-1. View Analysis Methodology..... | A.2-7 |
| Exhibit A.2-2. View Lines | A.2-8 |
| Exhibit A.2-3. View Sections..... | A.2-9 |
| Exhibit A.2-4. Field of View..... | A.2-10 |
| 3. Shading | |
| Exhibit A.3-1. Shadow Length Multipliers and Bearings for 34° Latitude-
Los Angeles | A.3-5 |
| Exhibit A.3-2. Maximum Shadow Length Generated for Given Source
Heights during Winter Solstice | A.3-6 |
| Exhibit A.3-3. Maximum Shadow Length Generated for Given Source
Heights during Summer Solstice | A.3-7 |
| Exhibit A.3-4. Shadow Plotting Methodology..... | A.3-8 |
| Exhibit A.3-5. Shadow Projection..... | A.3-9 |
| Exhibit A.3-6. Shadow Coverage..... | A.3-10 |
| 4. Nighttime Illumination | |
| Exhibit A.4-1. Selected City Municipal Code Lighting Regulations | A.4-5 |

B. Air Quality

| | |
|--|--------|
| 1. Construction Emissions | |
| Exhibit B.1-1. Reprint of SCAQMD Rule 403, page 14 | B.1-7 |
| Exhibit B.1-2. Reprint of SCAQMD Rule 403, Pages 15 and 16..... | B.1-8 |
| 2. Operational Emissions | |
| Exhibit B.2-1. Reprint of SCAQMD CEQA Air Quality Handbook,
pages 6-10 to 6-12..... | B.2-11 |

C. Biological Resources

| | |
|--|------|
| Exhibit C-1. Habitat-Oriented Biological Assessment Planning Zones | C-10 |
| Exhibit C-2. Biological Resource Areas (Metro Geographical Area)..... | C-11 |

LIST OF EXHIBITS, continued

| | |
|---|------|
| Exhibit C-3. Biological Resource Areas (Central Geographical Area) | C-12 |
| Exhibit C-4. Biological Resource Areas (Coastal and Southern Geographical Area) | C-13 |
| Exhibit C-5. Biological Resource Areas (Valley Geographical Area) | C-14 |
| Exhibit C-6. Natural Habitats and SEAs within the City of Los Angeles | C-15 |
| Exhibit C-7. Sensitive Species Compendium – City of Los Angeles | C-28 |
| Exhibit C-8. General References | C-38 |

D. Cultural Resources

| | |
|---|--------|
| 1. Paleontological Resources | |
| Exhibit D.1-1. Paleontological Potential by Rock Unit/Geologic Formation .. | D.1-9 |
| 3. Historic Resources | |
| Exhibit D.3-1. National Criteria and Standards | D.3-9 |
| Exhibit D.3-2. California Register Criteria and Evaluation System | D.3-11 |
| Exhibit D.3-3. City of Los Angeles Criteria | D.3-12 |
| Exhibit D.3-4. State Office of Historic Preservation List of Non-Adverse Repairs and Improvements | D.3-13 |
| Exhibit D.3-5. Architectural Styles and Periods | D.3-15 |

E. Geology

| | |
|---|-------|
| 4. Mineral Resources | |
| Exhibit E.4-1. State Mining and Geology Board Mineral Resource Zone Classifications | E.4-5 |

G. Water Resources

| | |
|--|-------|
| 1. Surface Water Hydrology | |
| Exhibit G.1-1. Development Classifications (Typical Percentage of Imperviousness, by Zone) | G.1-7 |
| 3. Groundwater Level | |
| Exhibit G.3-1. Los Angeles Coastal Groundwater Basins | G.3-8 |
| Exhibit G.3-2. San Fernando Valley Groundwater Basins | G.3-9 |

I. Noise

| | |
|--|--------|
| 1. Construction Noise | |
| Exhibit I.1-1. Noise Level Ranges of Typical Construction Equipment | I.1-8 |
| Exhibit I.1-2. Outdoor Construction Noise Levels | I.1-9 |
| Exhibit I.1-3. Presumed Ambient Noise Levels | I.1-9 |
| 3. Railroad Noise | |
| Exhibit I.3-1. Diesel Locomotives Noise | I.3-10 |
| Exhibit I.3-2. Electric Rapid Transit Noise | I.3-11 |
| Exhibit I.3-3. Average Locomotive, Railcar, and Rapid Transit Noise Levels | I.3-12 |
| Exhibit I.3-4. Variables Affecting Railcar Wheel/Rail Noise Emission | I.3-12 |
| Exhibit I.3-5. Average Rail Yard Noise Levels | I.3-13 |

J. Population and Housing

| | |
|--|--|
| 2. Population and Housing Displacement | |
|--|--|

LIST OF EXHIBITS, continued

Exhibit J.2-1. Maximum Affordable Rent for Very Low-
and Low-Income Households in the City of Los Angeles, FY 2003.....J.2-7

K. Public Services

1. Police Protection

| | |
|--|--------|
| Exhibit K.1-1. Location of LAPD Bureaus and Areas..... | K.1-5 |
| Exhibit K.1-2. Reporting District Map of Central Area..... | K.1-8 |
| Exhibit K.1-3. Reporting District Map of Rampart Area..... | K.1-9 |
| Exhibit K.1-4. Reporting District Map of Hollenbeck Area..... | K.1-10 |
| Exhibit K.1-5. Reporting District Map of Northeast Area..... | K.1-11 |
| Exhibit K.1-6. Reporting District Map of Newton Street Area | K.1-12 |
| Exhibit K.1-7. Reporting District Map of Hollywood Area | K.1-13 |
| Exhibit K.1-8. Reporting District Map of Wilshire Area..... | K.1-14 |
| Exhibit K.1-9. Reporting District Map of West Los Angeles Area | K.1-15 |
| Exhibit K.1-10. Reporting District Map of Pacific Area | K.1-16 |
| Exhibit K.1-11. Reporting District Map of Van Nuys Area | K.1-17 |
| Exhibit K.1-12. Reporting District Map of West Valley Area..... | K.1-18 |
| Exhibit K.1-13. Reporting District Map of North Hollywood Area | K.1-19 |
| Exhibit K.1-14. Reporting District Map of Mission Area | K.1-20 |
| Exhibit K.1-15. Reporting District Map of Foothill Area..... | K.1-21 |
| Exhibit K.1-16. Reporting District Map of Devonshire Area | K.1-22 |
| Exhibit K.1-17. Reporting District Map of Southwest Area..... | K.1-23 |
| Exhibit K.1-18. Reporting District Map of Harbor Area..... | K.1-24 |
| Exhibit K.1-19. Reporting District Map of 77th Street Area..... | K.1-25 |
| Exhibit K.1-20. Reporting District Map of Southeast Area..... | K.1-26 |

2. Fire Protection & Emergency Medical Services

| | |
|--|-------|
| Exhibit K.2-1. Los Angeles Fire Department Station Locations | K.2-7 |
|--|-------|

3. Public Schools

| | |
|--|--------|
| Exhibit K.3-1 Board of Education District 1..... | K.3-5 |
| Exhibit K.3-2. Board of Education District 2..... | K.3-6 |
| Exhibit K.3-3. Board of Education District 3..... | K.3-7 |
| Exhibit K.3-4. Board of Education District 4..... | K.3-8 |
| Exhibit K.3-5. Board of Education District 5..... | K.3-9 |
| Exhibit K.3-6. Board of Education District 6..... | K.3-10 |
| Exhibit K.3-7. Board of Education District 7..... | K.3-11 |
| Exhibit K.3-8. LAUSD School Addresses & Capacities With | K.3-12 |
| New and Continuing Multitrack Year-Round Schools | |
| Exhibit K.3-9. Reproduction of LAUSD Student Generation Factors..... | K.3-34 |

5. Libraries

| | |
|--|-------|
| Exhibit K.5-1. Los Angeles Public Library Branch Facilities Site Selection
Criteria | K.5-5 |
| Exhibit K.5-2. Los Angeles Public Library Branch Facilities | K.5-6 |

L. Transportation

Introduction

| | |
|---|-----|
| Exhibit L-1. Relationship of Project Type, Analysis Type and
Transportation Impact Categories to Be Screened | L-4 |
|---|-----|

LIST OF EXHIBITS, continued

| | |
|--|--------|
| Exhibit L-2. Scoping for Traffic Study | L-5 |
| Exhibit L-3. City of Los Angeles CMP Monitoring Locations | L-6 |
| 1. Intersection Capacity | |
| Exhibit L.1-1. Level of Service Definitions for Signalized Intersections | L.1-13 |
| Exhibit L.1-2. Level of Service Definitions for Two-Way and All-Way
Stop-Controlled Intersections | L.1-14 |
| Exhibit L.1-3. Pass-By Trip Discount Rates..... | L.1-15 |
| 2. Street Segment Capacity | |
| Exhibit L.2-1. Level of Service Definitions for Arterial Street Segments | L.2-7 |
| 3. Freeway Capacity | |
| Exhibit L.3-1. Level of Service Definitions for Freeway Segments | L.3-5 |

M. Public Utilities

2. Wastewater

| | |
|---|--------|
| Exhibit M.2-1. City of Los Angeles Wastewater Treatment System..... | M.2-11 |
| Exhibit M.2-2. Sewer Capacity Threshold Study Areas | M.2-12 |
| Exhibit M.2-3. Sewer Capacity Threshold Study Areas: Subregion A..... | M.2-13 |
| Exhibit M.2-4. Sewer Capacity Threshold Study Areas: Subregion B..... | M.2-14 |
| Exhibit M.2-5. Sewer Capacity Threshold Study Areas: Subregion C..... | M.2-15 |
| Exhibit M.2-6. Sewer Capacity Threshold Study Areas: Subregion D..... | M.2-16 |
| Exhibit M.2-7. Sewer Capacity Threshold Study Areas: Subregion E | M.2-17 |
| Exhibit M.2-8. Sewer Capacity Threshold Study Areas: Subregion F | M.2-18 |
| Exhibit M.2-9. Sewer Capacity Threshold Study Areas: Subregion G..... | M.2-19 |
| Exhibit M.2-10. Sewer Capacity Threshold Study Areas: Subregion H..... | M.2-20 |
| Exhibit M.2-11. Sewer Capacity Threshold Study Areas: Subregion I | M.2-21 |
| Exhibit M.2-12. Sewage Generation Factors | M.2-22 |

EXECUTIVE SUMMARY

Purpose

The *L.A. CEQA Thresholds Guide: Your Resource for Preparing CEQA Analyses in Los Angeles (Thresholds Guide)* is a guidance document that draws together practical information useful to City staff, project proponents, and the public involved in the environmental review of projects in the City of Los Angeles subject to the California Environmental Quality Act (CEQA). The CEQA process, established by state law, requires the review of proposed projects in order to identify and address potential environmental effects.

This is the City's initial effort to develop citywide guidance for CEQA impact analyses. The applicability and use of the *Thresholds Guide* may be re-evaluated after a period of use. The *Thresholds Guide* is intended to be available as a voluntary tool. It supports the City's development reform efforts to streamline and enhance the City's permit and development processes. The *Thresholds Guide* is a consensus document that represents the technical input from a citywide working group, comprised of representatives from 18 City departments and bureaus, including the Environmental Affairs Department (EAD).

Content

The *Thresholds Guide* includes two sets of criteria to evaluate project impacts: screening and significance criteria. The **screening criteria** provide assistance in responding to the questions in the State's Initial Study Checklist and, thus, determining the appropriate environmental document to prepare (e.g., negative declaration, mitigated negative declaration, or environmental impact report). The **significance thresholds** assist in determining whether a project's impacts would be presumed significant under normal

circumstances and, therefore, require mitigation to be identified.

The *Thresholds Guide* contains three types of significance thresholds - **quantitative, qualitative, and case-by-case**. Quantitative thresholds provide a measurable criterion with which to compare one or more characteristics of the proposed project, such as "the vehicle-to-capacity ratio increase at a study intersection is greater than 0.020." A qualitative threshold requires comparison to non-numerical criteria, such as "interference with a wildlife movement corridor." The case-by-case thresholds were developed for issue areas where a definitive threshold could not be established, either because impacts are site- or project-specific or because there is no consistent technical guidance available. The existence of screening criteria and significance thresholds may also encourage project proponents to incorporate impact-reducing measures into project designs, prior to submitting project applications to the City, to reduce potential impacts below the significance level.

The screening criteria and significance thresholds are based on a variety of factors, including existing local, state, and federal regulations, administrative practices of other public agencies, and commonly accepted professional standards. Each threshold has been reviewed with respect to meeting the following goals: objectivity and applicability, defensibility, practicality, nexus between impacts and mitigation, and legal liability.

The *Thresholds Guide* provides assistance in evaluating 46 of the most common environmental issues in the City of Los Angeles, grouped into the following categories:

- Air Quality
- Population and Housing

- Biological Resources
- Cultural Resources
- Geology
- Hazards
- Land Use
- Noise
- Public Services
- Public Utilities
- Transportation
- Visual Resources
- Water Resources

The information is organized generally in the same order in which the issues appear in the State's Initial Study Checklist, although the *Thresholds Guide* does not identify thresholds for all issues found in the Checklist.

Within each issue area, the *Thresholds Guide* includes three parts: **1. Initial Study Screening Process** (Initial Study Checklist Question, Introduction, Screening Criteria, and Evaluation of Screening Criteria); **2. Determination of Significance** (Significance Threshold, Environmental Setting, Project Impacts, Cumulative Impacts, and Sample Mitigation Measures); and **3. Data, Resources, and References** (Resources, Background Information, Selected Legislation, and Exhibits).

How the *Thresholds Guide* works

The *Thresholds Guide* provides technical assistance in evaluating the potential significance of a project's environmental impacts by putting in one place existing information and practices from a variety of sources which are useful for impact analyses. The *Thresholds Guide* applies to non-exempt, discretionary projects (including public and private projects and plans) in the City of Los Angeles under "normal" conditions. It recognizes that the impacts resulting from a particular action depend on the project setting, design, and operational components and that the determination of significance and the appropriate criteria for evaluation are the responsibility of the lead agency.

The *Thresholds Guide* does not change the authority of decision-makers or the lead agency or affect the City's CEQA Guidelines (including the list of categorical exemptions). The

Thresholds Guide does not change existing department procedures for processing CEQA documents or introduce new evaluation methods.

The purpose and applicability of the *Thresholds Guide* are fully described in the Preface and Content and Use Sections of the Introduction. The *Thresholds Guide* provides some general information about CEQA requirements, but should not be used as a substitute for professional or legal advice. For more information, the reader should refer to the CEQA Statutes and State and City Guidelines; current case law, regulations, and scientific methods; and consult with the appropriate City departments, as necessary.

Background and Process

Numerous public and private projects and plans are undertaken each year within the City of Los Angeles. Each of these must comply with all applicable laws, regulations, and policies, including CEQA. For those projects needing discretionary approval from the City of Los Angeles, the department granting the approval generally acts as the lead agency on behalf of the City and ensures that all CEQA requirements are fulfilled. The *Thresholds Guide* can simplify the CEQA process by offering a consistent set of evaluation criteria applicable to most discretionary projects in the City.

The *Thresholds Guide* was presented and discussed at a public workshop hosted by the Environmental Affairs Commission (EAC). The EAC sent recommendations on the *Thresholds Guide* to the Environmental Quality and Waste Management Committee of the City Council, and the full Council authorized departments to use the *Thresholds Guide* in CEQA analyses in August 2001 (see Council File 98-2064).

For information, and to view or download a copy of the *Thresholds Guide*, please point your browser to EAD's Home Page at <http://www.lacity.org/EAD>, and click on CEQA/.

INTRODUCTION

PREFACE

The *L.A. CEQA Thresholds Guide: Your Resource for Preparing CEQA Analyses in Los Angeles (Thresholds Guide)* is a guidance document that draws together practical information useful to City staff, project proponents, and the public involved in the environmental review of projects subject to the California Environmental Quality Act (CEQA). The *Thresholds Guide* is a resource available to provide information to those interested in the CEQA process.

The *Thresholds Guide* provides assistance in evaluating the significance of project impacts on 46 of the most common environmental issues in the City of Los Angeles. This guidance is supplemented by an introduction to each issue area, a recommended analysis method for project impacts, guidance for environmental setting and cumulative impact sections, sample mitigation measures, and references. The *Thresholds Guide* is geared toward readers familiar with the CEQA process. For additional information on the terminology and requirements of CEQA, please refer to the Glossary to the *Thresholds Guide*, The Los Angeles City CEQA Guidelines (City CEQA Guidelines), the State Guidelines for Implementation of the California Environmental Quality Act (State CEQA Guidelines) or the City's Guide to Understanding CEQA in the City of Los Angeles.

The preparation of the *Thresholds Guide* was initiated as part of the City's Development Reform efforts to streamline the City's permit and development processes. It is a tool that compiles information that is useful in the preparation of environmental documents. This information can be used to improve the level of consistency, predictability, and objectivity of the City's environmental documents, while reducing costs and time delays in the environmental review process.

CEQA requires the analysis of discretionary projects to disclose their potential effects on the environment and to allow public participation in the environmental review process. Central to the implementation of CEQA is the identification of "significant" or "potentially significant" impacts that would occur as a result of a proposed project, as this determines the level of review required and the need for mitigation measures to reduce or eliminate project impacts. For projects needing discretionary approval from the City of Los Angeles, the department granting the approval generally acts as the lead agency on behalf of the City and is known as the lead City agency.

The *Thresholds Guide* applies only to those non-exempt projects subject to CEQA that require an Initial Study, negative declaration, mitigated negative declaration, or EIR. It applies both to public and private projects, including residential, commercial, institutional, industrial, and infrastructure projects. Most screening criteria and significance thresholds also apply to Master planned developments, specific plans, zone changes, and other “plan” level proposals.

The *Thresholds Guide* does not impact the existing discretionary authority of decision-makers, although the guidance contained in it could provide more complete information to these decision-makers. The *Thresholds Guide* does not replace or invalidate the City’s CEQA Guidelines, as it addresses the content of environmental documents as opposed to procedural requirements. It has no effect on the City’s list of projects exempt from the CEQA process (see Article X of the City CEQA Guidelines, which lists project types eligible for categorical exemptions). The *Thresholds Guide* can be used as a complement to existing department procedures for processing CEQA documents, by building on the information in the CEQA Guidelines and providing technical assistance for the environmental analysis and determination of significance. The *Thresholds Guide* does not change the authority of the lead agency, as identified in the State CEQA Guidelines, to determine significance thresholds on a case-by-case basis dependent upon unique environments, evolving regulatory requirements, and the nature of projects encountered by each lead agency.

The guidance in the *Thresholds Guide* does not substitute for the use of independent judgment to determine significance or the evaluation of the evidence in the record, but is intended to provide sufficient flexibility to use the most appropriate criteria for a particular project. CEQA includes additional topics and requirements that are not addressed in the *Thresholds Guide*. The project evaluator and lead agency are still responsible for all CEQA requirements, whether or not they are discussed in the *Thresholds Guide*. The City CEQA Guidelines, the State CEQA Guidelines, and other references describe all of the requirements of the CEQA process and should be consulted if additional assistance is required.

As noted above, the fundamental purpose of CEQA is to publicly disclose and evaluate potential environmental impacts associated with proposed projects. As such, CEQA contains specific public notification and participation requirements. In addition, City policy in the General Plan Framework Element and a similar policy in the Transportation Element is to “assure that (sic) fair treatment of people of all races, cultures, incomes and education levels with respect to the development, implementation and enforcement of environmental laws, regulations, and policies, including affirmative efforts to inform and involve environmental groups, especially environmental justice groups, in early planning stages through notification

and two-way communication.¹” This assurance may involve efforts to identify and reach affected populations, including low-income communities and communities of color.

CONTENT AND USE

The *Thresholds Guide* presents two sets of criteria to evaluate project impacts: the screening and significance criteria. The screening criteria provide assistance in responding to Initial Study Checklist questions, and can help determine when further study is needed to decide whether a significant impact could potentially occur. Additional study (either in the context of an expanded Initial Study, negative declaration, or EIR) will assist project evaluators in determining whether the project impact falls above or below the significance threshold. The significance threshold identifies the level of impact over which mitigation (or a Statement of Overriding Considerations, if mitigation is not feasible) is required.

By defining screening criteria and significance thresholds, the *Thresholds Guide* provides guidance in determining the appropriate environmental document required for a project within the City of Los Angeles – negative declaration, mitigated negative declaration, or environmental impact report (EIR) – and whether a project’s impacts would be presumed significant under normal circumstances, and therefore, require mitigation. The existence of screening criteria and significance thresholds may also encourage project proponents to incorporate impact-reducing measures into project designs, prior to submitting project applications to the City, to reduce potential impacts below the significance level.

The screening criteria and significance thresholds presented in the *Thresholds Guide* are based on a variety of factors, including existing local, state, and federal regulations, administrative practices of other public agencies, and commonly accepted professional standards (common practice). Each threshold was then reviewed with respect to meeting the following goals: objectivity and applicability, defensibility, practicality, nexus between impacts and mitigation, and legal liability. This document, therefore, represents a compilation of existing information and practices and does not introduce new evaluation methods, nor does it diminish the value of independent judgment on the part of the project evaluator. However, the guidance provided in the *Thresholds Guide* can simplify the CEQA process by providing a consistent set of criteria applicable to most discretionary projects in the City. Because evaluation practices continue to evolve due to changing regulations, scientific methods, and court decisions, the project evaluator and lead City agency should always use the best information and evaluation methods available, including those from sources other than the *Thresholds Guide*.

¹ *City of Los Angeles, General Plan Framework Element, Policy 3.1.9, page 3-8.*

There are three types of significance thresholds identified in the *Thresholds Guide*: quantitative, qualitative, and case-by-case (also called factors for consideration). Quantitative thresholds provide a measurable criterion with which to compare one or more characteristics of the proposed project, such as “the vehicle-to-capacity ratio increase at a study intersection is greater than 0.020.” A qualitative threshold requires comparison to non-numerical criteria, such as “interference with a wildlife movement corridor.” For some issue areas, a definitive threshold could not be established, either because the significance of impacts is specific to site conditions or project operations, or because there is no consistent technical guidance available. For these issues, the case-by-case thresholds provide factors for the project evaluator to consider, in light of specific project circumstances, in the determination of significance.

The *Thresholds Guide* does not identify thresholds for all issues found in the State’s Initial Study Checklist, but focuses on those that are most commonly of concern throughout the City. In addition, the *Thresholds Guide* provides information on the topic of Shading, which is not listed in the Initial Study Checklist. It also provides expanded information on transportation issues, consistent with the City Department of Transportation’s traffic study policies and procedures.

The impact resulting from a particular action depends on the project setting, design, and operational components. Therefore, the use of the *Thresholds Guide* may be appropriate for projects located within City boundaries under “normal” conditions, but there may be circumstances in which another set of criteria better applies to the proposed action or setting, and should be used for the determination of significance. For City-sponsored projects located outside City boundaries, City departments conducting CEQA review must consider the local environmental setting, as well as applicable regulations and policies, and determine if another set of criteria applies or is more appropriate.

Since conditions may vary depending upon the type of project and/or approval that is required, the lead City agency responsible for the implementation of CEQA for a particular project may develop internal departmental direction (e.g., thresholds), not inconsistent with the guidance in the *Thresholds Guide*, to address issues that commonly arise within the jurisdiction of that department. Project applicants should consult with the lead City department regarding any additional or further defined screening criteria or significance thresholds that may apply.

The case study and flowcharts in Exhibits 1-4 illustrate the process of using the screening criteria and significance thresholds, and how their use relates to the Initial Study Checklist and the impact evaluation process. The exhibits all assume that a project is not exempt from CEQA

requirements. The case study (Exhibit 1) assesses operational noise impacts for four project types by posing a series of questions about each “project.” This exercise concludes with an Initial Study evaluation and a determination of the type of CEQA document appropriate for that project. The flowcharts (Exhibits 2-4) describe the steps in conceptual terms, focusing on three phases of the CEQA process: 1) the Initial Study Checklist Process (using the screening and significance criteria to determine which boxes to check on the Checklist); 2) the Initial Study Determination (what type of CEQA document to prepare); and 3) the Impact Evaluation and Mitigation Process. The impact from a particular project may fall (a) below the screening criteria, (b) between the screening criteria and the significance threshold, or (c) above the significance threshold.

Exhibit 1

CASE STUDY: OPERATIONAL NOISE

Initial Study Checklist Questions

X.a): Would the proposal result in increases in existing noise levels?

X.b): Would the proposal result in exposure of people to severe noise levels?

Initial Study Screening Criteria

- Would the proposed project introduce a stationary noise source that is likely to be audible beyond the property line of the project site?
- Would the project include 75 or more dwelling units or 100,000 square feet (sf) or greater of nonresidential development, or have the potential to generate 1,000 or more average daily vehicle trips (ADT)?

Significance Threshold

A project would normally have a significant impact on noise levels from project operation if the project causes the ambient noise level measured at the property line of an affected use to increase by 3 decibels (dBA) or more in community noise equivalency level (CNEL) to or within the "normally unacceptable" or "clearly unacceptable" category of the noise exposure chart prepared by the California Department of Health Services (DHS), or any 5 dBA or greater noise increase.

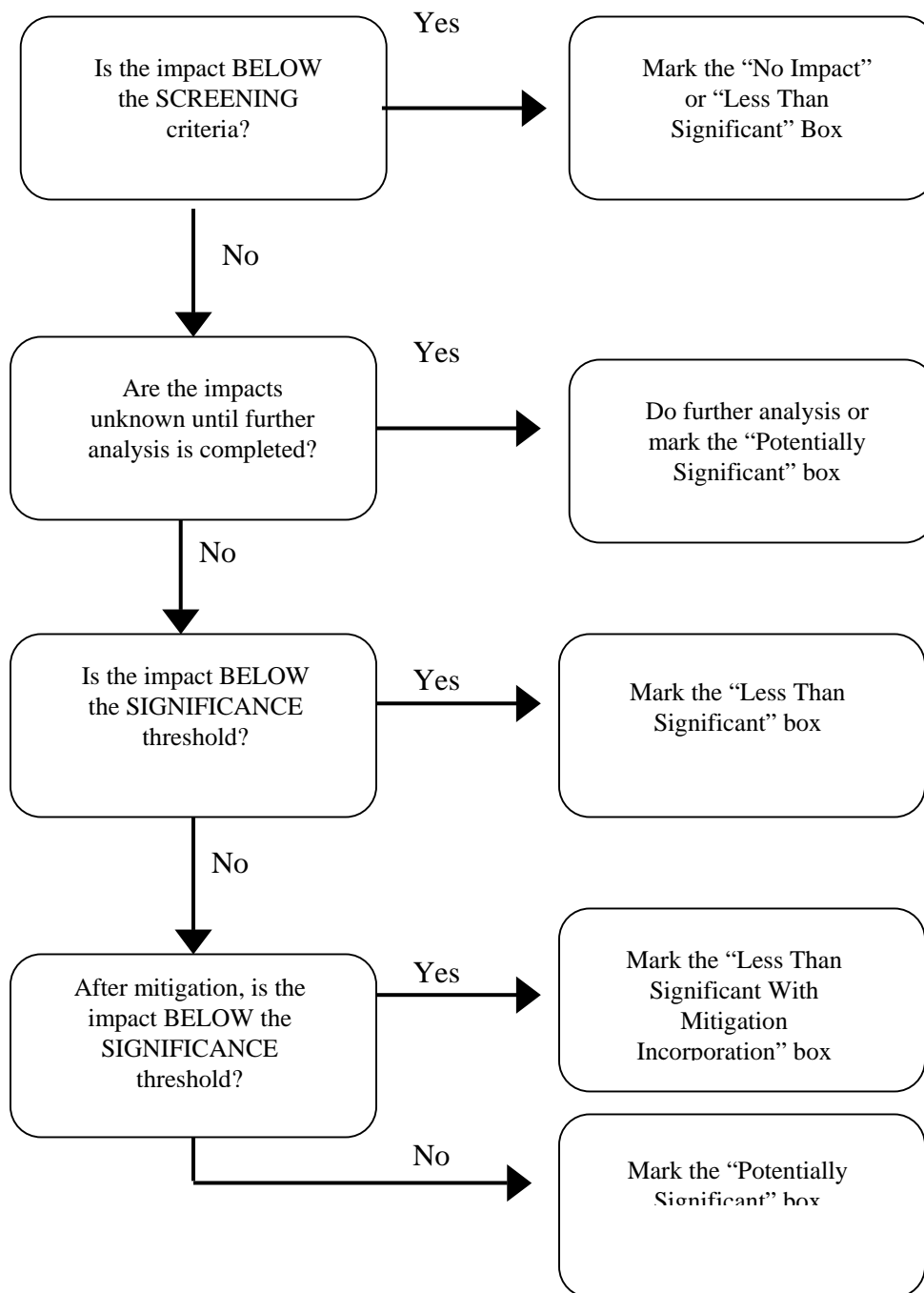
| Case | Introduce Stationary Source with Noise Emissions Audible Beyond Property Line? | Include more than 75 du, 100,000 sf nonresidential, or 1,000 ADT? | Increase in Ambient Level? | Increase Remaining After Mitigation | Initial Study Evaluation | Results/ Document Prepared |
|------|--|---|----------------------------|-------------------------------------|--|----------------------------|
| 1 | No | No | - | - | No Impact | Neg Dec |
| 2 | No | Yes | 2 dBA | - | Less Than Significant Impact | Neg Dec |
| 3 | Yes | No | 5 dBA | 2.5 dBA | Potentially Significant Unless Mitigation Incorporated | Mitigated Neg Dec |
| 4 | Yes | Yes | 7 dBA | 5 dBA | Potentially Significant Impact | EIR |

Notes: Assumes project is not exempt under CEQA.

The noise exposure chart prepared by the DHS is reproduced in the *Thresholds Guide*.

If the noise level before and/or after mitigation is not known or cannot be determined, additional analysis could be undertaken prior to completing the Initial Study Evaluation or within an EIR.

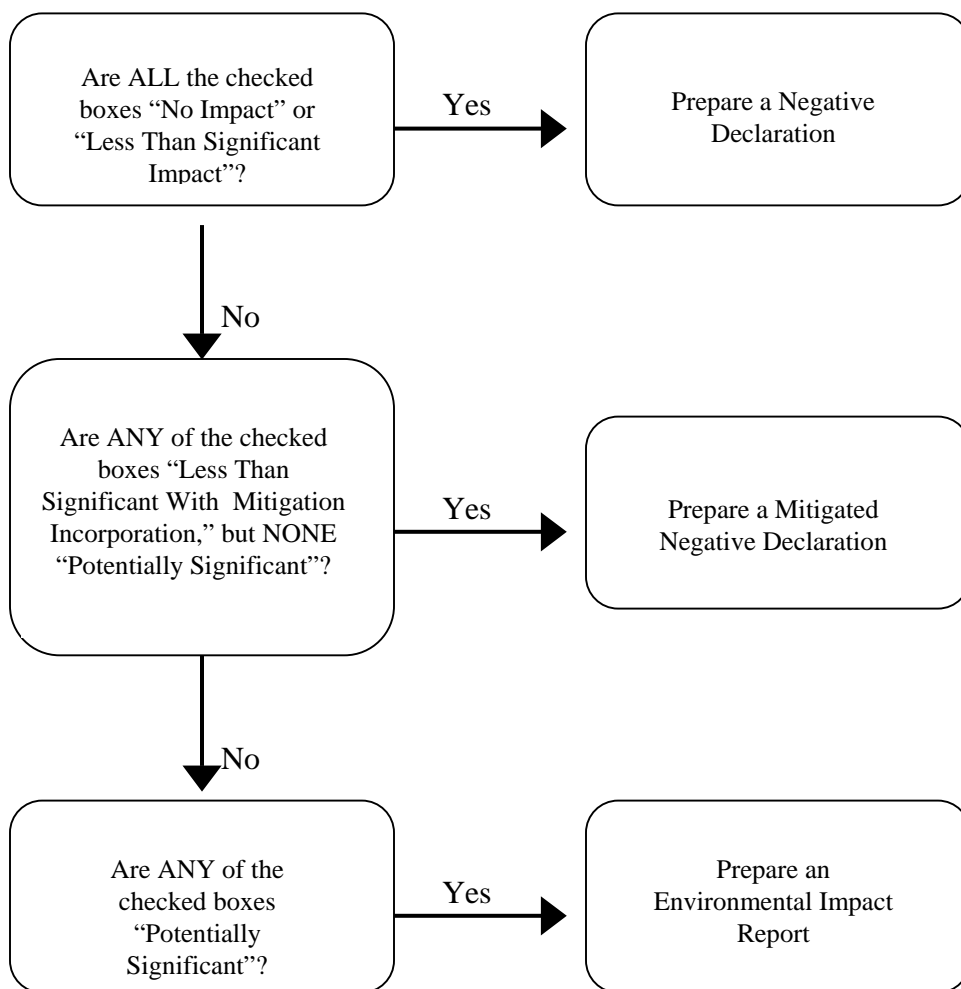
Exhibit 2 INITIAL STUDY CHECKLIST PROCESS*



*

Assumes the project has had no previous review and is not exempt under CEQA.

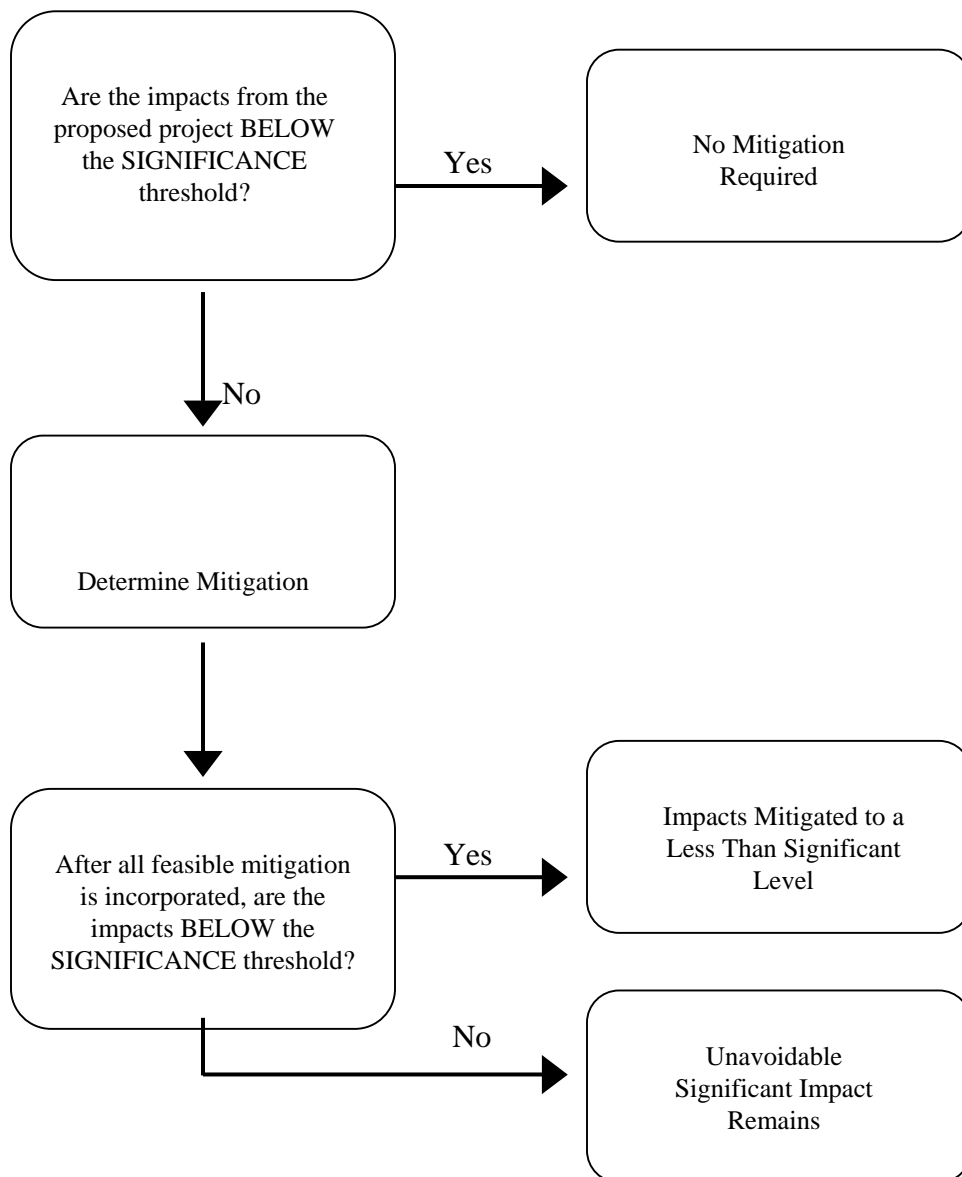
Exhibit 3 INITIAL STUDY DETERMINATION*



*

Assumes the project is not exempt under CEQA.

Exhibit 4 IMPACT EVALUATION AND MITIGATION PROCESS



Note: If a project would result in one or more significant impacts, the lead agency, prior to project approval, must adopt certain findings as stated in CEQA Section 21081. Additional requirements related to mitigation measures are described in Section 21081.6.

DOCUMENT STRUCTURE

The *Los Angeles CEQA Thresholds Guide* is arranged by issue area, generally in the same order in which the issues appear in the State's Initial Study Checklist. The major environmental categories covered in the document are as follows:

- Air Quality
- Biological Resources
- Cultural Resources
- Geology
- Hazards
- Land Use
- Noise
- Population and Housing
- Public Services
- Public Utilities
- Transportation
- Visual Resources
- Water Resources

For each environmental issue area, the following information is provided:

1. Initial Study Screening Process

Initial Study Checklist Question: This lists the question(s) from the State's Initial Study Checklist addressed within this issue area.

Introduction: The introduction provides a brief description of the issue area, including what types of project activities could be expected to have an impact, how the resource/issue would be affected, and important regulatory agencies and/or regulations.

Screening Criteria: The screening criteria assist in deciding when further study (additional review) is needed to determine whether a project impact could be significant. It assumes that the project is not exempt from CEQA requirements. Criteria are phrased as yes/no questions. For many issue areas, further study is recommended when one or more questions are answered with a "yes." A "no" response to all questions indicates that further study is not required, and there would normally be no significant impact from the proposed project on the subject issue.

Evaluation of Screening Criteria: This section contains any additional information needed to apply the screening criteria and identifies references that may be used in the evaluation.

2. Determination of Significance

Significance Threshold: The significance threshold provides guidance in determining whether or not a project impact would be significant. The threshold assumes that a project

exceeds the screening criteria. The quantitative and qualitative thresholds are phrased in the positive, so that if the project meets one or more of the criteria listed (a “yes” response), it would normally be considered to have a significant impact on the environment. Where a definitive threshold is not available, the *Thresholds Guide* provides case-by-case thresholds which consist of a list of conditions or criteria to be considered for an individual determination of significance.

Environmental Setting: This section identifies the type of information that is appropriate for a project setting or background section.

Project Impacts: This section provides a recommended methodology with which to analyze the proposed project, including the identification and evaluation of direct and indirect impacts, as appropriate, that may occur during construction or operation. It also identifies sources of relevant information and technical resources, and provides the basic steps to follow in the analysis. Impact methodologies are assumed to apply to both project level and plan level analyses unless otherwise specified. Other analysis methods may be appropriate, depending on project circumstances.

Cumulative Impacts: This section presents a method to evaluate cumulative impacts, based on either a related projects list or a planned development approach (the amount of overall growth expected for the project area, according to planning documents or forecasts, by the time of project completion). The methodology describes only the type of analysis that is appropriate and does not address the size or location of related projects to consider in the analysis. In cases where the methodology is the same as that for project impacts, the project impact section is referenced rather than repeating the information.

Sample Mitigation Measures: This section provides a sample list of measures that may be used to reduce project impacts. It does not address specific mitigation measures for certain project types, nor does it recommend or prioritize mitigation measures. Consideration of alternative projects (e.g., smaller scale, different uses) to reduce impacts is assumed to be part of the project alternatives analysis required in an EIR and is not included in the sample mitigation measures listed in the *Thresholds Guide*.

3. Data, Resources, and References

This section provides additional information related to the environmental issue. It may contain references to agencies or others with expertise in the subject area, reference documents, and selected legislation. For references that do not identify an agency or author, the entry refers to the City of Los Angeles. Several sections also provide exhibits and/or supplemental background information that illustrates or further explains concepts addressed in the section.

CONTRIBUTORS

Interdepartmental CEQA Manual Subcommittee

Mayor's Office
Building and Safety
Chief Legislative Analyst's Office
City Attorney's Office
Community Development Department
Community Redevelopment Agency
Department of City Planning
Department of Transportation
Department of Water and Power
Environmental Affairs Department
Fire Department
Harbor Department
Housing Department
Los Angeles World Airports
Public Works/Bureau of Engineering
Public Works/Integrated Solid Waste Management Office
Public Works/Bureau of Sanitation
Public Works/Bureau of Street Lighting
Recreation and Parks

Consultant Team

Planning Consultants Research (PCR)
Gregory Broughton, Principal
Laura Kaufman, Project Manager
Camp Dresser & McKee Inc.
Greenwood and Associates
Hamilton, Rabinovitz & Alschuler, Inc.
Historic Resources Group
Frank Hovore & Associates
Kaku Associates
Koral & Company
Psomas and Associates
RMW Paleo Associates

Pacific Rim Environmental, Julia Baucke

Environ Corporation

**INITIAL STUDY CHECKLIST QUESTIONS AND
RELATED SECTIONS IN L.A. CEQA THRESHOLDS GUIDE**

| INITIAL STUDY CHECKLIST QUESTION | THRESHOLDS GUIDE SECTION |
|--|---|
| I. AESTHETICS: <i>Would the project:</i> | |
| a) Have a substantial adverse effect on a scenic vista? | A.1 Aesthetics
A.2 Obstruction of Views |
| b) Substantially damage scenic resources, including, but not limited to, trees, rock outcroppings, and historic buildings within a state scenic highway? | A.1 Aesthetics
E.3 Landform Alterations |
| c) Substantially degrade the existing visual character or quality of the site and its surroundings? | A.1 Aesthetics
A.3 Shading |
| d) Create a new source of substantial light or glare, which would adversely affect day or nighttime views in the area? | (Glare Not Addressed)
A.4 Nighttime Illumination |

**INITIAL STUDY CHECKLIST QUESTIONS AND
RELATED SECTIONS IN L.A. CEQA THRESHOLDS GUIDE, continued**

| INITIAL STUDY CHECKLIST QUESTION | THRESHOLDS GUIDE SECTION |
|--|--|
| <p>II. AGRICULTURE RESOURCES: <i>In determining whether impacts to agricultural resources are significant environmental effects, lead agencies may refer to the California Agricultural Land Evaluation and Site Assessment Model (1997) prepared by the California Department of Conservation as an optional model to use in assessing impacts on agriculture and farmland. Would the project:</i></p> | <p>(Agriculture
Not Addressed)</p> |
| <p>III. AIR QUALITY: <i>Where available, the significance criteria established by the applicable air quality management or air pollution control district may be relied upon to make the following determinations. Would the project:</i></p> | |
| <p>a) Conflict with or obstruct implementation of the applicable air quality plan?</p> | <p>B.1 Construction Emissions
B.2 Operational Emissions
B.3 Toxic Air Contaminants</p> |
| <p>b) Violate any air quality standard or contribute substantially to an existing or projected air quality violation?</p> | <p>B.1 Construction Emissions
B.2 Operational Emissions
B.3 Toxic Air Contaminants</p> |

**INITIAL STUDY CHECKLIST QUESTIONS AND
RELATED SECTIONS IN L.A. CEQA THRESHOLDS GUIDE, continued**

| INITIAL STUDY CHECKLIST QUESTION | THRESHOLDS GUIDE SECTION |
|--|---|
| c) Result in a cumulatively considerable net increase of any criteria pollutant for which the project region is non-attainment under an applicable federal or state ambient air quality standard (including releasing emissions which exceed quantitative thresholds for ozone precursors)? | B.1 Construction Emissions
B.2 Operational Emissions |
| d) Expose sensitive receptors to substantial pollutant concentrations? | B.1 Construction Emissions
B.2 Operational Emissions
B.3 Toxic Air Contaminants |
| e) Create objectionable odors affecting a substantial number of people? | B.2 Operational Emissions |
| IV. BIOLOGICAL RESOURCES: Would the project: | |
| a) Have a substantial adverse effect, either directly or through habitat modifications, on any species identified as a candidate, sensitive, or special status species in local or regional plans, policies, or regulations, or by California Department of Fish and Game or U.S. Fish and Wildlife Service? | C. Biological Resources |

**INITIAL STUDY CHECKLIST QUESTIONS AND
RELATED SECTIONS IN L.A. CEQA THRESHOLDS GUIDE, continued**

| <u>INITIAL STUDY CHECKLIST QUESTION</u> | <u>THRESHOLDS GUIDE SECTION</u> |
|---|---------------------------------|
| b) Have a substantial adverse effect on any riparian habitat or other sensitive natural community identified in local or regional plans, policies, or regulations or by the California Department of Fish and Game or U.S. Fish and Wildlife Service? | C. Biological Resources |
| c) Have a substantial adverse effect on federally protected wetlands as defined by Section 404 of the Clean Water Act (including but not limited to, marsh, vernal pool, coastal, etc.) through direct removal | C. Biological Resources |
| d) Interfere substantially with the movement of any native resident or migratory fish or wildlife species or with established native resident or migratory wildlife corridors, or impede the use of native wildlife nursery sites? | C. Biological Resources |
| e) Conflict with any local policies or ordinances protecting biological resources, such as a tree preservation policy or ordinance? | C. Biological Resources |
| f) Conflict with the provisions of an adopted Habitat Conservation Plan, or other approved local, regional, or state habitat conservation plan? | C. Biological Resources |

**INITIAL STUDY CHECKLIST QUESTIONS AND
RELATED SECTIONS IN L.A. CEQA THRESHOLDS GUIDE, continued**

| | | |
|---|--|---|
| V. CULTURAL RESOURCES: <i>Would the project:</i> | | |
| a) | Cause a substantial adverse change in the significance of a historical resource as defined in '15064.5? | D.3 Historical Resources |
| b) | Cause a substantial adverse change in the significance of an archaeological resource pursuant to '15064.5? | D.2 Archaeological Resources |
| c) | Directly or indirectly destroy a unique paleontological resource or site or unique geologic feature? | D.1 Paleontological Resources
E.3 Landform Alterations |
| d) | Disturb any human remains, including those interred outside of formal cemeteries? | D.2 Archaeological Resources |

**INITIAL STUDY CHECKLIST QUESTIONS AND
RELATED SECTIONS IN L.A. CEQA THRESHOLDS GUIDE, continued**

| | | |
|---|--|-------------------------------|
| VI. GEOLOGIC PROBLEMS: <i>Would the project:</i> | | |
| a) | Expose people to potential substantial adverse effects, including the risk of loss, injury, or death involving: | |
| i) | Rupture of a known earthquake fault, as delineated on the most recent Alquist-Priolo Earthquake Fault Zoning Map issued by the State Geologist for the area or based on other substantial evidence of a known fault? Refer to Division of Mines and Geology Special Publications 42. | E.1 Geologic Hazards |
| ii) | Strong seismic ground shaking? | E.1 Geologic Hazards |
| iii) | Seismic-related ground failure, including liquefaction? | E.1 Geologic Hazards |
| iv) | Landslides? | E.1 Geologic Hazards |
| b) | Result in substantial soil erosion or the loss of topsoil? | E.2 Sedimentation and Erosion |
| c) | Be located on a geologic unit or soil that is unstable, or that would become unstable as a result of the project, and potentially result in on- or off-site landslide, lateral spreading, subsidence, liquefaction or collapse? | E.1 Geologic Hazards |

**INITIAL STUDY CHECKLIST QUESTIONS AND
RELATED SECTIONS IN L.A. CEQA THRESHOLDS GUIDE, continued**

| | | |
|----|---|-------------------------|
| d) | Be located on expansive soil, as defined in Table 18-1-B of the Uniform Building Code (1994), creating substantial risks of life or property? | Not Addressed |
| e) | Have soils incapable of adequately supporting the use of septic tanks or alternative waste water disposal systems where sewers are not available for the disposal of waste water? | E.3 Landform Alteration |

VII. HAZARDS AND HAZARDOUS MATERIALS: *Would the project:*

| | | |
|----|--|--|
| a) | Create a significant hazard to the public or the environment through the routine transport, use, or disposal of hazardous materials? | F.1 Risk of Upset/Emergency Preparedness
F.2 Human Health Hazards |
| b) | Create a significant hazard to the public or the environment through reasonably foreseeable upset and accident conditions involving the release of hazardous materials into the environment? | F.1 Risk of Upset/Emergency Preparedness
F.2 Human Health Hazards |
| c) | Emit hazardous emissions or handle hazardous or acutely hazardous materials, substances, or waste within one-quarter mile of an existing or proposed school? | F.2 Human Health Hazards |

**INITIAL STUDY CHECKLIST QUESTIONS AND
RELATED SECTIONS IN L.A. CEQA THRESHOLDS GUIDE, continued**

| | | | |
|----|--|------------|--|
| d) | Be located on a site which is included on a list of hazardous materials sites compiled pursuant to Government Code Section 65962.5 and as a result, would it create a significant hazard to the public or the environment? | F.2 | Human Health Hazards |
| e) | For a project located within an airport land use plan or where such a plan has not been adopted, within two miles of a public airport or public use airport, would the project result in a safety hazard for people residing or working in the project area? | F.1
K.2 | Risk of Upset/Emergency Preparedness
Fire Protection & Emergency Medical Services |
| f) | For a project within the vicinity of a private airstrip, would the project result in a safety hazard for people residing or working within the project area? | F.1
K.2 | Risk of Upset/Emergency Preparedness
Fire Protection & Emergency Medical Services |
| g) | Impair implementation of or physically interfere with an adopted emergency response plan or emergency evacuation plan? | F.1
K.2 | Risk of Upset/Emergency Preparedness
Fire Protection & Emergency Medical Services |
| h) | Expose people or structures to a significant risk of loss, injury or death involving wildland fires, including where wildlands are adjacent to urbanized areas or where residences are intermixed with wildlands? | K.2 | Fire Protection & Emergency Medical Services |

**INITIAL STUDY CHECKLIST QUESTIONS AND
RELATED SECTIONS IN L.A. CEQA THRESHOLDS GUIDE, continued**

VIII. HYDROLOGY AND WATER QUALITY: *Would the project:*

| | | |
|---|------------|--|
| a) Violate any water quality standards or waste discharge requirements? | G.2 | Surface Water Quality |
| b) Substantially deplete groundwater supplies or interfere substantially with groundwater recharge such that there would be a net deficit in aquifer volume or a lowering of the local groundwater table level (e.g., the production rate of pre-existing nearby wells would drop to a level which would not support existing land uses or planned uses for which permits have been granted)? | G.2
G.3 | Surface Water Quality
Groundwater Level |
| c) Substantially alter the existing drainage pattern of the site or area, including through the alteration of the course of a stream or river, in a manner which would result in substantial erosion or siltation on- or off-site? | G.1
G.2 | Surface Water Hydrology
Surface Water Quality |
| d) Substantially alter the existing drainage pattern of the site or area, including through the alteration of the course of a stream or river, or substantially increase the rate or amount of surface runoff in a manner which would result in flooding on- or off-site? | G.1 | Surface Water Hydrology |

**INITIAL STUDY CHECKLIST QUESTIONS AND
RELATED SECTIONS IN L.A. CEQA THRESHOLDS GUIDE, continued**

| | | | |
|----|--|--------------------------|--|
| e) | Create or contribute runoff water which would exceed the capacity of existing or planned stormwater drainage systems or provide substantial additional sources of polluted runoff? | G.1 | Surface Water Hydrology |
| f) | Otherwise substantially degrade water quality? | G.3 | Groundwater Level |
| g) | Place housing within a 100-year flood hazard area as mapped on a federal flood hazard Boundary or flood Insurance Rate Map or other flood hazard delineation map? | G.1
G.2
G.3
G.4 | Surface Water Hydrology
Surface Water Quality
Groundwater Level
Groundwater Quality |
| h) | Place within a 100-year flood hazard area structures which would impede or redirect flood flows? | G.4 | Groundwater Quality |
| i) | Expose people or structures to a significant risk of loss, injury or death involving flooding, including flooding as a result of the failure of a levee or dam? | G.1
G.3 | Surface Water Hydrology
Groundwater Level |
| j) | Inundation by seiche, tsunami, or mudflow? | E.1
G.3 | Geologic Hazards
Groundwater Level |

**INITIAL STUDY CHECKLIST QUESTIONS AND
RELATED SECTIONS IN L.A. CEQA THRESHOLDS GUIDE, continued**

| | | |
|---|---|--|
| IX. LAND USE AND PLANNING: <i>Would the project:</i> | | |
| a) | Physically divide an established community? | H.2 Land Use Compatibility |
| b) | Conflict with any applicable land use plan, policy, or regulation of an agency with jurisdiction over the project (including, but not limited to the general plan, specific plan, local coastal program, or zoning ordinance) adopted for the purpose of avoiding mitigating an environmental effect? | H.1 Land Use Consistency
H.2 Land Use Compatibility |
| c) | Conflict with any applicable habitat conservation plan or natural community conservation plan? | H.1 Land Use Consistency
H.2 Land Use Compatibility |
| X. MINERAL RESOURCES: <i>Would the project:</i> | | |
| a) | Result in the loss of availability of a known mineral resource that would be of value to the region and the residents of the state? | E.4 Mineral Resources |
| b) | Result in the loss of availability of a locally-important mineral resource recovery site delineated on a local general plan, general plan, or other land use plan? | E.4 Mineral Resources |

**INITIAL STUDY CHECKLIST QUESTIONS AND
RELATED SECTIONS IN L.A. CEQA THRESHOLDS GUIDE, continued**

XI. NOISE: *Would the project result in:*

| | | | |
|----|--|--------------------------|--|
| a) | Exposure of persons to or generation of noise levels in excess of standards established in the local general plan or noise ordinance, or applicable standards of other agencies? | I.1
I.2
I.3
I.4 | Construction Noise
Operational Noise
Railroad Noise
Airport Noise |
| b) | Exposure of persons to or generation of excessive groundborne vibration or groundborne noise levels? | I.1
I.2
I.3
I.4 | Construction Noise
Operational Noise
Railroad Noise
Airport Noise |
| c) | A substantial permanent increase in ambient noise levels in the project vicinity above levels existing without the project? | I.2
I.3
I.4 | Operational Noise
Railroad Noise
Airport Noise |
| d) | A substantial temporary or periodic increase in ambient noise levels in the project vicinity above the existing without the project? | I.1
I.2
I.3
I.4 | Construction Noise
Operational Noise
Railroad Noise
Airport Noise |

**INITIAL STUDY CHECKLIST QUESTIONS AND
RELATED SECTIONS IN L.A. CEQA THRESHOLDS GUIDE, continued**

| | | | |
|---|--|-------------------|--|
| e) | For a project located within an airport land use plan or, where such a plan has not been adopted, within two miles of a public airport or public use airport, would the project expose people residing or working in the project area to excessive noise levels? | I.1
I.2
I.4 | Construction Noise
Operational Noise
Airport Noise |
| f) | For a project within the vicinity of a private airstrip, would the project expose people residing or working in the project area to excessive noise levels? | I.1
I.2
I.4 | Construction Noise
Operational Noise
Airport Noise |
| XII. POPULATION AND HOUSING: <i>Would the project:</i> | | | |
| a) | Induce substantial population growth in an area, either directly (for example, by proposing new homes and businesses) or indirectly (for example, through extension of roads or other infrastructure)? | J.1 | Population and Housing Growth |
| b) | Displace substantial numbers of existing housing, necessitating the construction of replacement housing elsewhere? | J.1
J.2 | Population and Housing Growth
Population and Housing Displacement |
| c) | Displace substantial numbers of existing people, necessitating the construction of replacement housing elsewhere | J.2 | Population and Housing Displacement |

**INITIAL STUDY CHECKLIST QUESTIONS AND
RELATED SECTIONS IN L.A. CEQA THRESHOLDS GUIDE, continued**

XIII. PUBLIC SERVICES: *Would the project:*

a) Result in substantial adverse physical impacts associated with the provision of new or physically altered governmental facilities, need for new or physically altered governmental facilities, the construction of which could cause significant environmental impacts, in order to maintain acceptable service ratios, response times or other performance objectives for any of the above public services:

i) Fire protection?

K.2 Fire Protection & Emergency Medical Services

ii) Police protection

K.1 Police Protection

iii) Schools?

K.3 Public Schools

iv) Parks?

K.4 Recreation and Parks

v) Other public facilities?

K.5 Libraries

**INITIAL STUDY CHECKLIST QUESTIONS AND
RELATED SECTIONS IN L.A. CEQA THRESHOLDS GUIDE, continued**

XIV. RECREATION:

- | | | | |
|----|---|-----|----------------------|
| a) | Would the project increase the use of existing neighborhood and regional parks or other recreational facilities such that substantial physical deterioration of the family would occur or be accelerated? | K.4 | Recreation and Parks |
| b) | Does the project include recreational facilities or require the construction or expansion of recreational facilities which might have an adverse physical effect on the environment? | K.4 | Recreation and Parks |

XV. TRANSPORTATION/TRAFFIC: *Would the project:*

- | | | | |
|----|--|---------------------------------|--|
| a) | Cause an increase in traffic which is substantial in relation to the existing traffic load and capacity of the street system (i.e., result in a substantial increase in either the number of vehicle trips, the volume to capacity ratio on roads, or congestion at intersections? | L.1
L.2
L.3
L.4
L.8 | Intersection Capacity
Street Segment Capacity
Freeway Capacity
Neighborhood Intrusion Impacts
In-Street Construction Impacts |
| b) | Exceed, either individually or cumulatively, a level of service standard established by the county congestion management agency for designated roads or highways? | L.1
L.2
L.3 | Intersection Capacity
Street Segment Capacity
Freeway Capacity |

**INITIAL STUDY CHECKLIST QUESTIONS AND
RELATED SECTIONS IN L.A. CEQA THRESHOLDS GUIDE, continued**

| | | |
|---|---|--|
| c) | Result in a change in air traffic patterns, including either an increase in traffic levels or a change in location that results in substantial safety risks? | Not Addressed |
| d) | Substantially increase hazards due to a design feature (e.g., sharp curves or dangerous intersections) or incompatible uses (e.g., farm equipment)? | Not Addressed |
| e) | Result in inadequate emergency access? | L.5 Project Access |
| f) | Result in inadequate parking capacity? | L.7 Parking |
| g) | Conflict with adopted policies, plans, or programs supporting alternative transportation (e.g., bus turnouts, bicycle racks)? | L.6 Transit System Capacity |
| XVI. UTILITIES AND SERVICE SYSTEMS: Would the project: | | |
| a) | Exceed wastewater treatment requirements of the applicable Regional Water Quality Control Board? | M.2 Wastewater |
| b) | Require or result in the construction of new water or wastewater treatment facilities, the construction of which could cause significant environmental effects? | G.1 Surface Water Hydrology
M.1 Water
M.2 Wastewater |

**INITIAL STUDY CHECKLIST QUESTIONS AND
RELATED SECTIONS IN L.A. CEQA THRESHOLDS GUIDE, continued**

| | | | |
|----|--|-----|-------------------------|
| c) | Require or result in the construction of new storm water drainage facilities or expansion of existing facilities, the construction of which could cause significant environmental effects? | G.1 | Surface Water Hydrology |
| d) | Have sufficient water supplies available to serve the project from existing entitlements and resources, or are new or expanded entitlements needed? | M.2 | Wastewater |
| e) | Result in a determination by the wastewater treatment provider which serves or may serve the project that it has adequate capacity to serve the project's projected demand in addition to the provider's existing commitments? | M.1 | Water |
| f) | Be served by a landfill with sufficient permitted capacity to accommodate the project's solid waste disposal needs? | K.2 | Wastewater |
| g) | Comply with federal, state, and local statutes and regulations related to solid waste? | K.3 | Solid Waste |
| | | M.3 | Solid Waste |

**INITIAL STUDY CHECKLIST QUESTIONS AND
RELATED SECTIONS IN L.A. CEQA THRESHOLDS GUIDE, continued**

XVII. MANDATORY FINDINGS OF SIGNIFICANCE: *Does the project:*

- | | | |
|----|--|---|
| a) | Have the potential to degrade the quality of the environment, substantially reduce the habitat of a fish or wildlife species, cause a fish or wildlife population to drop below self-sustaining levels, threaten to eliminate a plant or animal community, reduce the number or restrict the range of a rare or endangered plant or animal or eliminate important examples of the major periods of California history or prehistory? | All sections, particularly:
C. Biological Resources
D.1 Paleontological Resources
D.2 Archaeological Resources
D.3 Historical Resources |
| b) | Have impacts that are individually limited, but cumulatively considerable? (“Cumulatively considerable” means that the incremental effects of a project are considerable when viewed in connection with the effects of past projects, the effects of other current projects, and the effects of probable future projects)? | All Sections |
| c) | Have environmental effects which will cause substantial adverse effects on human beings, either directly or indirectly? | Not addressed specifically, each section addresses indirectly |

LIST OF ABBREVIATIONS/ACRONYMS

| | |
|---------------------|--|
| AASHTO | American Association of State Highway and Transportation Officials |
| ACEC | Areas of Critical Concern |
| ACM | asbestos-containing material |
| ACOE | United States Army Corps of Engineers |
| ADT | average daily traffic |
| AEM | Area Equivalent Method |
| AEP | Association of Environmental Professionals |
| AF | acre feet |
| AQMP | Air Quality Management Plan |
| AQ-TAN | Air Quality Technical Analysis Note |
| ARMR | Archaeological Resource Management Reports |
| ASTM | American Society of Testing Methods |
| ATSAC | Automated Traffic Surveillance and Control |
| AVORS | Additional Valley Outfall Relief Sewer |
| AVR | average vehicle ridership |
| BACM | Best Available Control Measures |
| BACT | Best Available Control Technologies |
| Basin | South Coast Air Basin |
| BLM | Bureau of Land Management |
| BMP | best management practices |
| CAA | Clean Air Act |
| CAAA | Clean Air Act Amendments |
| CAC | California Administrative Code |
| CAL3QHC | air quality model |
| California Register | California Register of Historical Resources |
| CALINE/4 | air quality model |
| CalOSHA | California Occupational Safety and Health Administration |
| Caltrans | California Department of Transportation |
| CAP | Clean Air Program |
| CAPCOA | California Air Pollution Control Officers Association |
| CARB | California Air Resources Board |
| CBD | Central Business District |
| CCAA | California Clean Air Act |
| CCR | California Code of Regulations |
| CCSCE | Center for the Continuing Study of the California Economy |
| CDD | Community Development Department |
| CDFG | California Department of Fish and Game |
| CDMG | California Division of Mines and Geology |
| CEQ | Council of Environmental Quality |
| CEQA | California Environmental Quality Act |
| CFR | Code of Federal Regulations |
| CGC | California Government Code |
| CHAS | Comprehensive Housing Affordability Study |
| CHC | Cultural Heritage Commission |
| CIP | Capital Improvement Program |
| CIS | Coastal Interceptor Sewer |

List of Abbreviations/Acronyms, continued

| | |
|-----------|--|
| CiSWMPP | City Solid Waste Management Policy Plan |
| CIWMB | California Integrated Waste Management Board |
| CMA | Critical Movement Analysis |
| CMP | Congestion Management Program |
| CNDDDB | California Natural Diversity Data Base |
| CNEL | Community Noise Equivalent Level |
| CNPS | California Native Plant Society |
| CO | carbon monoxide |
| COS | Central Outfall Sewer |
| CRA | Community Redevelopment Agency |
| CRV | California Redemption Value |
| cu.yd. | cubic yards |
| CWA | Clean Water Act |
| CWC | California Water Code |
| D/C | demand to capacity |
| dB | decibel |
| dBA | A-weighted decibel scale |
| DFO | Designated Federal Official |
| DHS | Department of Health Services |
| DMV | California Department of Motor Vehicles |
| DOF | Department of Finance |
| DOT | United States Department of Transportation |
| DWP | Department of Water and Power |
| DWR | Department of Water Resources |
| EAD | Environmental Affairs Department |
| EDI | City of Los Angeles Environmental Data Index |
| EIR | Environmental Impact Report |
| EIS | Environmental Impact Statement |
| EMFAC | emission factors |
| EPA | U.S. Environmental Protection Agency |
| ERCs | Emission Reduction Credits |
| EVIS | East Valley Interceptor Sewer |
| FAA | Federal Aviation Administration |
| FAR | Federal Aviation Regulation |
| FEMA | Federal Emergency Management Agency |
| FHWA | Federal Highway Administration |
| FIRM | Flood Insurance Rate Maps |
| FLMPA | Federal Land Management and Policy Act of 1976 |
| gpcd | gallons per capita per day |
| gpd | gallons per day |
| gpm | gallons per minute |
| Gr.sq.ft. | gross square feet |
| gsf | gross square feet |
| HABS | Historic American Building Survey |
| HAPs | Hazardous Air Pollutants |
| HI | hazard index |

List of Abbreviations/Acronyms, continued

| | |
|-------------------|--|
| HNH | Helicopter Noise Model |
| HOV | high occupancy vehicles |
| HPOZ | Historic Preservation Overlay Zone |
| HRA | health risk assessment |
| HSC | Health and Safety Code |
| HTP | Hyperion Treatment Plant |
| HUD | Department of Housing and Urban Development |
| HVAC | heating, ventilation, and air conditioning |
| ICO | interim control ordinance |
| INM | Integrated Noise Model |
| ISWM | Integrated Solid Waste Management |
| ISWMO | Integrated Solid Waste Management Office |
| ITE | Institute of Transportation Engineers |
| IWG | Interagency Working Group |
| L.A. | Los Angeles |
| LACMTA | Los Angeles County Metropolitan Transportation Authority |
| LADOT | Los Angeles Department of Transportation |
| LAFD | Los Angeles Fire Department |
| LAGWRP | Los Angeles-Glendale Water Reclamation Plant |
| LAMC | Los Angeles Municipal Code |
| LAPD | Los Angeles Police Department |
| LAPL | Los Angeles Public Library |
| LARWQCB | Los Angeles Regional Water Quality Control Board |
| LAUSD | Los Angeles Unified School District |
| LAX | Los Angeles International Airport |
| Ldn | Day-Night Sound Level |
| LEQV2 | noise model |
| LGC | Local Government Commission |
| LOS | level of service |
| LUPAMS | Land Use Planning and Mapping System |
| LUST | leaking underground storage tank |
| MAAQI | Mobile Assessment for Air Quality Impacts |
| MACT | Maximum Achievable Control Technology |
| MFI | Median Family Income |
| mgd | million gallons per day |
| MOU | Memorandum of Understanding |
| mph | miles per hour |
| MPO | Metropolitan Planning Organization |
| MRZ | Mineral Resource Zone |
| MUTCD | Manual on Uniform Traffic Control Devices |
| MWD | Metropolitan Water District of Southern California |
| NAAQS | National Ambient Air Quality Standard |
| NAGPRA | Native American Graves Protection and Repatriation Act of 1990 |
| National Register | National Register of Historic Places |
| NCHRP | National Cooperative Highway Research Program |
| NCOS-NOS | North Central Outfall Sewer-North Outfall Sewer |

List of Abbreviations/Acronyms, continued

| | |
|-------------------|--|
| NEJAC | National Environmental Justice Advisory Council |
| NEPA | National Environmental Policy Act |
| NESHAPs | National Emissions Standards for Hazardous Air Pollutants |
| NO ₂ | nitrogen dioxide |
| NOP | Notice of Preparation |
| NORS | North Outfall Replacement Sewer |
| NOS | North Outfall Sewer |
| NOS-LCSFVRS | North Outfall Sewer-La Cienega, San Fernando Valley Relief Sewer |
| NO _x | nitrogen oxides |
| NPDES | National Pollutant Discharge Elimination System |
| NPS | National Park Service |
| NSPS | New Source Performance Standard |
| NSR | New Source Review |
| OEJ | Office of Environmental Justice |
| OHP | California Office of Historic Preservation |
| OPR | Office of Planning and Research |
| OSHA | Occupational Safety and Health Administration |
| Pb | lead |
| PM | particulate matter |
| PM ₁₀ | coarse particulates |
| PM _{2.5} | fine particulates |
| POD | Pedestrian Oriented District |
| PRC | Public Resources Code |
| RACM | Reasonably Available Control Measures |
| RCP&G | Regional Comprehensive Plan and Guide |
| RD | Reporting District |
| RECLAIM | Regional Clean Air Incentives Market |
| ROG | Reactive Organic Gas |
| ROW | right-of-way |
| RTCs | RECLAIM Trading Credits |
| RTIP | Regional Transportation Improvement Program |
| RTP | Regional Transportation Plan |
| RWQCB | Regional Water Quality Control Board |
| SANDAG | San Diego Association of Governments |
| SCAG | Southern California Association of Governments |
| SCAQMD | South Coast Air Quality Management District |
| SEA | Significant Ecological Area |
| sf | square feet |
| SIP | State Implementation Plan |
| SMGB | State Mining and Geology Board |
| SO ₂ | sulfur dioxide |
| SOCAB | South Coast Air Basin |
| SOUND32 | noise model |
| SOV | single occupant vehicle |
| SO _x | sulfur oxides |
| sq.ft. | square feet |

List of Abbreviations/Acronyms, continued

| | |
|-----------------|---|
| SRRE | Source Reduction and Recycling Element |
| TDM | Transportation Demand Management |
| The Gas Company | Southern California Gas Company |
| TIA | Transportation Impact Assessment |
| TITP | Terminal Island Treatment Plant |
| TOD | Transit Oriented District |
| TRB | Transportation Research Board |
| TSM | Transportation System Management |
| TSP | Transportation Specific Plan |
| TWRP | Donald C. Tillman Water Reclamation Plant |
| U.S. | United States |
| UCLA | University of California at Los Angeles |
| ULARA | Upper Los Angeles River Area |
| ULI | Urban Land Institute |
| USAF | United States Air Force |
| USFS | United States Forest Service |
| USFWS | United States Fish and Wildlife Service |
| USGS | United States Geological Survey |
| V/C | Volume to Capacity |
| VOC | Volatile Organic Compound |
| WDR | Waste Discharge Requirements |
| ZI | Zoning Information |

GLOSSARY

Alternatives - A range of reasonable alternatives to the project, or to the location of the project, which would feasibly attain the project's objectives but would avoid or substantially lessen any of the significant effects of the project. The comparative merits of the alternatives are evaluated in an EIR or EIS.

Applicant - A legal entity or person who proposes to carry out a project and needs a lease, permit, license, certificate, or other entitlement for use, or who is requesting financial assistance from one or more public agencies to carry out a project.

Approval - The action by a decision-making body, which commits the City to a definite course of action with regard to a project, intended to be carried out by any person.

California Environmental Quality Act (CEQA) - Statute enacted by the California legislature contained in the California Public Resources Code, Section 21000 et seq. The *Thresholds Guide* provides guidance on the determination of significant impacts, one provision of CEQA.

California Law – California Law consists of 29 codes, covering various subject areas, the State Constitution and Statutes. Codes included the following: Business and Professions Code, Civil Code, Code of Civil Procedure, Commercial Code, Corporations Code, Education code, Election Code, Evidence Code, Family Code, Financial Code, Fish and Game Code, Food and Agricultural Code, Government Code, Harbors and Navigation Code, Health and

Safety Code, Insurance Code, Labor Code, Military and Veterans Code, Penal Code, Probate Code, Public Contract Code, Public Resources Code, Public Utilities Code, Revenue and Taxation Code, Streets and Highways Code, Unemployment Insurance Code, Vehicle Code, Water Code, and Welfare and Institutions Code.

Categorical Exemption - An exemption from the requirements of CEQA based on a finding by the Secretary For Resources and the Los Angeles City Council that certain types of projects do not have a significant effect on the environment.

CEQA Guidelines - The CEQA Guidelines provide agencies with criteria and procedures for the evaluation of projects and the preparation of environmental documents. The State CEQA Guidelines are contained in Title 14, Division 6 of the California Administrative Code. The Los Angeles City CEQA Guidelines are adopted by ordinance of the City Council.

Code of Federal Regulations (CFR) - is a codification of the general and permanent rules published in the Federal Register by the Executive departments and agencies of the Federal Government. The CFR is divided into 50 titles, which represent broad areas subject to Federal regulation. Each title is divided into chapters, which usually bear the name of the issuing agency. Each chapter is further subdivided into parts covering specific regulatory areas. Large parts may be subdivided into subparts.

Community Plan – A portion of the General Plan that focuses on the setting and

needs of a particular area. It supports the policies of the General Plan. Los Angeles has 35 Community Planning Areas. The 35 Community Plans make up the City's Land Use Element.

Decision-Making Body - A group or individual having project approval authority.

Discretionary Project - An activity defined as a project which requires the exercise of judgment, deliberation, or a decision on the part of the public agency or body in the process of approving or disapproving a particular activity, as distinguished from activities where the public agency or body merely has to determine whether there has been compliance with applicable statutes, ordinances, or regulations.

Entitlement - Used to describe discretionary land use approval granted by the Planning Department. Includes Zone Variances, Zone Changes, Conditional Use Permits, General Plan Amendments, Specific Plan Exceptions, Subdivisions, Parcel Maps, and Site Plan Review.

Environment - Environment, for the purposes of implementing CEQA, is the physical conditions which exist within the area which will be affected by a proposed project, including land, air, water, minerals, flora, fauna, ambient noise, and objects of historic or aesthetic significance.

Environmental and Public Facilities Maps - Show the location of and describe various environmental features and public facilities. The City Planning Department Citywide Division prepared the 42 maps in 1996.

Environmental Assessment Form (EAF) - An environmental form submitted to the

Environmental Review Section of the City Planning Department which provides the necessary information to determine the recommended environmental clearance for projects requiring any discretionary action.

Environmental Data Index (EDI) - The EDI is a citywide tabular report describing the geographical distribution of a wide array of environmental characteristics on a census tract basis. Data for 30 environmental elements are included. The City Planning Department prepared the EDI in 1978.

Environmental Documents- Environmental documents, according to CEQA, include Initial Study, Negative Declaration, draft and final EIR, Joint EIR/EIS, Notice of Preparation and General Exemption, Notice of Completion, Notice of Determination, and Notice of Exemption.

Environmental Impact Report (EIR) - An Environmental Impact Report is a concise statement setting forth the environmental effects and considerations pertaining to a project as specified in Section 21100 of CEQA.

Environmental Impact Statement (EIS) - An Environmental Impact Statement may be required pursuant to the National Environmental Policy Act (NEPA) if a federal agency or funding is involved. Like an EIR, an EIS describes the environmental impacts of a proposed project and its alternatives.

Feasible - Feasible means capable of being accomplished in a successful manner within a reasonable period of time, taking into account economic, environmental, social, and technological factors.

Federal Register – The Federal Register is the official daily publication for Rules, Proposed rules, and Notices of Federal agencies and organizations, as well as Executive Orders and other Presidential Documents.

Framework Element – This strategy for long-term growth sets a citywide context to guide the update of the Community Plans and citywide elements of the General Plan. The Framework Element refines adopted City policy and updates and supersedes Concept Los Angeles, a strategy to preserve residential neighborhoods by focusing growth into centers. Approved by City Council in December 1996.

General Exemption - An exemption from the requirements of CEQA is granted if it can be seen with reasonable certainty that the project in question could not possibly have a significant effect on the environment.

General Plan – A “blueprint” for future development with a long-term outlook. Required by State law to be prepared by each county and city and include seven elements: land use, circulation, housing, conservation, open space, noise, and safety. May also include optional elements. Includes policies, goals, objectives, and programs. Development must not only meet specific zoning requirements, but also the broader policies, goals and objectives set forth in the General Plan. The City’s General Plan is organized into the following Elements: Framework; Land Use; Air Quality; Transportation; Housing; Infrastructure Systems; Open Space and Conservation; Noise; Public Facilities and Services; Historic Preservation and Cultural Resources; Safety; and Urban Form and Neighborhood Design.

Initial Study - A comprehensive analysis of those aspects of the environment, which could potentially affect a project or be affected by a project conducted to determine whether a project may have a significant effect on the environment.

Lead Agency - The public agency which has the principal responsibility for carrying out or approving a project. The Lead Agency will prepare the environmental documents for the project either directly or by contract.

Lead City Agency - A Lead City Agency is the City department, bureau, division, section, office, or agency which has the principal responsibility of carrying out a project which is subject to the provisions of CEQA, or has the principal responsibility for processing the application for a lease, permit, license, or other entitlement for use for a project which is subject to the provisions of CEQA. If more than one City Agency meets the Lead City Agency criteria, the Lead City Agency shall be the City Agency that normally acts first on such projects.

Ministerial Project - Activities undertaken by public agencies pursuant to a statute, ordinance, or regulation that sets forth the conditions upon which the undertaking must or must not be granted. A ministerial decision involves only the use of fixed standards or objective measurements without professional judgment.

Mitigated Negative Declaration (MND) - When significant impacts may occur as a result of the implementation of a project, but mitigation and/or project modification reduce impacts to a less than significant level, then a Mitigated Negative Declaration

is issued with discussion and conditions attached.

Mitigation - Mitigation includes avoiding the impact altogether by not taking a certain action or parts of an action; minimizing impacts by limiting the degree or magnitude of the action and its implementation; rectifying the impact by repairing, rehabilitating, or restoring the impacted environment; reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action; or compensating for the impact by replacing or providing substitute resources or environments.

National Environmental Policy Act (NEPA) - The National Environmental Policy Act is the federal law requiring an environmental assessment for federal actions that involve impacts on the environment. NEPA is set forth in 42 U.S.C.A. 4321 et seq.

Negative Declaration (ND) - A statement by the Lead Agency briefly setting forth the reasons why the project, although not otherwise exempt, will not have a significant effect on the environment and therefore does not require the preparation of an EIR.

Notice of Completion (NOC) - A brief notice filed with the State Clearinghouse in the Governor's Office of Planning and Research by a Lead Agency as soon as it has completed a draft EIR and is prepared to send out copies for review.

Notice of Determination (NOD) - A public notice filed with the City and County Clerk by the Lead City Agency after a project subject to the provisions of CEQA and involving a Negative Declaration, Mitigated

Negative Declaration or an EIR has been approved.

Notice of Exemption (NOE) - A public notice which may be filed with the City and County Clerk by a Lead City Agency after the decision-making body has approved a project and has determined that it is a ministerial, categorically exempt, or emergency project, or is otherwise exempted pursuant to the provisions of Section 21080 (b) of the California Public Resources Code.

Notice of Preparation (NOP) - A brief notice sent by a Lead City Agency to notify Responsible Agencies and interested parties that the Lead City Agency plans to prepare an EIR for a proposed project.

Office of Planning and Research (OPR) - Assists in the understanding and implementation of CEQA by (1) preparing and updating the State CEQA Guidelines; (2) evaluating Categorical Exemptions; (3) distributing documents to state agencies through the State Clearinghouse; (4) coordinating between other public agencies; and (5) preparing and distributing publications related to the understanding and use of CEQA.

Participating City Agency - A City department, bureau, division, section, office, officer, or agency, which is required by Charter or action of the City Council to review a particular class of projects and make comments or recommendations to the Lead City Agency.

Responsible Agency - A public agency, such as a city or county, which proposes to carry out or has approval power over a project, but is not the Lead Agency for the project.

Significant Effect - A substantial, or potentially substantial, adverse change in any of the physical conditions within the area affected by the proposed activity including land, air, water, minerals, flora, fauna, ambient noise, and objects of historic or aesthetic significance. This *Thresholds Guide* is intended to assist in the determination of significant effects.

Specific Plan – describes the allowable land uses, identifies open space, and details infrastructure availability and financing for a portion of a community. Specific plans implement, but are not technically a part of the General Plan. Los Angeles has various specific plans throughout the City, such as West Los Angeles, Warner Center, etc.

State Clearinghouse - In the Governor's Office of Planning and Research. Responsible for distributing environmental documents to state agencies, departments, boards, and commissions for review and comment. Coordinates the responses to ensure accurate and consistent responses from the state.

Statement of Overriding Considerations - A statement with findings identifying public objectives that, in the opinion of the decision-making body, warrant approval of a project notwithstanding its significant adverse impact(s) on the environment.

Statutory Exemption - Exemption from the requirements of CEQA based on the determination by the California Legislature that a specific type of project should be exempt from CEQA.

Zoning – The purpose of zoning regulations is to implement the policies of the General Plan. Zoning lists the kinds of uses allowed on a parcel and sets standards such as

minimum lot size, maximum building height, and minimum front yard depth. Zoning must comply with the general plan, is adopted by ordinance, and carries the weight of local law. The City's Zoning is found in Chapter 1 of the Los Angeles Municipal Code (LAMC).

A. AESTHETICS AND VISUAL RESOURCES

A. AESTHETICS AND VISUAL RESOURCES

INTRODUCTION

Aesthetics, views, shading, and nighttime illumination issues are related elements in the visual environment. Aesthetics generally refer to the identification of visual resources and the quality of what can be seen, or overall visual perception of the environment. Views refer to visual access and obstruction, or whether it is possible to see a focal point or panoramic view from an area. Shading issues are concerned with effects of shadows cast by existing or proposed structures on adjacent land uses. Nighttime illumination addresses the effects of a proposed project's exterior lighting upon adjoining uses.

A.1. AESTHETICS

1. INITIAL STUDY SCREENING PROCESS

A. Initial Study Checklist Questions

- I.a): Would the project have a substantial adverse effect on a scenic vista?
- I.b): Would the project substantially damage scenic resources, including, but not limited to, trees, rock outcroppings, and historic buildings within a state scenic highway?
- I.c): Would the project substantially degrade the existing visual character or quality of the site and its surroundings?

B. Introduction

Aesthetic impact assessment generally deals with the issue of contrast, or the degree to which elements of the environment differ visually.¹ Aesthetic features occur in a diverse array of environments, ranging in character from urban centers to rural regions and wildlands. Adverse visual effects can include the loss of natural features or areas, the removal of urban features with aesthetic value, or the introduction of contrasting urban features into natural areas or urban settings.²

Natural features may include, but are not limited to: open space; native or ornamental vegetation/landscaping; topographic or geologic features; and natural water sources. The loss of natural aesthetic features or the introduction of contrasting urban features may have a local impact, or, if part of a larger landscape, may contribute to a cumulative decline in overall visual character.

Urban features that may contribute to a valued aesthetic character or image include: structures of architectural or historic significance or visual prominence; public plazas, art or gardens; heritage oaks or other trees or plants protected by the City; consistent design elements (such as setbacks, massing, height, and signage) along a street or district; pedestrian amenities; landscaped medians or

¹ *Visual contrast has four components: form, line, color and texture. Differences in these elements generate visual contrast. The Bureau of Land Management (BLM) (Contrast Rating System), Soil Conservation Service (Visual Absorption Capability), and Federal Highway Administration (FHWA) (Visual Absorption Capacity) all utilize established qualitative and quantitative methods to measure potential visual impacts and the ability of natural areas to absorb visual impacts.*

park areas; etc. Aesthetic character may be purposely generated, nurtured or preserved, as is the case with City-designated scenic corridors and historical districts, or may exist without such cause or purpose, such as may be the case with certain retail districts or residential neighborhoods.

The introduction of contrasting features or development into aesthetically valued urban areas can overpower familiar features, eliminate context or associations with history, or create visual discord where there have been apparent efforts to maintain or promote a thematic or consistent character.

There is an extraordinary range of aesthetic characteristics and contrasts within the City of Los Angeles, including suburban neighborhoods, dense urban areas, the Port, airports, and hillside residential areas. Given the size and diversity of the City, there are no aesthetic standards that apply to all areas. However, the Community Plan and any applicable specific plan, local coastal plan, or redevelopment plan may contain specific guidelines and requirements related to aesthetics. General aesthetic requirements that apply to individual zoning districts or to types of land uses are provided in the Los Angeles Municipal Code (LAMC). Selected requirements, including the Landscape Ordinance, are included in Exhibit A.1-1. While certain screening and significance thresholds can be identified for this issue, a degree of discretionary judgment may be required to determine the "value" of the aesthetic resource and potential project impacts.

C. Screening Criteria

- Does the project include a proposed zone change or variance that would increase density, height, and bulk in areas where there is a consistent theme, style, or building height and setbacks?
- Does the project include a proposal to develop or allow development in an existing natural open space area (not including previously developed or infill lots)?
- Would the project result in the removal of one or more features that contribute to the valued aesthetic character or image of the neighborhood, community, or localized area?
- Would the project introduce features that would detract from the existing valued aesthetic quality of a neighborhood, community, or localized area by conflicting with important aesthetic elements or the quality of the area (such as theme, style, setbacks, density, massing, etc.) or by being inconsistent with applicable design guidelines?

² See C. BIOLOGICAL RESOURCES, as appropriate.

A "yes" response to any of the preceding questions indicates further study in an expanded Initial Study, Negative Declaration, Mitigated Negative Declaration or EIR may be required. Refer to the Significance Threshold for Aesthetics, and review the associated Methodology to Determine Significance, as appropriate.

A "no" response to all of the preceding questions indicates that there would normally be no significant impact on Aesthetics from the proposed project.

D. Evaluation of Screening Criteria

Review the description of the proposed project, including drawings or renderings. Features that contribute to a valued aesthetic image may include, but are not limited to: structures of architectural or historical significance or visual prominence; public plazas, art, or gardens; heritage oaks or other trees protected by the City; or other features of recognized value to the aesthetic or visual character of an area. Projects that detract from the existing aesthetic quality of an area may include, but are not limited to, major contrasts in building height and bulk (e.g., buildings "too big" for a street), excessive vegetation loss or grading of slopes in natural areas, introduction of high rise structures in low density areas, etc. Compare the project features with the existing characteristics of the project site and the surrounding area. Compare this information to the Screening Criteria.

2. DETERMINATION OF SIGNIFICANCE

A. Significance Threshold

The determination of significance shall be made on a case-by-case basis, considering the following factors:

- The amount or relative proportion of existing features or elements that substantially contribute to the valued visual character or image of a neighborhood, community, or localized area, which would be removed, altered, or demolished;
- The amount of natural open space to be graded or developed;
- The degree to which proposed structures in natural open space areas would be effectively integrated into the aesthetics of the site, through appropriate design, etc;
- The degree of contrast between proposed features and existing features that represent the area's valued aesthetic image;

- The degree to which a proposed zone change would result in buildings that would detract from the existing style or image of the area due to density, height, bulk, setbacks, signage, or other physical elements;
- The degree to which the project would contribute to the area's aesthetic value; and
- Applicable guidelines and regulations.

B. Methodology to Determine Significance

Environmental Setting

In a description of the environmental setting, include the following information:

- Identification and description of the natural or built feature(s) that gives the existing neighborhood/local area its valued aesthetic character or image;
- Summary of adopted plans or policies that relate to the aesthetics of the project area, such as those found in a specific plan, Redevelopment Plan, local coastal plan, the Community Plan, or the Planning and Zoning Code, including the Landscape Ordinance; and
- Description of any feature on the project site or in the surrounding area that is listed, designated or otherwise recognized by the City (e.g., a scenic corridor, historic district, heritage oak trees).

Project Impacts

Based on the project description, and a review of the project site and surrounding area, identify the degree to which the proposed project would result in the loss, removal, alteration, or destruction of any existing natural or urban aesthetic feature(s) that contributes to the valued aesthetic character of the area. In addition, identify the major features of the proposed project that would be added to the site, including building heights, bulk, setbacks, architectural style, or any proposed zone changes or variances. Evaluate the degree to which the introduction of new features or the loss of existing aesthetic elements would alter, degrade, or contrast with the existing valued aesthetic character of the area.

Examples of contrast in areas where there is a consistent architectural theme, style or other aesthetic character could include, but are not limited to, the following:

- The project's architectural style, building materials, massing, or size would contrast with adjacent development, such that the value or quality of the area is diminished;
- The project would cause or contribute to a change in the overall character of the area (e.g., from residential to commercial, single-family to multi-family, etc.) and/or new development would contrast with existing architectural styles or themes; and
- The project would grade or remove open space or natural lands and introduce contrasting built features.

Cumulative Impacts

Review the list of related projects and identify those projects that would result in the removal, alteration, or destruction of similar aesthetic features as the proposed project, and/or would add structural or other features that would contrast conspicuously with the valued aesthetic character of the same area as the project. Consider both natural and built features that give the area its image or character. Determine whether the impact of the related projects, in combination with the proposed project, would result in a significant aesthetic impact, using the methodology described above.

Sample Mitigation Measures

Potential mitigation measures include the following:

- Replace existing natural aesthetic features proposed for removal;
- Minimize grading of natural and semi-natural open space;
- Modify structure design to eliminate or screen contrasting/detracting features;
- Consider adaptive reuse of important existing structures;
- Place new utilities underground, where appropriate;
- Incorporate policies and/or design which effectively integrates natural aesthetics into the project (i.e., cluster development, greenbelts, landscaping, etc.);

- Utilize architectural styles, materials, scale, massing, setbacks, signage, circulation patterns, pedestrian orientation, streetscape amenities, and landscaping common to and/or consistent with the character of existing surrounding uses;
- Continue the existing aesthetic treatments along the frontage of new structures (such as street furniture, landscaping, street trees, parks, or pedestrian-oriented walks);
- Screen roof and mechanical equipment, garbage dumpsters, and equipment from public view; and
- Use building styles and finishes that integrate effectively with the natural terrain.

See also the Landscape Ordinance for additional suggestions.

3. DATA, RESOURCES, AND REFERENCES

City of Los Angeles General Plan, including Framework Element, Draft Open Space and Conservation Element, Scenic Highways Plan of the Circulation Element, District Plans, Community Plans, and Local Coastal Program. Plans are available from the City Planning Department's Central Maps and Publications office at 200 N. Spring St., 5th Floor, Los Angeles, California 90012; Telephone: (213) 978-1255.

LAMC, Chapter 1, Planning and Zoning Code. Available from the Central Maps and Publications Office (see above), on <http://www.lacity.org/PLN/>

Landscape Ordinance, No. 170,978 as amended, and Guidelines to Implement the Landscape Ordinance. Available from the Central Maps and Publications Office (see above).

See also C. BIOLOGICAL RESOURCES; and D.3. HISTORICAL RESOURCES

Exhibit A.1-1**SELECTED AESTHETIC-RELATED REGULATIONS IN THE LOS ANGELES MUNICIPAL CODE**

Chapter 1, Article 2, Sec. 12.21.1. Building heights and setbacks shall not exceed the maximum heights identified per zoning district in this section.

Chapter 4, Article 6. Oak trees meeting certain requirements shall be relocated or replaced. Oak tree reports shall be prepared for tentative map approval.

Chapter 1, Article 7, Sec. 17.05 S, and T. The Mulholland Scenic Parkway and Valley Circle Boulevard - Plummer Street Scenic Corridor shall have trails along the roadways, which meander within a landscaped parkway. Signs and road related fixtures in the corridor areas to be of a design to blend with the scenic environment. Attractive masonry walls or landscaping shall provide screening of adjacent developments.

Chapter 1, Article 7, Sec. 17.08 F. Subdividers shall either plant street trees or make cash payments for such plantings.

Chapter 1, Article 2, Sec. 12.22 A 23. Mini-shopping centers shall construct a six-foot masonry wall along residential zones and trash storage areas. Three-foot high decorative screening walls or hedges shall be constructed between parking areas and sidewalks/parkways. All center street frontages will include a landscaped setback. At least 5 percent of surface parking areas shall be landscaped. Street frontages and parking areas shall be planted with shade trees. Off-site commercial signs, flashing signs, pole signs or roof signs are prohibited.

Chapter 1, Article 2, Sec. 12.21 A 6(d) and (e), and (i). Public and private parking areas shall be enclosed by a wall, except in the "M2" and "M3" Zones, along an alley, public parking area, or a "P", "PB", "C" or "M" Zone. Unimproved or non-parking portions of parking lots shall be landscaped.

Chapter 1, Article 2, Sec. 12.21.1 A 3 (See also Division 62). Restrictions on the number, size and location of parking area signs within "P" and "CR" Zones. Sign plans shall be submitted with applications for signs. Prohibited signs shall include posters, pennants, or banners, flashing signs or signs.

Chapter 1, Article 2, Sec. 12.14 A, and Sec. 12.17 A 3(b), and Sec. 12.17.1 A 2(b)(4). The display/storage of merchandise within the "C2", "C5" and "CM" Zones shall be confined to the rear of the lot as measured from street frontages.

Chapter 1, Article 2, Sec. 12.13.5 A 3, and Sec. 12.14 A, and 12.14A, and Sec. 12.18 B 5(b) and (d). All activities, including storage, in the "C1.5" Zone, and certain activities in the "C2" Zone, shall be conducted wholly within an enclosed building. Auto stations in the "C2" Zone shall have a six-foot

high wall along lot lines, which about "A" or "R" Zones. Open storage areas in the "MR2" Zone shall be enclosed on all sides with a solid wall not less than eight feet in height sufficient to screen the use from public view.

Chapter 1, Article 2, Sec. 12.19 A 1(4)(2), and 12.20 A 1(e). Automobile dismantling yards, junkyards and certain types of storage in the "M2" or "M3" Zones shall be enclosed within a building or an eight-foot solid masonry wall.

City of Los Angeles Landscape Ordinance, No. 170,978, as amended, and Guidelines. Updates the City's requirements for landscaping at new buildings, based on a point system.

A.2. OBSTRUCTION OF VIEWS

1. INITIAL STUDY SCREENING PROCESS

A. Initial Study Checklist Question

I.a): Would the project have a substantial adverse effect on a scenic vista?

B. Introduction

The term "views" generally refers to visual access to, or the visibility of, a particular sight from a given vantage point or corridor. "Focal views" focus on a particular object, scene, setting, or feature of visual interest; "panoramic views" or vistas provide visual access to a large geographic area, for which the field of view can be wide and extend into the distance. Examples of focal views include natural landforms, public art/signs, individual buildings, and specific, important trees. Panoramic views are usually associated with vantage points looking out over a section of urban or natural areas that provide a geographic orientation not commonly available. Examples of panoramic views might include an urban skyline, valley, mountain range, the ocean, or other water bodies.

The State of California and the City of Los Angeles have recognized the value of access to visual resources through planning and zoning regulations, which designate, preserve, and enhance public views.¹ Through the General Plan, Community Plans, and the designation of scenic resources, the City specifies development standards, which help prevent the obstruction of views. These standards include the regulation of building height, mass, and floor to area ratio, as well as landscaping and grading, which are the principal issues in view obstruction. Individual specific or master plans may include additional standards such as view-sensitive site planning, structure design and grading requirements, transfer of development rights to avoid development in sensitive viewsheds, and preservation of mountain ridges and other visual resources to minimize obstruction of views.

Structures and other elements (e.g., towers, buildings, walls, signs, manufactured slopes, and landscaping) constructed or added as part of a project may obstruct focal or panoramic views. (To

¹ See California Government Code Section (CGC) 65302, which permits the Land Use Element of a General Plan to make provision for protection of aesthetic resources and views; *Nollan v. California Coastal Commission*, 483 U.S. 825 (1987) where view protection was identified as a legitimate government interest; and the 1979 Scenic Highway Plan where views of aesthetic resources are identified as meriting protection and enhancement.

evaluate the aesthetic impact of a particular element, see A.1. AESTHETICS.)

C. Screening Criteria

- Would the project occur within or adjacent to a valued focal or panoramic vista or within view of any designated scenic highway, corridor, or parkway?
- Would the project obstruct, interrupt, or diminish a valued focal and/or panoramic view?
- Does the project propose standards for height and bulk of structures and other elements that inadequately protect existing visual resources and/or views?

A "yes" response to any of the preceding questions indicates further study in an expanded Initial Study, Negative Declaration, Mitigated Negative Declaration, or EIR may be required. Refer to the Significance Thresholds for Obstruction of Views, and review the associated Methodology to Determine Significance, as appropriate.

A "no" response to all of the above questions indicates that there would normally be no significant impact on Views from the proposed project.

D. Evaluation of Screening Criteria

Review the description of the proposed project, project site, and surrounding area. Review the Scenic Highways Plan, the applicable Community Plan, and the Los Angeles Municipal Code (LAMC), if necessary, to determine whether the project site is located in or near a designated scenic area or contains any identified scenic vistas. Also, review applicable zoning ordinances, interim control ordinances (ICOs), specific plans, or other plans applicable to the project site to determine potential viewsheds or vistas, specific criteria concerning viewshed impact mitigation, as well as height and bulk requirements. Assess whether existing views would be obstructed, interrupted, or diminished by structures or other vertical elements constructed as part of the proposed project. Compare this information to the Screening Criteria.

2. DETERMINATION OF SIGNIFICANCE

A. Significance Threshold

The determination of significance shall be made on a case-by-case basis, considering the following factors:

- The nature and quality of recognized or valued views (such as natural topography, settings, man-

made or natural features of visual interest, and resources such as mountains or the ocean);

- Whether the project affects views from a designated scenic highway, corridor, or parkway;
- The extent of obstruction (e.g., total blockage, partial interruption, or minor diminishment); and
- The extent to which the project affects recognized views available from a length of a public roadway, bike path, or trail, as opposed to a single, fixed vantage point.

B. Methodology to Determine Significance

Environmental Setting

Characterize the existing view environment of the project site and surrounding vicinity (e.g., cityscape or open space, undeveloped or urbanized, existence of any water elements, etc.). Describe the site and surrounding area with respect to existing land uses, topography, landforms, location within or proximity to scenic highways or corridors and natural or built areas of scenic value. Identify and characterize existing views of the project site and valued views from the site. Note whether views are limited or unique, and identify the visual elements associated with the view. Use photographs and/or drawings, as appropriate (see Exhibits A.2-1 and A.2-2).

Project Impacts

Using the information from the Evaluation of Screening Criteria and Environmental Setting, determine the nature and quality of any key visual components identified. Identify project elements that would obstruct or interrupt existing views and the probable extent to which views would be impacted. Obstructing or interrupting views from a designated scenic highway, corridor, or parkway would likely be viewed as an adverse impact.

To determine the extent to which a project would affect views available from along a public roadway, bike path, trail, or other view corridor, and from single, fixed vantage points, identify the areas from which the project is visible. Consider whether and to what degree the project could impact views from these locations.

View obstruction may be determined with view sections, field of view analysis, line-of-sight analysis, or other appropriate method (see Exhibits A.2-3 and A.2-4, and 3. Data, Resources, and References).

For long-range programs or projects that propose policy changes, where specific structure

designs (i.e., elevations and/or building footprints) have not been identified, use the maximum development envelope (i.e., maximum heights, minimum setbacks, maximum lot coverage, and maximum contiguous floorplate) permitted according to the applicable zoning.

Cumulative Impacts

Review the list of related projects and identify those that would affect the same view opportunities as the project. Using the same methodology as described above for Project Impacts, discuss the combined visual impact of the project plus related projects on the identified view opportunities.

Sample Mitigation Measures

Projects are required to comply with the view preservation requirements (i.e., limits on structure location, height and massing, controls on landscaping and grading) of the Scenic Highway Plan. Compliance with the siting and development standards of the General Plan, Community Plans, specific plans, other applicable plans, zoning ordinances and ICOs is also required. Potential mitigation measures include the following:

- Design structures to conform to the existing natural terrain (e.g. multi-level structures on hillsides which are "stepped" in line with the slopes);
- Reduce the width and/or height of new structures to reduce the extent of obstruction;
- Design street networks to minimize view obstruction and/or enhance existing views;
- Locate new structures on portions of the site that do not interfere with existing views;
- Use open space areas to minimize view obstruction and/or enhance existing views; and
- Transfer buildable floor area from a view impacted area to a non-view impacted area on the same or different site. Requires preparation and City approval of a transfer of floor area plan in accordance with Ordinance 163,617; or apply for density transfer to floor area averaging in accordance with City procedures.

3. DATA, RESOURCES, AND REFERENCES

City Planning Department, 201 North Figueroa Street, 3rd Floor, Los Angeles, California 90012; Telephone: (213) 977-6083. Plan check services are available at the Construction Services Center, at 201 North Figueroa Street, 3rd Floor, Los Angeles, CA. 90012. Start at Building and Safety Department Counter and staff will refer visitors to the Planning Dept. as appropriate. Additional information is available from the City Planning Department, Community Planning Bureau, 200 N. Spring, 6th Floor, Los Angeles, California 90012; Telephone: Eastside (213) 978-1183, Metro/Central (213) 978-1179, South LA (213) 978-1168, West/Coastal (213) 978-1177 and Valley 6262 Van Nuys Blvd., Van Nuys, CA 91401, (818) 374-5050.

Scenic Highways Plan, 1979.

See also A.1. AESTHETICS.

Line of Sight/View Analysis

Potential view obstruction may be determined through the following analysis:

After the scenic features or view opportunities have been identified, identify the locations (view points) from which these scenic features are visible. Graphics should be prepared that clearly convey the view line (line-of-sight from the view point to the scenic view - either to a focal point or several representative lines-of-sight along a panoramic view), as shown in Exhibits A.2-1 and A.2-2.

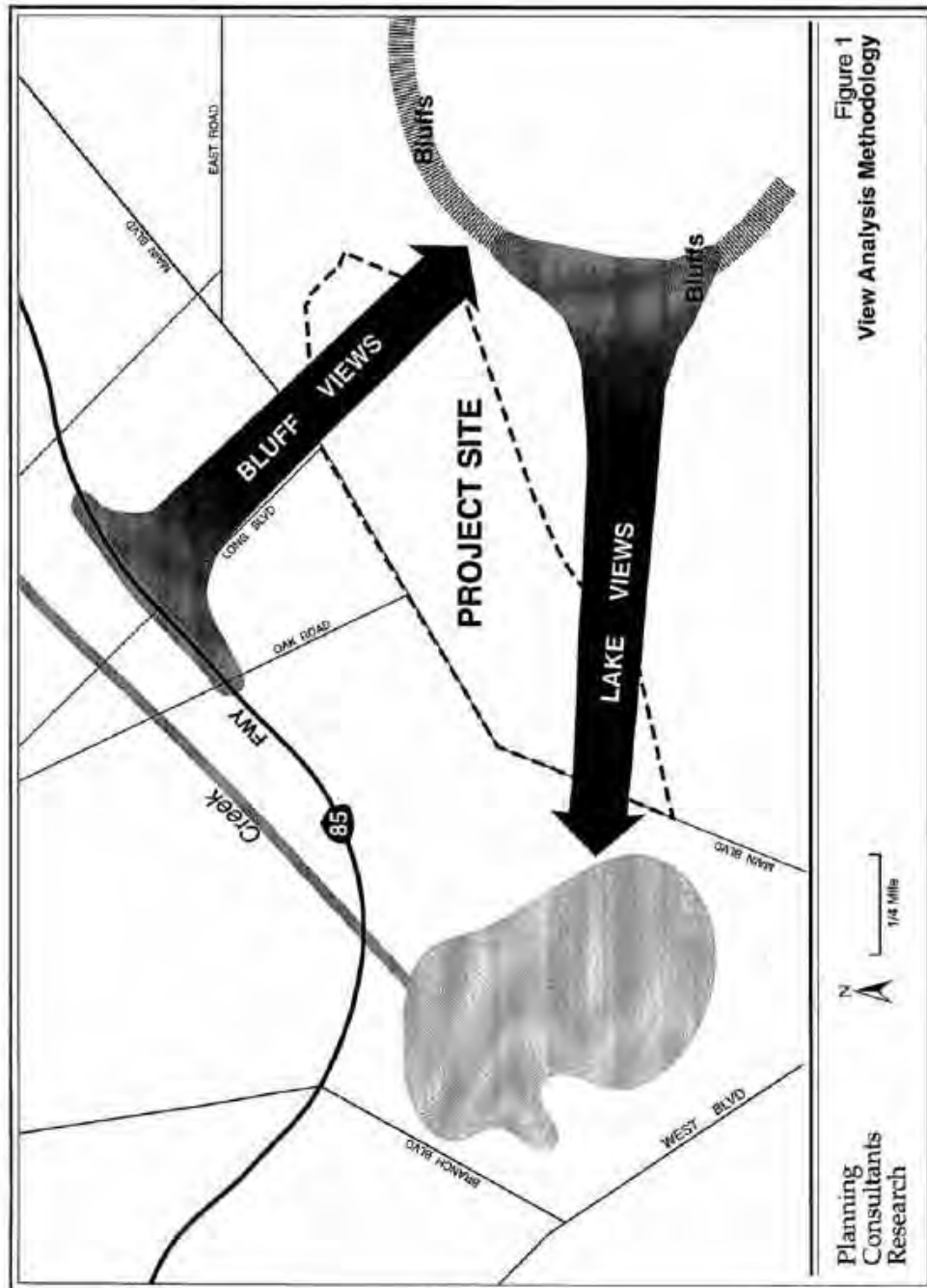
Next, for each view line, a view section (cross-section) may also be prepared. View sections, (see Exhibit A.2-3), depict locations and elevations of the view point, view resources and project elements. These sections should identify the extent to which the view is clear or obstructed by existing and proposed structures.

Where a view line is obstructed by a proposed structure or vertical element, prepare a field of view graphic, as shown in Exhibit A.2-4, to portray the extent of the obstruction. The field of view graphic should show where the view is interrupted, and allow for the measurement of potential obstruction by project elements, through representation of the intersection of view lines and proposed structures. This methodology may be adapted to different circumstances, including where the scenic view is either panoramic or a focal point and where the view location is either a single point or a segment.

Sample of Policies in the Scenic Highway Plan

- Policies. Scenic resources, including natural and man-made features, should be identified, preserved, and enhanced.
- Scenic Highway Selection Criteria. Scenic highways should include either a public right-of-way (ROW) which traverses an undeveloped area of scenic quality or which traverses an urban area which contains cultural, historical, or aesthetic values.
- Corridor Development Criteria. Grading should be minimized. Landscaping should be utilized to preserve and enhance the natural setting. Existing vegetation and views should be preserved.
- Programs. Corridor plans shall be developed for each scenic highway. Federal and State funds should be sought for acquisition, access, development, preservation and enhancement of scenic corridors. Scenic corridor projects should be included in the Capital Improvement Program (CIP). Property and scenic easements should be acquired.
- Policies. Corridor Plans for each scenic highway should include development controls for landscaping, contour grading, screening, hiking, biking and equestrian trails, view protection, provisions for scenic turnouts, vista points, rest stops, and other complementary facilities.
- Corridor Development Criteria. Development should be controlled adjacent to scenic highways and land adjacent to the ROW required to insure perpetuation of the corridor's scenic qualities. The scenic highway should be developed with construction materials compatible with the setting. Existing vegetation and views should be preserved. Only traffic, identification and informational signs should be permitted. Building height, setbacks, spacing, location and design should be regulated. In urban scenic corridors, screening/buffering, sign control, street lighting, landscaping, mini-parks, green median strips, street furniture, walkway design, murals, and fountains should be utilized.

**Exhibit A.2-1
VIEW ANALYSIS METHODOLOGY**



**Exhibit A.2-2
VIEW LINES**

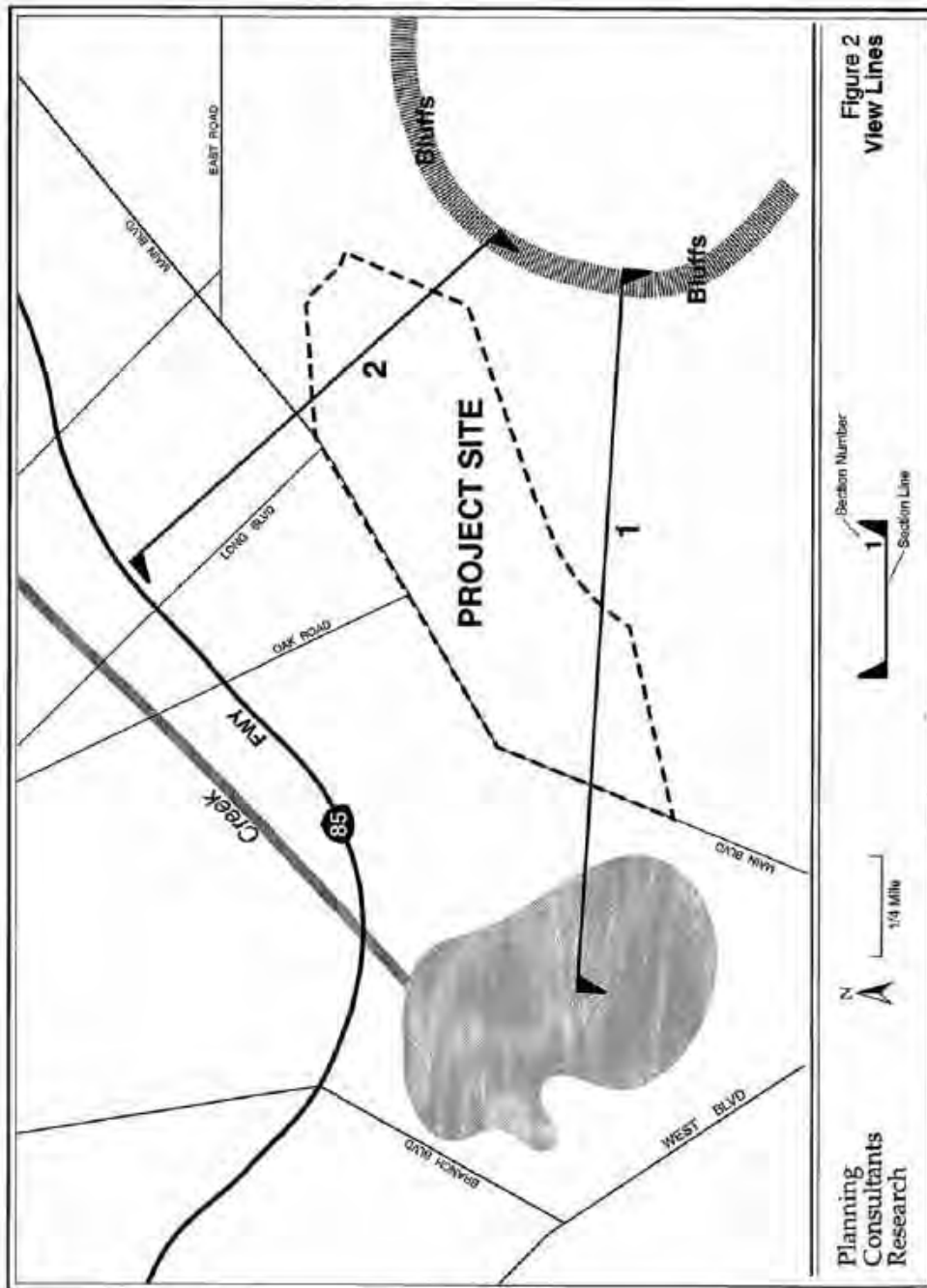


Exhibit A.2-3 VIEW SECTIONS

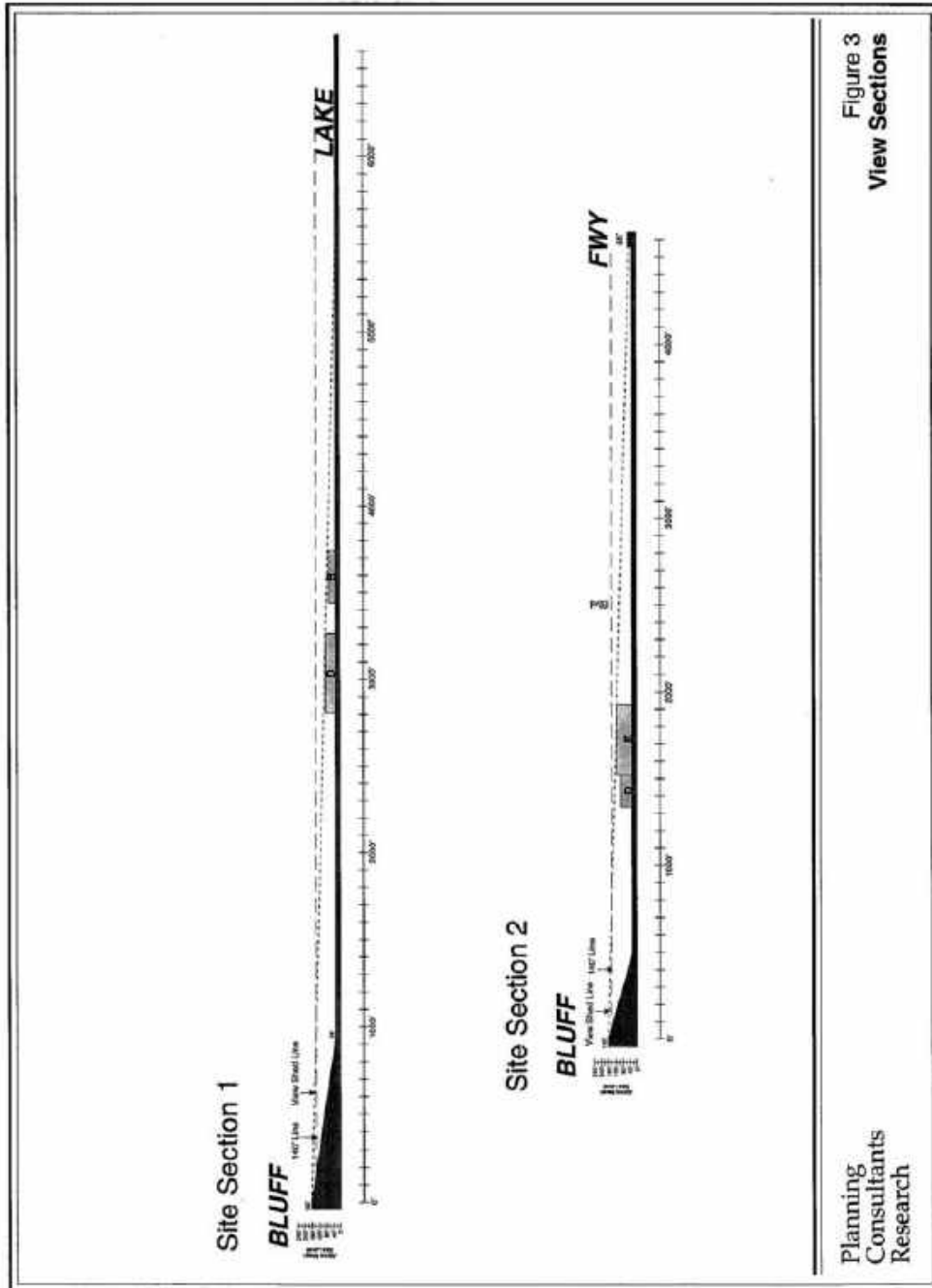
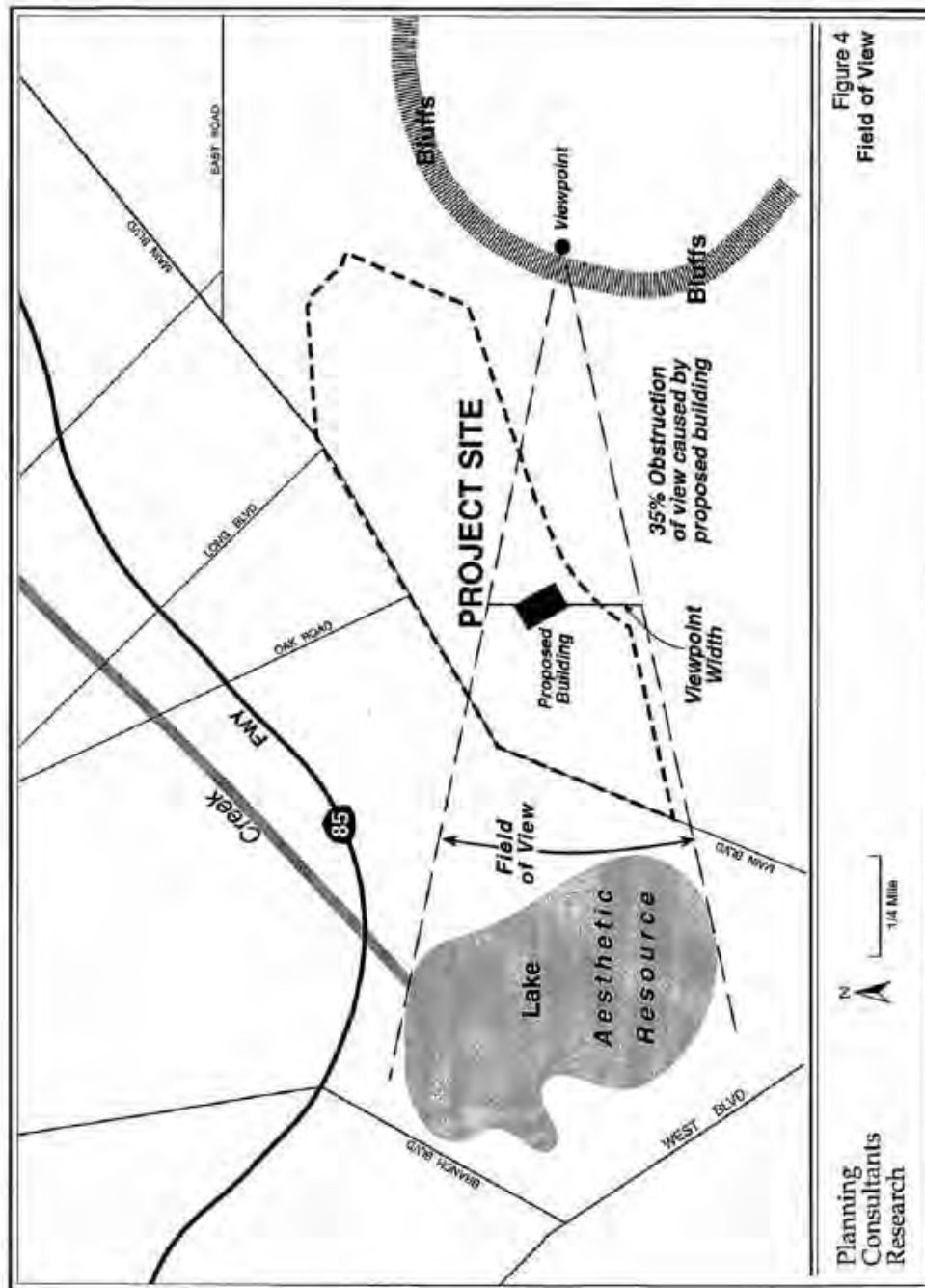


Exhibit A.2-4 FIELD OF VIEW



A.3. SHADING

1. INITIAL STUDY SCREENING PROCESS

A. Initial Study Checklist Question

I.c): Would the project substantially degrade the existing visual character or quality of the site and its surroundings?

B. Introduction

Shading refers to the effect of shadows cast upon adjacent areas by proposed structures. Consequences of shadows upon land uses may be positive, including cooling effects during warm weather, or negative, such as the loss of natural light necessary for solar energy purposes or the loss of warming influences during cool weather. Shadow effects are dependent upon several factors, including the local topography, the height and bulk of the project's structural elements, sensitivity of adjacent land uses, season, and duration of shadow projection. Facilities and operations sensitive to the effects of shading include: routinely useable outdoor spaces associated with residential, recreational, or institutional (e.g., schools, convalescent homes) land uses; commercial uses such as pedestrian-oriented outdoor spaces or restaurants with outdoor eating areas; nurseries; and existing solar collectors. These uses are considered sensitive because sunlight is important to function, physical comfort, or commerce.

Shading of existing sensitive uses can occur with the development of new structures located to the south of these uses. The relative effects of shading from structures are site-specific.

C. Screening Criteria

- Would the project include light-blocking structures in excess of 60 feet in height above the ground elevation that would be located within a distance of three times the height of the proposed structure to a shadow-sensitive use on the north, northwest or northeast¹?

¹ Depending upon the position of the sun relative to the earth's rotation, shadows cast by a structure are projected east or west of true north according to the time of day and the season. For an explanation of the variation in shadow bearings specific to the latitude of Los Angeles, see *Project Impacts*.

A "yes" response to the preceding question indicates further study in an expanded Initial Study, Negative Declaration, Mitigated Negative Declaration or EIR may be required. Refer to the Significance Threshold for Shading, and review the associated Methodology to Determine Significance, as appropriate.

A "no" response to the preceding question indicates that there would normally be no significant impact on Shading from the proposed project.

D. Evaluation of Screening Criteria

Review the description of the proposed project, project site and surrounding area. Locate shadow-sensitive uses in the area, including, but not limited to residential, commercial, institutional or other land use types where sunlight is important to function, physical comfort, or commerce. First, calculate the distance and direction between the project and each shadow-sensitive use and determine whether the project would include light-blocking structures in excess of 60 feet in height or the equivalent. For example, structures or structural elements in excess of 30 feet in height, and located at an elevation 30 feet higher than surrounding land uses, would be equivalent to a structure in excess of 60 feet at the same elevation as the surrounding land uses. Next, determine whether shade-sensitive uses exist to the north, northeast, or northwest within a distance of three times the height of the proposed structure(s). For example, identify shade-sensitive uses located within 270 feet and north of a proposed 90-foot tall structure. Compare this information to the Screening Criteria.

2. DETERMINATION OF SIGNIFICANCE

A. Significance Threshold

A project impact would normally be considered significant if shadow-sensitive uses would be shaded by project-related structures for more than three hours between the hours of 9:00 a.m. and 3:00 p.m. Pacific Standard Time (between late October and early April), or for more than four hours between the hours of 9:00 a.m. and 5:00 p.m. Pacific Daylight Time (between early April and late October).

B. Methodology to Determine Significance

Environmental Setting

In a description of the environmental setting, include a description of shade-sensitive uses in the surrounding area located to the north of the project site. Identify the distance from the project to each use and describe any elevation differences between the sensitive use(s) and the project site.

Facilities and operations that are sensitive to the effects of shading generally include, but are not limited to, routinely useable outdoor spaces associated with residential, recreational or institutional land uses; commercial uses such as pedestrian-oriented outdoor spaces or restaurants with outdoor eating areas; nurseries; and existing solar collectors.

Project Impacts

Review the project description and identify any proposed light-blocking structures or structural elements that would exceed 60 feet in height relative to nearby shade-sensitive uses. Determine the number of hours shadow-sensitive uses would be shaded by project-related structures.

As appropriate, diagram the footprint of the proposed structure(s) and nearby shade sensitive uses. Calculate and diagram the length of shadows that would be cast by proposed buildings during extreme conditions, as represented by the Winter Solstice (December 22) and Summer Solstice (June 21). The Spring and Fall Equinox represent intermediate conditions.

Exhibit A.3-1 identifies shadow length values and shadow bearings in the Los Angeles area for the solstices and equinox for morning, noon, and afternoon hours. The shadow length multiplier values represent the length of a shadow proportional to the height of a given building, at specific times of day. Hence, a building of 100 feet in height would cast a shadow 303 feet long at 9:00 a.m. during the Winter Solstice.

Exhibit A.3-2 provides morning and afternoon maximum shadow lengths generated for given structure heights during the Winter Solstice. Exhibit A.3-3 provides the same information calculated for the Summer Solstice. Use these tables, together with the shadow bearings provided in Exhibit A.3-1, to determine shadow patterns from the proposed project.

Exhibit A.3-4 shows how to plot shadows generated by individual buildings for a specific season and time of day. For buildings located on topography elevated above surrounding

shadow-sensitive uses, the differences in ground elevation between the building and a shadow-sensitive use is added to the shadow length to account for the elevation difference.

Based on the shadow patterns, determine the number of hours a project structure would shade an adjacent sensitive use. For programs or long range projects where specific structure design (i.e., building footprints and/or dimensions) have not been determined, use the maximum development envelope (i.e., maximum heights, minimum setbacks, and maximum lot coverage permitted according to the zoning) and determine shadow patterns as described above.

Cumulative Impacts

Review the list of related projects and identify those, which would affect the same shadow-sensitive uses as the proposed project. Calculate the project shadows of the related projects and determine the combined effect of these shadows, along with those of the proposed project, using the methodology described above.

Sample Mitigation Measures

Potential mitigation measures include the following:

- Limit the width/size of structural elements above 60 feet in height; and
- Move proposed structures further from shadow-sensitive uses.

3. DATA, RESOURCES, AND REFERENCES

City of Los Angeles specific plans, particularly West Los Angeles and Warner Center. Available from the City Planning Department's Central Maps and Publications Office at 200 N. Spring Street, 5th Floor, Los Angeles, California 90012; Telephone: (213) 978-1255 or <http://www.lacity.org/PLN/>.

Exhibit A.3-1
SHADOW LENGTH MULTIPLIERS AND BEARINGS
FOR 34° LATITUDE - LOS ANGELES

| Time | | Shadow Length Multiplier ^a | | Shadow Bearing ^{b,c} |
|---|--|---------------------------------------|--|-------------------------------|
| Winter Solstice
(December 22) | | | | |
| 9 a.m. | | 3.03 | | 45/West |
| NOON | | 1.60 | | 0/North |
| 3 p.m. | | 3.03 | | 45/East |
| | | | | |
| Spring/Fall Equinox
(March 22/September 22) | | | | |
| 8 a.m. | | 2.18 | | 73/West |
| NOON | | 0.72 | | 0/North |
| 4 p.m. | | 2.18 | | 73/East |
| | | | | |
| Summer Solstice
(June 22) | | | | |
| 9 a.m. | | 2.18 | | 85/West |
| 1 p.m. (solar noon) | | 0.16 | | 0/North |
| 5 p.m. | | 2.18 | | 85/East |

^a Shadow length is identified per unit of height; the height of the structure is multiplied by the shadow length multiplier. Therefore, a 100-foot building would cast a shadow 303 feet long during the Winter Solstice at 9 a.m. (e.g., 100 x 3.03).

^b Shadow bearing is identified in degrees from north. 45/West means 45 degrees west of north; 73/East means 73 degrees east of north, etc.

^c Shadow sensitive uses located greater than 45° west or east of due north would not be affected by winter shadows, regardless of the distance between the proposed building and the shadow-sensitive use. Similarly, shadow sensitive uses located greater than 85° west or east of due north would not be affected by summer shadows.

Source: Planning Consultants Research, 1995.

Exhibit A.3-2
MAXIMUM SHADOW LENGTH GENERATED FOR
GIVEN SOURCE HEIGHTS DURING WINTER SOLSTICE

| Source Height
(in feet) ^a | Maximum Shadow Length
(in feet) ^b | | Source Height
(in feet) ^a | Maximum Shadow Length
(in feet) ^b |
|---|---|--|---|---|
| 60 | 182 | | 310 | 939 |
| 70 | 212 | | 320 | 970 |
| 80 | 242 | | 330 | 1,000 |
| 90 | 273 | | 340 | 1,030 |
| 100 | 300 | | 350 | 1,061 |
| 110 | 333 | | 360 | 1,091 |
| 120 | 364 | | 370 | 1,121 |
| 130 | 394 | | 380 | 1,151 |
| 140 | 424 | | 390 | 1,182 |
| 150 | 455 | | 400 | 1,212 |
| 160 | 485 | | 410 | 1,242 |
| 170 | 515 | | 420 | 1,273 |
| 180 | 545 | | 430 | 1,303 |
| 190 | 576 | | 440 | 1,333 |
| 200 | 606 | | 450 | 1,364 |
| 210 | 636 | | 460 | 1,394 |
| 220 | 667 | | 470 | 1,424 |
| 230 | 697 | | 480 | 1,454 |
| 240 | 727 | | 490 | 1,485 |
| 250 | 758 | | 500 | 1,515 |

^a Height increments could include either of the following: (1) the height of a proposed building; or (2) in cases of varying topography, the height of a proposed building together with the differential in finished ground elevations between the proposed building and an adjacent shadow-sensitive use.

^b Shadow length at 9:00 a.m. or 3:00 p.m. during the Winter Solstice.

Source: Planning Consultants Research, 1995.

Exhibit A.3-3
MAXIMUM SHADOW LENGTH GENERATED FOR
GIVEN SOURCE HEIGHTS DURING SUMMER SOLSTICE

| Source Height
(in feet) ^a | Maximum Shadow Length
(in feet) ^b | | Source Height
(in feet) ^a | Maximum Shadow Length
(in feet) ^b |
|---|---|--|---|---|
| 60 | 80 | | 310 | 412 |
| 70 | 93 | | 320 | 426 |
| 80 | 106 | | 330 | 439 |
| 90 | 120 | | 340 | 452 |
| 100 | 133 | | 350 | 466 |
| 110 | 146 | | 360 | 479 |
| 120 | 160 | | 370 | 492 |
| 130 | 173 | | 380 | 505 |
| 140 | 186 | | 390 | 519 |
| 150 | 200 | | 400 | 532 |
| 160 | 213 | | 410 | 545 |
| 170 | 226 | | 420 | 559 |
| 180 | 239 | | 430 | 572 |
| 190 | 253 | | 440 | 585 |
| 200 | 266 | | 450 | 599 |
| 210 | 279 | | 460 | 612 |
| 220 | 293 | | 470 | 625 |
| 230 | 306 | | 480 | 638 |
| 240 | 319 | | 490 | 652 |
| 250 | 333 | | 500 | 665 |

^a Height increments could include either of the following: (1) the height of a proposed building; or (2) in cases of varying topography, the height of a proposed building together with the differential in finished ground elevations between the proposed building and an adjacent shadow-sensitive use.

^b Shadow length at 9:00 a.m. or 5:00 p.m. during the Summer Solstice (June 22).

Source: Planning Consultants Research, 1995.

Exhibit A.3-4

SHADOW PLOTTING METHODOLOGY

To plot potential shadows, use the following steps:

- Draw the building footprint. Measure the shadow lengths for the structure along the shadow bearings identified for the Winter Solstice in Exhibit A.3-1. Project the shadows the distance indicated in Exhibit A.3-2, from each corner of the structure. Connect the end points of the shadows cast, at the times of day for which shadow projections were made, by drawing an arc which incorporates the end points of the morning, noon and afternoon shadows, as projected from a single corner of the structure (see Exhibit A.3-5). This represents the coverage of the shadow cast by the structure throughout the day.
- Undertake the above on a separate footprint for each season identified in Exhibit A.3-1.
- At 9:00 a.m. on the Winter Solstice, shadows project at 45° west of true north. As time approaches noon, shadows both move closer to true north (at a rate of 15° per hour) and also shorten in length. After the noon hour, shadows begin to move east and elongate until 3:00 p.m., at which time they project at 45° east of true north. Summer shadows move, shorten and then lengthen in the same way throughout the day, except that they project further southward (i.e., 85° from true north during the Summer Solstice and progressing at a rate of 21.25° per hour) and reach maximum lengths shorter than those of winter shadows.
- Subdivide the shadow into equal sections which represent where the end point of the shadow will be located during each hour of the day (i.e., six equal sections to represent the six hours between 9:00 a.m. and 3:00 p.m. during the winter and eight equal sections to represent the eight hours between 9:00 a.m. and 5:00 p.m. during the summer).
- Place the sun shadow layout generated above onto a base map, which shows adjacent lot lines and the approximate location of shadow-sensitive uses (see Exhibit A.3-6).
- Determine the length of time during the day that a land use receives a shadow cast by the structure. The shadow projected by a structure, moves at a constant rate from west to east, corresponding to the movement of the sun throughout the day, and thus allowing a general determination of shadow movement, onto and away from a shade-sensitive use.

Exhibit A.3-5 Shadow Projection

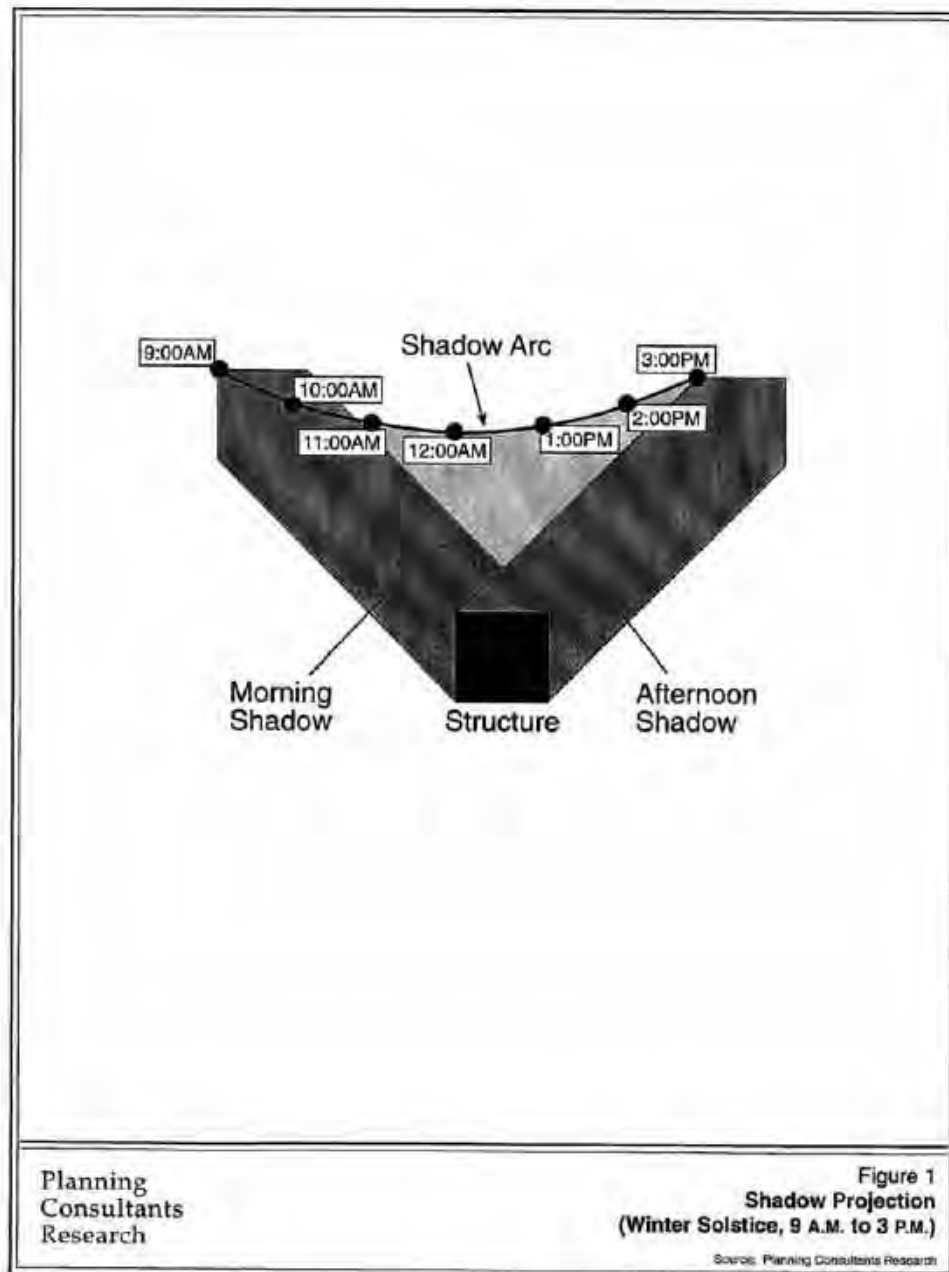
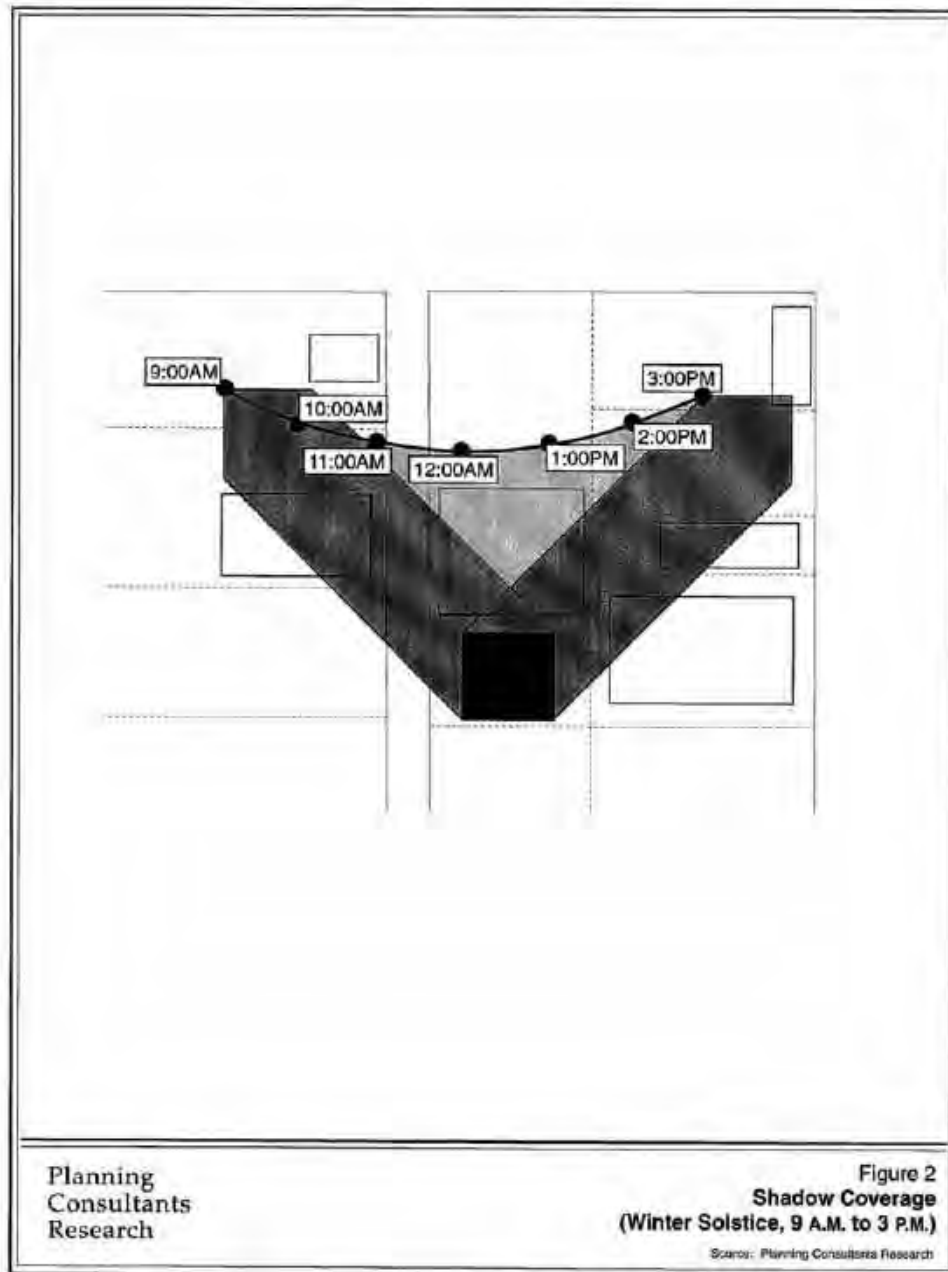


Exhibit A.3-6
Shadow Coverage



A.4. NIGHTTIME ILLUMINATION

1. INITIAL STUDY SCREENING PROCESS

A. Initial Study Checklist Question

I.d): Would the project create a new source of substantial light or glare which would adversely affect day or nighttime views in the area?

B. Introduction

This section involves the extent to which a proposed project's artificial lighting affects the visual environment. Nighttime illumination of varying intensities is characteristic of most urban and suburban land uses including those in the City of Los Angeles. Artificial lighting has become more widely utilized in recent years to address security concerns and aesthetics.

New light sources introduced by a project may increase ambient nighttime illumination levels. Additionally, nighttime spillover of light onto adjacent properties has the potential to interfere with certain functions, including vision, sleep, privacy, and general enjoyment of the natural nighttime condition. The significance of the impact depends on the type of use affected, proximity to the affected use, the intensity of the light source, and the existing ambient light environment. Uses considered sensitive to nighttime light include, but are not limited to, residential, some commercial and institutional uses, and natural areas.¹ The City regulates a number of light sources (see Exhibit A.4-1).

C Screening Criteria

- Would the proposed project introduce light likely to increase ambient nighttime illumination levels beyond the property line of the project site?
- Does the project include lighting that would routinely spillover onto a light-sensitive land use?

A "yes" response to both of the preceding questions indicates further study in an expanded

¹ *The effect of artificial lighting on biological resources is addressed in C. BIOLOGICAL RESOURCES.*

Initial Study, Negative Declaration, Mitigated Negative Declaration or EIR may be required. Refer to the Significance Threshold for Nighttime Illumination, and review the associated Methodology to Determine Significance, as appropriate.

A "no" response to either of the preceding questions indicates that there would be no significant Nighttime Illumination impact from the proposed project.

D. Evaluation of Screening Criteria

Review the description of the proposed project for the types of lighting included. Review surrounding land use information to determine the location of light-sensitive land uses. Light-sensitive land uses may include, but are not limited to, residences, including board and care facilities; commercial or institutional uses that require minimal nighttime illumination for proper function, physical comfort, or commerce; and natural areas. Determine the potential for routine spillover of light or an increase in ambient light levels by considering the project's proximity to light-sensitive uses, the intensity of project light sources, and the existing ambient light environment.

2. DETERMINATION OF SIGNIFICANCE

A. Significance Threshold

The determination of significance shall be made on a case-by-case basis, considering the following factors:

- The change in ambient illumination levels as a result of project sources; and
- The extent to which project lighting would spill off the project site and effect adjacent light-sensitive areas.

B. Methodology to Determine Significance

Environmental Setting

In a description of the environmental setting, include the following information:

- Description of existing ambient light conditions on-site and in the surrounding vicinity, including background lighting conditions, and existing light spill-over from the project site; and

- Identification and description of the light-sensitive land uses in the area.

Project Impacts

Using the information from the Evaluation of Screening Criteria and Environmental Setting, determine the change in illumination resulting from project light sources. Describe the proposed light sources, including a locational graphic, as appropriate. Note whether existing light sources on site will remain or be removed. Assess the extent to which project lighting (including illuminated signage) would spill off the project site onto adjacent light-sensitive areas, considering the direction in which the light would be focused, whether shielding techniques would be used, and the extent to which project lighting would illuminate such sensitive land uses.

For projects involving a change in policies or long-range programs where proposed land uses are known, but specific structure designs (i.e., building or use footprints) have not been determined, identify general locations where high-intensity lighting or signage would likely occur, and evaluate the potential impacts on light-sensitive uses.

Cumulative Impacts

Review the list of related projects and identify any projects that may cause routine spill-over of light onto the same light-sensitive land uses as the project. Evaluate the impact from these projects, combined with the impact of the proposed project, using the methodology described above.

Sample Mitigation Measures

Potential mitigation measures include the following:

- Use high pressure sodium and/or cut-off fixtures instead of typical mercury-vapor fixtures for outdoor lighting;
- Prohibit or limit signs with flashing, mechanical, strobe, or blinking lights; moving parts; or lighted monument signs;
- Provide structural and/or vegetative screening from sensitive uses;

- Design exterior lighting to confine illumination to the project site, and/or to areas which do not include light-sensitive uses; and
- Restrict the operation of outdoor lighting for recreational activities to the hours of 7:00 a.m. to 10:00 p.m.

3. DATA, RESOURCES, AND REFERENCES

Los Angeles Municipal Code (LAMC), available from the City Clerk or <http://lacity.org/lacity102.htm>.

Illumination Engineering Society of North America. American National Standard Practice for Roadway Lighting.

Illumination Engineering Society of North America. Lighting Handbook, Reference and Application.

Exhibit A.4-1
SELECTED CITY MUNICIPAL CODE LIGHTING REGULATIONS

Chapter 1, Article 2, Sec. 12.21 A 5(k). All lights used to illuminate a parking area shall be designed, located and arranged so as to reflect the light away from any streets and adjacent premises.

Chapter 1, Article 2, Sec. 12.12.1 A 3(b). All signs permitted in the "P" Zone may be illuminated, but shall comply with the requirements set forth in Section 62.200 of this Code, and shall not contain any flashing, moving or animated parts or features.

Chapter 1, Article 2, Sec. 12.12.1.5 A 2(a). Parking buildings in the "PB" Zone shall be constructed with a continuous, enclosing wall at least three and one-half feet in height at each floor level. Said wall need not be solid but shall be constructed of materials so as to block light emitted from the building.

Chapter 1, Article 2, Sec. 12.14 A (6g). Lights used to illuminate service stations shall be arranged so as to reflect the light away from the adjacent premises in an "A" or "R" Zone, and the light standard for such lights shall not exceed 20 feet in height.

Chapter 1, Article 2, Sec. 12.22 A 23(b)(1). Mini-Shopping Centers shall have low-level security type lighting. All exterior lighting shall be directed onto the mini-shopping center site, and all flood lighting shall be designed to eliminate glare to adjoining properties.

Chapter 1, Article 2, Sec. 12.50 E. No illuminated or flashing signs shall be installed or maintained within an Airport Hazard Area which would either make it difficult for flyers to distinguish between said lights and aeronautical lights, or which would result in glare in the eyes of flyers.

Chapter 1, Article 7, Sec. 17.08 C. Plans for street lighting shall be submitted to and approved by the Bureau of Street Lighting for subdivision maps.

Division 62, Sec. 91.6205 M. No sign shall be illuminated in such a manner as to produce a light intensity of greater than three foot-candles above ambient lighting, as measured at the property line of the nearest residentially zoned property.

Chapter 9, Article 3, Section 93.0117. No exterior light source may cause more than two foot-candles of lighting intensity or generate direct glare onto exterior glazed windows or glass doors; elevated habitable porch, deck, or balcony; or any ground surface intended for uses such as recreation, barbecue or lawn areas or any other property containing a residential unit or units.

Note: A project may be subject to additional requirements of a specific plan, if it is located within a specific plan area.

This page intentionally left blank.

B. AIR QUALITY

B. AIR QUALITY

INTRODUCTION

This section addresses the air quality impacts of projects. Air quality impacts may occur during the construction or operation phase of a project, and may come from stationary, mobile, or area sources. The topic of air quality has been divided into the following sections:

- Construction emissions
- Operational emissions
- Toxic air contaminants

The California Health and Safety Code (HSC) defines air pollution as any discharge, release, or other propagation into the atmosphere, and includes, but is not limited to, smoke, charred paper, dust, soot, grime, carbon, fumes, gases, odors, particulate matter, acids, or any combination thereof. Sources of air pollution can be classified as either stationary sources (e.g., industrial processes, generators), mobile sources (e.g., automobiles, trucks), or area sources (e.g., residential water heaters).

As described below, the South Coast Air Quality Management District (SCAQMD) is the main regulatory authority in the region (the South Coast Air Basin (Basin), which includes the City of Los Angeles) with regard to air quality issues. In April 1993, the SCAQMD adopted a CEQA Air Quality Handbook that provides guidance for the CEQA analysis of potential air quality impacts of new projects. The CEQA Air Quality Handbook addresses screening criteria for stationary and mobile source emissions; the effects of certain pollutants (e.g., toxics, carbon monoxide) on sensitive receptors; and area sources (e.g., landfills, construction sites, etc.). It also provides recommended thresholds to assist in determining the significance of potential project impacts from these sources. The SCAQMD is the responsible agency for air quality permits. Compliance with SCAQMD rules and permit conditions is a component of the region's efforts to achieve and maintain air quality standards.

The City of Los Angeles has not adopted specific Citywide significance thresholds for air quality impacts. However, because of the SCAQMD's regulatory role in the air basin, this *Thresholds Guide* references the screening criteria, significance thresholds and analysis methodologies in the CEQA Air Quality Handbook to assist in evaluating projects proposed within the City. Because the CEQA Air Quality Handbook may not be appropriate for every project, it is the responsibility of the lead City department to determine the appropriate standards for a particular

project.

Regulatory Framework

The Federal and California Clean Air Acts require that federal, state, and local authorities adopt air pollution reduction measures to meet health-based air quality standards (ambient air quality standards) for six specific (known as “criteria”) pollutants within certain timelines. The state standards are stricter than the federal standards. The current air quality planning efforts, and the responsibilities of agencies involved in these efforts, are described below.

Federal Clean Air Act (CAA)

Title I of the CAA identifies attainment, nonattainment, and unclassifiable areas with regard to the criteria pollutants, and sets deadlines for all areas to reach attainment for the following criteria pollutants: ozone; nitrogen dioxide (NO₂); sulfur dioxide (SO₂); particulates (PM₁₀); carbon monoxide (CO); and lead (Pb). The CAA required each state with one or more non-attainment areas to prepare a State Implementation Plan (SIP) to describe how and when each area of the state will meet attainment for all criteria pollutants. The South Coast Air Basin was identified as the only “extreme” nonattainment area for ozone and a “serious” nonattainment area for PM₁₀ and CO. Compliance with these standards must be demonstrated in the Basin as follows: ozone by the year 2010; PM₁₀ by the year 2006; and CO by the year 2000.

Title II of the CAA contains a number of provisions with regard to mobile sources, including requirements for reformulated gasoline, new tailpipe emission standards for cars and trucks, nitrogen oxides (NO_x) standards for heavy-duty vehicles, and a program for cleaner fleet vehicles. Identification and regulation of hazardous air pollutants are addressed in Title III. Under Title V, conditions for operating permits are specified. In 1997, EPA promulgated new ambient air quality standards for fine particulates (PM_{2.5}) and ozone. The implementation guidelines, including deadlines, are under development.

California Clean Air Act (CCAA)

The CCAA designates air basins as either in attainment or nonattainment for each state air quality standard. The South Coast Air Basin is designated as a “severe” nonattainment area for ozone, CO, NO₂, and PM₁₀. The CCAA set specific targets for achieving clean air, including an annual five-percent reduction in pollutants (averaged every five consecutive three-year periods) until attainment is reached. It also incorporates the permit programs of the CAA, including New Source Review (NSR) of stationary sources, and requires a mandatory vehicle inspection program for vehicles registered in nonattainment areas (smog check).

Air Quality Management Plan (AQMP)

The 2003 AQMP describes a comprehensive air pollution control program focused on attaining the state and federal ambient air quality standards and planning requirements in the Basin and those portions of the Southeast Desert Air Basin that are under the SCAQMD's jurisdiction, (the Antelope and Coachella Valleys). It calls for the implementation of all-feasible control measures, and the advancement and use of technologies for which breakthroughs are on the horizon. The AQMP is updated every 3 years. Revisions to the Plan are considered amendments to the SIP.

Regional Comprehensive Plan and Guide (RCP&G)

The RCP&G, developed by the Southern California Association of Governments (SCAG), was adopted in May 1995. It provides a framework for regional goals, and assists local jurisdictions in meeting state and federal requirements and devising appropriate land use strategies. The components of the RCP&G, which include air quality, transportation and land use, among others, each contain goals and strategies for identifying and reducing cumulative impacts from new projects and plans, as required by CEQA and other state and federal regulations.

Framework and Air Quality Elements

The City approved a comprehensive update to the long-term growth strategy in its General Plan. The Framework Element sets policy direction for the City's 35 Community Plan areas, in which detailed land use plans are described, and 12 citywide Elements (e.g., Transportation and Housing). The Framework Element supports land use and transportation policies and patterns that will assist the region in meeting air quality goals, for example, by encouraging the location of residential and commercial uses near transit centers and continuing the City's "centers" development concept.

The Air Quality Element was adopted in November 1992. The objectives are to aid the region in attaining state and federal air quality standards, while continuing to allow economic growth and improvement in the quality of life for City residents. This Element also discusses how the City plans to implement local programs contained in the SCAQMD's AQMP.

Los Angeles County Congestion Management Program

The Congestion Management Program (CMP) for Los Angeles County was developed to meet the requirements of Section 65089 of the California Government Code and addresses regional congestion by linking transportation, land use, and air quality decisions. The goals of the CMP

include the following:

- To link land use, transportation, and air quality decisions;
- To develop a partnership among transportation decision-makers on devising appropriate transportation solutions that include all modes of travel; and
- To propose transportation projects that are eligible for state gas tax funds.

Responsibilities of Regulatory Agencies

Environmental Protection Agency (EPA)

The EPA administers the CAA and other air quality legislation. As a regulatory agency, EPA's principal functions include the following: (1) setting federal ambient air quality standards; (2) preparing guidance for and approval of SIPs to meet or maintain these ambient air quality standards; (3) establishing national emission limits for major sources of air pollution; (4) inspecting and monitoring emission sources; (5) enforcing federal air quality laws and promulgating new regulations; and, (6) providing financial and technical support for air quality research and development programs.

California Air Resources Board (CARB)

The CARB is the state agency responsible for the coordination and administration of both state and federal air pollution control programs in California. The CARB prepares and submits a SIP to EPA, undertakes research, sets state ambient air quality standards, provides technical assistance to local air districts, compiles emission inventories, develops suggested control measures, establishes emission standards for motor vehicles, and provides oversight of air district control programs.

SCAQMD

SCAQMD shares responsibility with the CARB for ensuring that all state and federal ambient air quality standards are achieved and maintained throughout the Basin. Local air districts, including the SCAQMD, are responsible for the preparation of AQMPs, inspection of stationary sources, monitoring of ambient air quality, and planning activities such as modeling and maintenance of the emission inventory. State law assigns to local air districts the primary responsibility for the control of air pollution from stationary sources, while reserving an oversight role for the CARB. Local air districts are also responsible for developing mobile source strategies necessary to achieve the ambient air quality standards, while CARB regulates tailpipe emissions

from mobile sources.

SCAG

SCAG is a joint powers agency encompassing the counties of Los Angeles, Orange, Imperial, Riverside, San Bernardino, and Ventura and is the Metropolitan Planning Organization (MPO) for this region. SCAG's responsibility with respect to air quality planning is primarily in developing transportation, land use and energy conservation measures as part of the RCP&G, Regional Transportation Improvement Program (RTIP), and Regional Transportation Plan (RTP). SCAG also has statutory authority in conjunction with the SCAQMD for the implementation and monitoring of land use strategies and transportation control measures contained in the AQMP. SCAG prepares the required air quality conformity analyses for transportation plans, programs, and projects to comply with the federal Transportation Conformity Rule. As part of the CEQA process for regionally significant projects, SCAG evaluates the consistency of such projects with the goals and policies of the RCP&G.

B.1. CONSTRUCTION EMISSIONS

1. INITIAL STUDY SCREENING PROCESS

A. Initial Study Checklist Questions

III.a) Would the project conflict with or obstruct implementation of the applicable air quality plan?

III.b) Would the project violate any air quality standard or contribute substantially to an existing or projected air quality violation?

III.c) Would the project result in a cumulatively considerable net increase of any criteria pollutant for which the project region is non-attainment under an applicable federal or state ambient air quality standard (including releasing emissions which exceed quantitative thresholds for ozone precursors)?

III.d) Would the project expose sensitive receptors to substantial pollutant concentrations?

B. Introduction

Construction of new projects has the potential to create air quality impacts through earth moving operations and the use of heavy-duty equipment. Fugitive dust emissions result from land clearing, demolition, ground excavation, cut and fill operations, and equipment traffic over temporary roads at construction sites. Mobile source emissions, primarily nitrogen oxides (NO_x), result from the use of construction equipment such as bulldozers, trucks, and scrapers. These emissions are most significant when using heavy-duty, diesel-fueled equipment. Mobile source emissions also result from vehicle trips by construction workers to and from the project site. Emissions can vary substantially from day to day, depending on the level of activity, the specific type of operation and, for dust, the prevailing weather conditions. The assessment of construction air quality impacts considers each of these potential sources individually, as well as collectively.

As described in B. AIR QUALITY (the Introduction to the Air Quality sections), a number of plans, policies and regulations have been adopted by agencies at the local, state and federal levels to address air quality concerns. Each of these plans contains regulations, control

strategies, or policies and programs designed to reduce the air pollutant emissions of new, and in some cases existing, development projects. The primary strategy related to construction emissions implemented and enforced by the South Coast Air Quality Management District (SCAQMD) is Rule 403, Fugitive Dust. Exhibits B.1-1 and B.1-2 reproduce a list of dust control strategies allowed by Rule 403. Compliance with SCAQMD rules and permit conditions is a component of the region's efforts to achieve and maintain air quality standards.

Refer to B.2. OPERATIONAL EMISSIONS for a discussion of carbon monoxide (CO) hotspots and F.2. HUMAN HEALTH HAZARDS for removal of asbestos containing material.

C. Screening Criteria

- Would site preparation or construction activities for the proposed project result in substantial emissions that would not be controlled on site by existing regulations?

A "yes" response to the preceding question indicates that further study in an expanded Initial Study, Negative Declaration, Mitigated Negative Declaration, or EIR, may be required. Refer to the Significance Threshold for Construction Emissions, and review the associated Methodology to Determine Significance as appropriate.

A "no" response to the preceding question indicates that there would normally be no significant impact from Construction Emissions from the proposed project.

D. Evaluation of Screening Criteria

Although the City of Los Angeles has not adopted specific guidance with regard to construction emissions, a number of sources are available to assist in this evaluation. SCAQMD's CEQA Air Quality Handbook contains a Screening Table for Construction based on construction emissions occurring over a three-month (quarterly) period (CEQA Air Quality Handbook pages 6-12). The table lists the sizes and amounts of various types of development projects and construction activities, over which a potentially significant air quality impact could occur, considering both dust generation and exhaust from construction equipment. In addition, the Environmental Protection Agency (EPA) publication, Compilation of Air Pollutant Emission Factors (AP-42), contains emission factors and methodologies for calculating emissions from off-highway mobile construction equipment and non-vehicular equipment. AP-42 also contains factors to estimate the dust generation per acre of graded land.

2. DETERMINATION OF SIGNIFICANCE

A. Significance Threshold

Although the City has not adopted a Citywide significance threshold for construction emissions, SCAQMD's CEQA Air Quality Handbook and/or EPA's AP-42 contain emission factors and assessment methodologies. It is the responsibility of the lead City department to determine the appropriate standards. This *Thresholds Guide* reprints guidance from the CEQA Air Quality Handbook to assist in the evaluation of project impacts, as determined appropriate by each lead City agency.

Project-related factors to be used in a case-by-case evaluation of significance include the following:

Combustion Emissions from Construction Equipment

Type, number of pieces and usage for each type of construction equipment;
Estimated fuel usage and type of fuel (diesel, natural gas) for each type of equipment; and
Emission factors for each type of equipment.

Fugitive Dust

Grading, Excavation and Hauling:

Amount of soil to be disturbed on-site or moved off-site;
Emission factors for disturbed soil;
Duration of grading, excavation and hauling activities;
Type and number of pieces of equipment to be used; and
Projected haul route.

Heavy-Duty Equipment Travel on Unpaved Roads:

Length and type of road;
Type, number of pieces, weight and usage of equipment; and
Type of soil.

Other Mobile Source Emissions

Number and average length of construction worker trips to project site, per day; and
Duration of construction activities.

B. Methodology to Determine Significance

Environmental Setting

In a description of the environmental setting, provide the regulatory framework and discuss regional and local air quality, including ambient air monitoring data from the monitoring station closest to or most representative of the project site. Monitoring data may be obtained from the SCAQMD Air Quality Evaluation Staff or the CEQA Air Quality Handbook. Identify the location of sensitive receptors, such as residences, schools, childcare centers, hospitals, parks, or similar uses, in relation to the project site.

Project Impacts

Using the information described in the significance factors listed above, and guidance from the appropriate source, calculate the emissions from all construction-related activities, including equipment, earth moving, and worker travel, using the worst-case day. Identify measures that will be taken as part of the construction activity to reduce air emissions, including measures to comply with Rule 403. Determine the impact from all project-related construction emissions.

Cumulative Impacts

Review the related projects list and identify those projects with construction schedules that would coincide with the schedule of the proposed project. Estimate the potential emissions from the related projects that would occur during construction of the proposed project, based on available information and using the methodology above. Determine the combined emissions for the proposed and related projects and the resulting cumulative impact.

Sample Mitigation Measures

All construction projects must comply with the requirements of SCAQMD Rule 403, Fugitive Dust, which requires the implementation of Reasonably Available Control Measures (RACM) for all fugitive dust sources, and the Air Quality Management Plan (AQMP), which identifies Best Available Control Measures (BACM) and Best Available Control Technologies (BACT) for area sources and point sources, respectively.

Potential mitigation measures beyond current requirements include the following:

Establish an on-site construction equipment staging area and construction worker parking lot, located on either paved surfaces or unpaved surfaces subjected to soil stabilization treatments, as close as possible to a public highway. Control access to public roadways by limiting curb cuts/driveways to minimize project construction impacts upon roadway traffic operations;

Properly maintain non-vehicular equipment engines to minimize the volume of exhaust emissions;

Use electricity from power poles, rather than temporary diesel or gasoline powered generators;

Use on-site mobile equipment powered by alternative fuel sources (i.e., methanol, natural gas, propane or butane);

Pave construction roads;

Inspect construction equipment prior to leaving the site and wash off loose dirt with wheel washers, as necessary; and

Provide ridesharing or shuttle service for construction workers.

3. DATA, RESOURCES, AND REFERENCES

Air Quality Element, 1992. Available from the City Planning Department's Central Publications Unit at 200 N. Spring St., 5th Floor, Los Angeles, California 90012; Telephone: (213) 978-1255.

EPA, Compilation of Air Pollutant Emission Factors, AP-42.

SCAQMD, CEQA Air Quality Handbook, 1993. AQMP and Appendices, adopted August 2003.

SCAQMD, Rules and Regulations. Volumes I, II and III. Information regarding a particular rule or regulation may be obtained by calling the SCAQMD at (909) 396-3600 or 1-(800)-CUT-SMOG.

See also B. AIR QUALITY for description of regulatory framework, including the regulations and agencies involved.

Exhibit B.1-1

REPRINT OF SCAQMD RULE 403 (Amended December 1998), PAGE 14

REASONABLY AVAILABLE CONTROL MEASURES FOR HIGH WIND CONDITIONS**FUGITIVE DUST****SOURCE CATEGORY****CONTROL MEASURES****Earth-moving**

(1A) Cease all active operations, OR
 (2A) Apply water to soil not more than 15 minutes prior to moving such soil. **Disturbed surface areas**

(0B) On the last day of active operations prior to a weekend, holiday, or any other period when active operations will not occur for not more than four consecutive days: apply water with a mixture of chemical stabilizer diluted to not less than 1/20 of the concentration required to maintain a stabilized surface for a period of six months; OR

(1B) Apply chemical stabilizers prior to wind event; OR

(2B) Apply water to all unstabilized disturbed areas 3 times per day, if there is any evidence of wind-driven fugitive dust, watering frequency is increased to a minimum of 4 times per day; OR

(3B) Take the actions specified in Table 2, Item (3C); OR

(4B) Utilize any combination of control actions (1B), (2B) and (3B) such that, in total, these actions apply to all disturbed surface areas.

Unpaved roads

(1C) Apply chemical stabilizers prior to wind event; OR

(2C) Apply water **twice [once]** per hour during active operation; OR

(3C) Stop all vehicular traffic.

Open storage piles

(1D) Apply water **twice [once]** per hour; OR

(2D) Install temporary coverings.

Paved road track-out

(1E) Cover all haul vehicles; OR

(2E) Comply with the vehicle freeboard requirements of Section 23114 of the California Vehicle Code for both public and private roads.

All Categories

(1F) Any other control measures approved by the Executive Officer and the U.S. EPA as equivalent to the methods specified in Table 1 may be used.

*Measures in [brackets] are reasonably control measures and only apply to sources not within the South Coast Air Basin.

Exhibit B.1-2

REPRINT OF SCAQMD RULE 403 (Amended December 1998), PAGES 15 AND 16**DUST CONTROL FOR EXEMPTION FROM PARAGRAPH (d)(4)****FUGITIVE DUST****SOURCE CATEGORY****CONTROL ACTIONS****Earth-moving (except construction cutting and filling areas, and mining operations)**

(1a) Maintain soil moisture content at a minimum of 12 percent, as determined by ASTM method D-2216, or other equivalent method approved by the Executive Officer, the California Air Resources Board, and the U.S. EPA. Two soil moisture evaluations must be conducted during the first three hours of active operations during a calendar day, and two such evaluations each subsequent four-hour period of active operations; OR

(1a-1) For any earth-moving which is more than 100 feet from all property lines, conduct watering as necessary to prevent visible dust emissions from exceeding 100 feet in length in any direction.

Earth-moving: Construction fill areas:

(1b) Maintain soil moisture content at a minimum of 12 percent, as determined by ASTM method D-2216, or other equivalent method approved by the Executive Officer, the California Air Resources Board, and the U.S. EPA. For areas which have an optimum moisture content for compaction of less than 12 percent, as determined by ASTM Method 1557 or other equivalent method approved by the Executive Officer and the California Air Resources Board, and the U.S. EPA, complete the compaction process as expeditiously as possible after achieving at least 70 percent of the optimum soil moisture content. Two soil moisture evaluations must be conducted during the first three hours of active operations during a calendar day, and two such evaluations during each subsequent four-hour period of active operations.

Earth-moving: Construction cut areas and mining operations

(1c) Conduct watering as necessary to prevent visible emissions from extending more than 100 feet beyond the active cut or mining area unless the area is inaccessible to watering vehicles due to slope conditions or other safety factors.

Exhibit B.1-2, continued

REPRINT OF SCAQMD RULE 403 (Amended December 1998), PAGES 15 AND 16

DUST CONTROL FOR EXEMPTION FROM PARAGRAPH (d)(3)**FUGITIVE DUST****SOURCE CATEGORY****CONTROL ACTIONS****Disturbed surface areas (except completed grading areas)**

(2a/b) Apply dust suppression in sufficient quantity and frequency to maintain a stabilized surface. Any areas which cannot be stabilized, as evidenced by wind driven fugitive dust must have an application of water at least twice per day to at least 80 [70] percent of the unstabilized areas.

Disturbed surface area: Completed grading areas

- (2c) Apply chemical stabilizers within five working days of grading completion; OR
- (2d) Take actions (3a) or (3c) specified for inactive disturbed surface areas

Inactive disturbed surface areas

(3a) Apply water to at least 80 [70] percent of all inactive disturbed surface areas on a daily basis when there is evidence of wind driven fugitive dust, excluding any areas which are inaccessible to watering vehicles due to excessive slope or other safety conditions; OR

(3b) Apply dust suppressants in sufficient quantity and frequency to maintain a stabilized surface; OR

(3c) Establish a vegetative ground cover within 21 [30] days after active operations have ceased. Ground cover must be of sufficient density to expose less than 30 percent of unstabilized ground within 90 days of planting, and at all times thereafter; OR

(3d) Utilize any combination of control actions (3a), (3b), and (3c) such that, in total, these actions apply to all inactive disturbed surface areas.

Unpaved Roads

(4a) Water all roads used for any vehicular traffic at least once per every two hours of active operations [3 times per normal 8 hour work day]; OR

(4b) Water all roads used for any vehicular traffic once daily and restrict vehicle speeds to 15 miles per hour; OR

*Measures in [brackets] are reasonably available control measures and only apply to sources not within the South Coast Air Basin.

Exhibit B.1-2, continued

REPRINT OF SCAQMD RULE 403 (Amended December 1998), PAGES 15 AND 16

DUST CONTROL FOR EXEMPTION FROM PARAGRAPH (d)(3)**FUGITIVE DUST****SOURCE CATEGORY****CONTROL ACTIONS****Unpaved Roads (cont'd.)**

(4c) Apply a chemical stabilizer to all unpaved road surfaces in sufficient quantity and frequency to maintain a stabilized surface.

Open storage piles

(5a) Apply chemical stabilizers; OR

(5b) Apply water to at least 80 [70] percent of the surface area of all open storage piles on a daily basis when there is evidence of wind driven fugitive dust; OR

(5c) Install temporary coverings, OR

(5d) Install a three-sided enclosure with walls with no more than 50 percent porosity, which extend, at a minimum, to the top of the pile.

All Categories

(6a) Any other control measures approved by the Executive Officer and the U.S. EPA as equivalent to the methods specified in Table 2 may be used.

*Measures in [brackets] are reasonably available control measures and only apply to sources not within the South Coast Air Basin.

B.2. OPERATIONAL EMISSIONS

1. INITIAL STUDY SCREENING PROCESS

A. Initial Study Checklist Questions

III.a): Would the project conflict with or obstruct implementation of the applicable air quality plans?

III.b): Would the project violate any air quality standard or contribute substantially to an existing or projected air quality violation?

III.c): Would the project result in a cumulatively considerable net increase of any criteria pollutant for which the project region is non-attainment under an applicable federal or state ambient air quality standard (including exceeding emissions which exceed quantitative thresholds for ozone precursors)?

III.d): Would the project expose sensitive receptors to substantial pollutant concentrations?

III.e): Would the project create objectionable odors affecting a substantial number of people?

B. Introduction

Operational emissions are defined as those, which occur after project construction activities have been completed, and the project becomes operational. Operational emissions are produced by the occupants of a facility or development and by both mobile and stationary sources connected to the facility or development. Depending on the characteristics of the individual project, operational activities have the potential to generate emissions of criteria and/or toxic air contaminants. This section focuses on emissions of criteria pollutants by point, mobile, and area sources. Toxic air emissions, which may occur during operational activities, are discussed separately in B.3. TOXIC AIR CONTAMINANTS.

Stationary source emissions include point source emissions that have an identifiable location, such as a smokestack, as well as area source emissions, such as fumes or minor sources of exhaust, which are emitted by multiple, small sources. Stationary point sources include project equipment and processes such as power plants and refinery boilers, while area sources originate from diverse sources such as generators and residential water heaters. Certain industrial and commercial operations, such as dairies and wastewater treatment plants, may

result in odors that impact sensitive receptors in the surrounding area.

Mobile source emissions occur as a result of motor vehicle, train, ship, and airplane travel. Motor vehicle emissions result from passenger vehicles and truck travel throughout the South Coast Air Basin (Basin) and are generally analyzed on a regional basis. Projects can be either direct sources of vehicle trips, such as a bus or shipping service, or indirectly generate or attract trips from or to the project site, such as a regional shopping center or employee work site.

Motor vehicle emissions can influence local air quality through changes in carbon monoxide (CO) concentrations, which are usually highest at busy intersections, parking garages, or other focused areas of vehicle activity. Because CO dissipates quickly, and based on methodologies established by the South Coast Air Quality Management District (SCAQMD) and California Air Resources Board (CARB), changes in CO concentrations are generally analyzed only where they would be in proximity to sensitive receptors.

Regulatory Framework

As described in B. AIR QUALITY, a number of plans, policies, and regulations have been adopted by local, state and federal agencies to address air quality concerns. Each of these plans and regulations are designed to reduce criteria pollutants for which state and federal health-based standards have been set.

Emissions from new, expanded and/or relocated stationary sources are regulated extensively by the SCAQMD through Regulation XIII, New Source Review (NSR); the permitting process for specific equipment and industrial processes; and compliance with source-specific regulations. NSR requires that any net increase in air pollutants from new or modified sources is offset by a reduction in emissions from another source. If the potential to emit is small (less than four tons/year) for any given criteria pollutant, a facility is exempt from providing emission offsets. However, if potential annual emissions are equal to or greater than four tons of reactive organic gases (ROG), nitrogen oxides (NO_x), sulfur oxides (SO_x), or particulate matter (PM₁₀), they must be offset by Emission Reduction Credits (ERCs). The rule also requires that new sources install Best Available Control Technology (BACT) as a means of limiting air emissions.

In October 1993, the SCAQMD adopted the Regional Clean Air Incentives Market (RECLAIM) program to provide certain stationary source facilities added flexibility in meeting emission reduction requirements and to lower the cost of compliance. RECLAIM facilities are those that generate four or more tons of NO_x and SO_x per year. Each facility is assigned an emissions cap that decreases over time, and is allowed to select appropriate and cost-effective strategies to meet the emissions cap. Facilities are allowed "RECLAIM Trading Credits"

(RTCs) to account for excess reduction of emissions, which can be traded (sold) to other facilities that are not able to reduce emissions as effectively.

Title V of the Clean Air Act Amendments (CAAA) requires certain facilities to obtain a single, facility-wide air permit, which consolidates and replaces all previously issued air permits for individual pieces of equipment. Locally, Title V is implemented through SCAQMD's Regulation XXX and is applicable to a facility if it is a Major stationary source or subject to Title IV, solid waste incineration requirements, a New Source Performance Standard (NSPS), or a National Emission Standard for Hazardous Air Pollutants (NESHAP). Major sources are facilities with actual emissions of 8 tons per year of volatile organic compounds (VOC), NO_x, or any single Hazardous Air Pollutant (HAP) or with yearly emissions in excess of 80 tons of SO_x, 40 tons of CO, or 56 tons of PM₁₀.

The SCAQMD's Rule 2202, On-Road Motor Vehicle Mitigation Options (required for employers of more than 250 people), provides a menu of strategies to reduce or otherwise mitigate the mobile source emissions resulting from employee commute trips. In addition, land use strategies and improvements to public transit that result in fewer single occupant vehicle (SOV) trips are being implemented by various agencies in the region, including the City. Other mobile source emission reduction strategies, such as market incentives and intercredit trading programs, are currently under study. Tailpipe emissions are regulated by CARB.

In air quality nonattainment and maintenance areas, transportation plans, programs, and projects must contribute to reducing motor vehicle emissions and be drawn from a conforming air quality plan. Conformity is a determination made by the Metropolitan Planning Organization (MPO) and United States Department of Transportation (DOT) that the transportation plans and programs meet the "purpose" of the State Implementation Plan (SIP), namely, reducing pollutant emissions to meet the National Ambient Air Quality Standards (NAAQS). All federally assisted and regionally significant projects, including non-federally assisted projects, are subject to the federal Transportation Conformity Rule. The Southern California Association of Governments (SCAG) is the MPO for the 5-county southern California region, including Los Angeles County and its member cities.

Because the City of Los Angeles has not established or adopted Citywide screening criteria or significance thresholds for operational emissions, the *Thresholds Guide* reprints guidance from the SCAQMD's CEQA Air Quality Handbook to assist in the evaluation of project impacts. The Screening Criteria, Evaluation of Screening Criteria, Significance Threshold and Project Impact sections that appear in this document are all reprinted from, or summaries of, the guidance in the CEQA Air Quality Handbook. For further information, please refer to the CEQA Air Quality Handbook, available from the SCAQMD. It is the responsibility of the lead City department to determine the appropriate significance criteria.

C. Screening Criteria

Would the proposed project:

Result in a development and/or activity level equal to or greater than the thresholds provided in the CEQA Air Quality Handbook's Screening Table for Operation – Daily Thresholds of Potential Significance for Air Quality¹ (see Exhibit B.2-1)?

Conflict with the regional population forecast and distribution in the most recent Air Quality Management Plan (AQMP)?

Have the potential to create or be subjected to an objectionable odor or localized CO hot spot that could impact sensitive receptors?

A "yes" response to any of the preceding questions indicates that further study in an expanded Initial Study, Negative Declaration, Mitigated Negative Declaration, or EIR may be required. Refer to the Significance Threshold for Operational Emissions, and review the associated Methodology to Determine Significance as appropriate.

A "no" response to all of the preceding questions indicates that there would normally be no significant impact from Operational Emissions from the proposed project.

D. Evaluation of Screening Criteria

Review the description of the proposed project, and identify all new or modified sources of stationary and mobile source emissions. Use Exhibit B.2-1 to assess the potential to exceed the daily emissions thresholds for criteria pollutants. Consider the population likely to result from project implementation and identify conflicts with the regional population forecast and distribution in the most recent AQMP. Determine the potential for objectionable odors to impact sensitive receptors. Sensitive land uses include residences, board and care facilities, schools, playgrounds, hospitals, parks, childcare centers, and outdoor athletic facilities.

Compare this information to the Screening Criteria.

¹ *This table is based on potential mobile source emissions for specified land uses and is not intended to screen for stationary sources. Stationary sources are screened on an individual basis by SCAQMD permit staff. (J. Nadler, SCAQMD, personal communication, October 1997.)*

2. DETERMINATION OF SIGNIFICANCE

A. Significance Threshold

A proposed project would normally have a significant impact on air quality from project operations if any of the following would occur:

Operational emissions exceed 10 tons per year of volatile organic gases or any of the daily thresholds presented below (as reprinted from the CEQA Air Quality Handbook):

| Pollutant | Significance Threshold
(lbs./day) |
|------------------|--------------------------------------|
| ROG | 55 |
| NO _x | 55 |
| CO | 550 |
| PM ₁₀ | 150 |
| SO _x | 150 |

Either of the following conditions would occur at an intersection or roadway within one-quarter mile of a sensitive receptor:

The proposed project causes or contributes to an exceedance of the California 1-hour or 8-hour CO standards of 20 or 9.0 parts per million (ppm), respectively; or

The incremental increase due to the project is equal to or greater than 1.0 ppm for the California 1-hour CO standard, or 0.45 ppm for the 8-hour CO standard.

The project creates an objectionable odor at the nearest sensitive receptor.

B. Methodology to Determine Significance

Environmental Setting

In a description of the environmental setting, include the following information:

The air quality regulatory framework;

Description of existing ambient air quality conditions as indicated by data from the SCAQMD monitoring station closest to, or most representative of, the project site;

Summary of regional climate and air quality conditions, including a wind rose (which diagrams the frequency of occurrence for each wind direction), if odors are anticipated;

Description of the project site and surrounding area, including the location of sensitive receptors; and

Summary of the existing transportation system and traffic conditions, such as traffic volumes, Level of Service (LOS), transit facilities, etc.

Project Impacts

Project-related factors to be used in evaluating significance include the following:

Type, number of pieces, and usage of equipment;

Rate, quantity, and type of fuel consumption;

Emission factors, assuming implementation of applicable rules and regulations;

Type(s) and size(s) of land uses, including location of vehicle driveways and parking facilities;

The location and usage of equipment or processes that may emit odors;

Modes of transportation, fleet mix, length, number, and type (e.g., work, non-work) of trips, main routes;

Number of employees per land use category; and

Vehicle speeds and ambient temperature.

Pollutant emission rates for known pieces of equipment or processes, as well as energy consumption, are generally available from the manufacturer or from the SCAQMD. If information regarding the number and type of equipment proposed is not available, stationary source emissions may be estimated by using other indicators, such as emission rates per square foot of development. Standardized default values are provided in the CEQA Air Quality Handbook, or consult CARB source classification codes and Environmental Protection Agency (EPA) emission factors.

There are three main methods of determining mobile source and energy consumption emissions as identified by the SCAQMD, depending on the level of detail needed. These include the use of:

Screening Tables 9-7 and 9-8 in the CEQA Air Quality Handbook;

Computer modeling, using the most recent version of Mobile Assessment for Air Quality Impacts (MAAQI); and

Methodology and emission factors in Appendix 9 of the CEQA Air Quality Handbook.

The MAAQI model, and the methodology in Appendix 9 of the CEQA Air Quality Handbook, allow estimation of emissions of criteria pollutants from vehicle trips associated with new or modified development, incorporating the most recent vehicle emission factors (EMFAC) from CARB. User-defined inputs to the models include project type, average vehicle miles traveled, year, season, trip speed, and other parameters. This information would be identified in the project traffic study. (See Appendix 9 of the CEQA Air Quality Handbook for more information.) Determine project-related mobile source emissions and compare to the daily emissions threshold reprinted from the CEQA Air Quality Handbook in the significance threshold.

Localized Mobile Sources (CO Hotspots)

Calculate future CO levels and the incremental increase in CO levels resulting from the proposed project at an intersection, driveway, parking facility, or roadway within one-quarter mile of a sensitive receptor. Assess whether there is an exceedance of the California standards.

Where more detailed or site specific analysis is desired, the CEQA Handbook recommends a dispersion model to estimate potential CO "hotspots," such as CALINE and CAL3QHC. For a detailed explanation of the CALINE4 model, refer to the California Air Resources Board publication *Air Quality Technical Analysis Note (AQ-TAN): Microscale CO Procedures for California Users*. Caltrans has also prepared a "CO Protocol" which is available for use within California and was developed based on information specific to California roads and driving conditions. Project-specific information from the traffic study or SCAQMD default values may be used.

Ambient CO concentrations through the year 2010 are presented in the CEQA Handbook and in the SCAQMD's *Draft Technical Report V-I: Assessment of Nitrogen Dioxide and Carbon Monoxide in the South Coast Air Basin*.

Based on the project's operational components, including activities and measures designed to reduce odors, determine whether the project would create an objectionable odor at the nearest sensitive receptor. Consider patterns of air flow/prevaling winds as applicable.

Using the information from the Evaluation of Screening Criteria, the project evaluation described above, and guidance from the appropriate source, calculate the emissions from operational activities, using the worst-case conditions. Identify measures that will be taken as part of the project to reduce air emissions. Determine the impact from all project sources.

Cumulative Impacts

Review the list of related projects and identify those that would have pollutant or odor emissions. Determine the potential impacts of all such projects, together with the proposed project, using the methodology above.

Sample Mitigation Measures

Potential mitigation measures include the following:

Install on-site pollution control equipment;

Modify industrial processes to reduce emissions;

Provide telecommunications centers near residential areas;

Establish shuttle service from residential areas to transit centers or commercial core areas;

Construct off-site pedestrian facility improvements, such as overpasses and wider sidewalks;

Contribute to regional transit systems (e.g., right-of-way, capital improvements, etc.);

Construct, contribute, or dedicate land for the provision of off-site bicycle trails linking the facility to designated bicycle commuting routes;

Provide video-conferencing facilities;

Implement home dispatching system where employees receive routing schedule by phone instead of driving to work;

Use low-emission fleet vehicles;

Provide on-site child care facilities;

Provide services, facilities, or incentives to reduce employee work trips. Consider ride share programs or shuttle service for employees;

Include adequate ventilation systems in parking structures to dissipate CO emissions;

Contribute to signal synchronization at congested areas;

Locate sensitive receptors away from potential "hotspots;" and

Provide barriers, such as wall or vegetative screen, between hotspots and sensitive receptors.

See L.1 INTERSECTION CAPACITY for Transportation Demand Management (TDM) measures.

See M.4 ENERGY for energy conservation mitigation measures.

3. DATA, RESOURCES, AND REFERENCES

SCAQMD, CEQA Staff (909-396-3109) and www.aqmd.gov/ceqa.

CARB. AQ-TAN. Microscale CO Procedures for California Users. June 1988.

CARB. CALINE4 - A Dispersion Model For Predicting Air Pollutant Concentrations Near Roadways. Revised June 1989. www.dot.ca.gov/hq/env/air/calinesw.htm.

California Department of Transportation (Caltrans). CO Transportation Project Protocol, 1997.

Local Government Commission (LGC), Land Use Strategies for More Livable Places, June 1992. (This publication may be obtained by writing to LGC, 909 12th Street, Suite 205, Sacramento, CA 95814.)

SCAQMD, Draft Technical Report V-I: Assessment of NO₂ and CO in the SCAB. December 1990.

See also B. AIR QUALITY and B.1. CONSTRUCTION EMISSIONS.

Urbemis 2002 (version 7.4.2) A Model that Estimates Air Pollution from a Wide Variety of Land Use Projects. www.aqmd.gov/ceqa/urbemis.htm.

Exhibit B.2-1

REPRINT OF SCAQMD CEQA AIR QUALITY HANDBOOK, PAGES 6-10 TO 6-12

SCREENING TABLE FOR OPERATION

DAILY THRESHOLDS OF POTENTIAL SIGNIFICANCE FOR AIR QUALITY

| Primary Land Use | Potentially Significant Air Quality Impact |
|---|--|
| Residential | |
| Single Family Housing | 166 units |
| Apartments | 261 units |
| Condominiums | 297 units |
| Mobile Homes | 340 units |
| Retirement Community | 612 units |
| Education | |
| Elementary School | 220,000 sq.ft. |
| High School | 177,000 sq.ft. |
| Community College | 150,000 sq.ft. |
| University ^a | 813 students |
| Commercial | |
| Airport ^a | 15 Daily Commercial Flights |
| Business Park | 136,000 sq.ft. |
| Day Care | 26,000 sq.ft. |
| Discount Store ^a | 32,000 sq.ft. |
| Fast Food w/o Drive-Thru | 3,500 sq.ft. |
| Fast Food with Drive-Thru | 2,800 sq.ft. |
| Hardware Store ^a | 28,000 sq.ft. |
| Hotel | 213 rooms |
| Medical Office | 61,000 sq.ft. |
| Motel | 220 rooms |
| Movie Theater ^a | 30,000 sq.ft. |
| Car Sales ^a | 43,000 sq.ft. |
| Office (small, 10-100) | 96,221 sq.ft. |
| Office (medium, 100-200) | 139,222 sq.ft. |
| Office (large, 200->) | 201,000 sq.ft. |
| Office Park | 171,000 sq.ft. |
| Racquet Club | 98,000 sq.ft. |
| Research Center | 245,000 sq.ft. |
| Resort Hotel | 199 rooms |
| Restaurant | 23,000 sq.ft. |
| Restaurant (high-turnover) ^a | 9,000 sq.ft. |

Exhibit B.2-1, continued

REPRINT OF SCAQMD CEQA AIR QUALITY HANDBOOK, PAGES 6-10 TO 6-12

SCREENING TABLE FOR OPERATION

DAILY THRESHOLDS OF POTENTIAL SIGNIFICANCE FOR AIR QUALITY

| Primary Land Use | Potentially Significant Air Quality Impact |
|--|--|
| Commercial (cont'd.) | |
| Shopping Center (small, 10-500) | 22,000 sq.ft. |
| Shopping Center (medium, 500-1,000) | 50,000 sq.ft. |
| Shopping Center (large, 1,000-1,600) | 64,000 sq.ft. |
| Special Activity Center ^a
(Stadiums and Amusement Parks) | 87 employees |
| Supermarket | 12,500 sq.ft. |
| Industrial/Mining | |
| Light Industrial | 276,000 sq.ft. |
| Heavy Industrial ^a | 1,284,000 sq.ft. |
| Industrial Park | 276,000 sq.ft. |
| Aircraft Manufacturing & Repairs | b |
| Bulk Terminals | b |
| Cement Plant | b |
| Chemical Plant | b |
| Hazardous Waste Treatment & Storage | b |
| Manufacturing | 500,000 sq.ft. |
| Mining | b |
| Pulp/Paper Mills | b |
| Refinery | b |
| Institutional/Governmental | |
| Clinic ^a | 94,000 sq.ft. |
| Government Center ^a | 83,000 sq.ft. |
| Hospital ^a | 176 Beds |
| Library | 51,000 sq.ft. |
| Nursing Home | 741 Beds |
| U.S. Post Office | 26,000 sq.ft. |
| Freeway Lane Addition | All |
| Designation of a New Transportation Corridor | All |
| New Freeway/Highway | All |
| Auxiliary Lanes | Beyond One Ramp |

Exhibit B.2-1, continued

REPRINT OF SCAQMD CEQA AIR QUALITY HANDBOOK, PAGES 6-10 TO 6-12

SCREENING TABLE FOR OPERATION

DAILY THRESHOLDS OF POTENTIAL SIGNIFICANCE FOR AIR QUALITY

| Primary Land Use | Potentially Significant Air Quality Impact |
|---|--|
| Institutional/Governmental (cont'd.) | |
| Waterport | b |
| Sewage Treatment Plant | b |
| Rail | All |
| Cogeneration Project | b |
| Landfill | b |
| Incineration | Hazardous, Medical or Municipal Waste |
| Power Generating Facility | b |
| Waste-To-Energy Plant | b |
| <p>^a Trip generation rates from the 5th Edition ITE Manual were based upon small sample sizes.</p> <p>^b New facilities, expansions or other changes that could result in emissions exceeding the significance thresholds.</p> <p>These size construction projects have the potential to exceed the daily emissions significance thresholds. Local governments should use these thresholds as screening tools when a project proponent first approaches the lead agency for a permit, to determine whether or not the proposed project will be significant. Moreover, using these thresholds, a project proponent should be advised to include feasible mitigation measures at the project design level rather than in later stages of the project.</p> <p><i>Definitions:</i></p> <p>“Manufacturing” means to make goods and articles by hand or machinery, often on a large scale and with division of labor.</p> <p>“Industry” means any large-scale business activity or manufacturing productive enterprises collectively, especially as distinguished from agriculture.</p> | |

B.3. TOXIC AIR CONTAMINANTS

1. INITIAL STUDY SCREENING PROCESS

A. Initial Study Checklist Questions

- III.a): Would the project conflict with or obstruct implementation of the applicable air quality plan?
- III.b): Would the project violate any air quality standard or contribute substantially to an existing or projected air quality violation?
- III.d): Would the project expose sensitive receptors to substantial pollutant concentrations?

B. Introduction

The California Health and Safety Code (HSC) Section 39655 defines a toxic air contaminant as "an air pollutant which may cause or contribute to an increase in mortality or an increase in serious illness, or which may pose a present or potential hazard to human health." Toxic air contaminants are further classified as carcinogenic or non-carcinogenic substances.

Due to the adverse potential health effects of exposure to toxic air contaminants, both the federal and state governments have established lists of pollutants, which are either regulated at the state level through AB 1807, or at the federal level through the National Emissions Standards for Hazardous Air Pollutants (NESHAPs). The state regulations governing toxic air contaminants are more stringent than federal regulations. The primary responsibility for the implementation of these regulations within the City resides with the South Coast Air Quality Management District (SCAQMD) through its permitting authority. SCAQMD Rules 1401 (New Source Review (NSR) of Carcinogenic Air Contaminants) and 212 (Standards for Approving Permits) implement HSC Section 41700 that requires efforts to be undertaken to prevent new emissions that endanger public health.¹ The California Air Pollution Control Officers Association (CAPCOA) has set forth specific guidelines for the assessment of non-carcinogenic air contaminants from stationary point sources.

¹ SCAQMD Rule 1402 regulates toxic emissions from existing facilities.

SCAQMD's CEQA Air Quality Handbook (pages 3-6 to 3-7) lists the federal and state legislation that governs the regulation of toxic air contaminants. In addition to AB 1807 (Tanner Air Toxics Act), AB 2588 addresses toxic "hot spots," AB 3205 regulates toxic releases within 1,000 feet of schools, and AB 3374 involves monitoring of disposal sites.

Under Title III of the 1990 Clean Air Act Amendments (CAAA), the Environmental Protection Agency (EPA) was required to publish a list of categories of major sources of the Hazardous Air Pollutants (Toxics or HAPs) listed in Section 112 by November 1991. That list was then divided into a 10-year regulatory schedule for developing Maximum Achievable Control Technology (MACT) standards for every category or subcategory with specific accomplishments required in 2, 4, 7, and 10 year periods after enactment.

A carcinogenic air contaminant is a substance that has been shown to cause cancer in animals or humans. There is no specific concentration of carcinogenic air contaminants that can be considered completely safe. Thus, the amount of increased risk a person has of getting cancer from exposure to carcinogenic air toxics is used as an indicator of potential significant health effects.

Non-carcinogenic toxic air contaminants are defined as those which cause health effects other than cancer, such as lung, kidney, or liver diseases; respiratory or eye irritation; and nervous, reproductive or immune system disorders. By using health studies and adding safety margins, health experts have set reference exposure levels for these toxic chemicals. The risk of non-cancer health effects is described as a ratio, or hazard index. It compares an individual's highest exposure levels at a given site to the reference exposure level for that toxic.

Impacts from toxic air contaminants can occur during either the construction or operational phases of a project. During certain construction activities, potential releases of toxic air contaminants could occur during site remediation activities, or during building demolition. Toxic air contaminants may also be released during industrial or manufacturing processes, or other activities that involve the use, storage, processing, or disposal of toxic materials.

For a discussion of accidental chemical releases, please refer to F.1. RISK OF UPSET/EMERGENCY PREPAREDNESS. Exposure to asbestos is discussed in F.2. HUMAN HEALTH HAZARDS.

C. Screening Criteria

- Would the project use, store, or process carcinogenic or non-carcinogenic toxic air contaminants which could result in airborne emissions?

A "yes" response to the preceding question indicates that further study in an expanded Initial Study, Negative Declaration, Mitigated Negative Declaration, or EIR may be required. Refer to the significance threshold for Toxic Air Contaminants, and review the associated Methodology to Determine Significance, as appropriate.

A "no" response to the preceding question indicates that there would normally be no significant impact from Toxic Air Contaminants from the proposed project.

D. Evaluation of Screening Criteria

Review the proposed project and its associated components, including demolition, site preparation, construction, and operation. Determine the potential for toxic airborne emissions. Professional assistance may be required. Compare this information to the Screening Criteria.

2. DETERMINATION OF SIGNIFICANCE

A. Significance Threshold

The determination of significance shall be made on a case-by-case basis, considering the following factors:

- The regulatory framework for the toxic material(s) and process (es) involved;
- The proximity of the toxic air contaminants to sensitive receptors;
- The quantity, volume and toxicity of the contaminants expected to be emitted;
- The likelihood and potential level of exposure; and
- The degree to which project design will reduce the risk of exposure.

B. Methodology to Determine Significance

Environmental Setting

In a description of the environmental setting, include a discussion of the applicable regulatory setting and existing facilities or operations in the area, which may release toxic air

emissions. Identify the location and type of all sensitive uses, which could be impacted by project emissions.

Project Impacts

Review the proposed project including construction and operation activities. Identify and evaluate project features or components that would reduce the risk of exposure. The CEQA Air Quality Handbook defines the following land uses as sensitive receptors: residences, schools, playgrounds, child care facilities, long-term health care facilities, rehabilitation centers, convalescent centers, retirement homes, and outdoor athletic facilities. Consider the regulatory framework and determine the resulting risk of exposure. Additional information to assist with project evaluation is provided in the CEQA Air Quality Handbook.

Cumulative Impacts

Review the related projects and identify those that would involve the potential release of toxic air contaminants and could contribute to a concentration of toxic air contaminants. Evaluate the potential cumulative impacts as described above for Project Impacts. Information to assist with cumulative evaluation is provided in the CEQA Air Quality Handbook.

Sample Mitigation Measures

New sources of toxic air contaminants are regulated in the South Coast Air Basin (Basin) by the SCAQMD. Permit requirements generally result in emissions that are considered to be less than significant by the SCAQMD. Consult the CEQA Air Quality Handbook for additional information.

Potential mitigation measures include the following:

- Provide barriers that reduce emissions (e.g., screens, vents, closed systems);
- Use non-toxic or less toxic substances in project construction or operation; and
- Investigate opportunities and implement programs to improve efficiency and/or reduce the amount of waste emissions generated.

3. DATA, RESOURCES, AND REFERENCES

SCAQMD, Toxics Division. Information on health risk assessments, toxics permits and compliance may be obtained by calling the SCAQMD Toxics and Waste Management Branch at (909) 396-2388.

CAPCOA, Air Toxics Assessment Manual, 1987 and Air Toxics "Hot Spots" Program Risk Assessment Guidelines. (updated yearly). Available by calling CAPCOA at (916) 676-4323.

California Air Resources Board (CARB). Documents available for each AB 1807 toxic air contaminant which is identified. Contact the CARB's Public Information Office at (916) 322-2990 or call ARB Air Quality Measures Branch (916) 445-6318. California Air Toxics Program web page <http://www.arb.ca.gov/toxics/toxics.htm>.

HSC Section 44300 et sec. Air Toxics "Hot Spots" Information and Assessment Act of 1987 and Section 39650 et sec. Toxic Air Contaminants (Chapter 3.5).

SCAQMD, Procedures for Preparing Risk Assessments to Comply with Air Toxics Rules of the SCAQMD.

Environmental Protection Agency (EPA), Guideline on Air Quality Models (revised). EPA-450/2-78-027R. Available at <http://www.epa.gov/>

See also B. AIR QUALITY, B.1. CONSTRUCTION EMISSIONS, and B.2. OPERATIONAL EMISSIONS.

C. BIOLOGICAL RESOURCES

C. BIOLOGICAL RESOURCES

1. INITIAL STUDY SCREENING PROCESS

A. Initial Study Checklist Questions

- IV.a): Would the project have a substantial adverse effect, either directly or through habitat modifications, on any species identified as a candidate, sensitive, or special status species in local or regional plans, policies, or regulations, or by the California Department of Fish and Game or U.S. Fish and Wildlife Service?
- IV.b): Would the project have a substantial adverse effect on any riparian habitat or other sensitive natural community identified in local or regional plans, policies, regulations or by the California Department of Fish and Game or U.S. Fish and Wildlife Service?
- IV.c): Would the project have a substantial adverse effect on federally protected wetlands as defined by Section 404 of the Clean Water Act (including, but not limited to, marsh, vernal pool, coastal, etc.) through direct removal, filling, hydrological interruption, or other means?
- IV.d): Would the project interfere substantially with the movement of any native resident or migratory fish or wildlife species or with established native resident or migratory wildlife corridors, or impede the use of native wildlife nursery sites?
- IV.e): Would the project conflict with any local policies or ordinances protecting biological resources, such as a tree preservation policy or ordinance?
- IV.f): Would the project conflict with the provisions of an adopted Habitat Conservation Plan, Natural Community Conservation Plan, or other approved local, regional, or state habitat conservation plan?

B. Introduction

A wide variety of sensitive biological resources, including both plant and animal species, reside in or use resources within the City of Los Angeles. The City encompasses a variety of open space and natural areas that serve as habitat for sensitive species. Much of this natural open space is found in or is adjacent to the foothill regions of the San Gabriel, Santa Susana, Santa Monica and Verdugo Mountains, the Simi Hills, and along the coastline between Malibu and the Palos Verdes Peninsula.

Many of the outlying areas are contiguous with larger natural areas, and may be part of significant wildlife habitats or movement corridors. In contrast, the central and valley portions of the City contain fewer natural areas.

Various-sized remnants of native habitats, such as hillside and canyon areas, wetland habitats, dunes, beaches and marine habitats exist in many areas of the City. Although these areas may have been modified from their natural conditions, they are still important habitats for wildlife. Habitat values are generally highest in areas of relatively large acreage adjacent to other similar habitat systems. Some sensitive biotic resources may persist even in urbanized settings, such as oak trees, rare plants, peregrine falcons, Monarch butterflies and bats.

Federal and state agencies, including the U.S. Fish and Wildlife Service (USFWS) and the California Department of Fish and Game (DFG), maintain listings of sensitive species and habitat (i.e., federal or state listed endangered, federal or state listed threatened, Species of Special Concern, federal or state candidate species; and federally listed critical habitat).

A project may impact biological resources through the loss or destruction of individuals of a sensitive species or through degradation of sensitive habitat. Habitat degradation may occur through grading or excavation, increases in water or air pollutants, increased noise, light, or vibration, interruption of fresh or salt water supplies, reduction in food supplies or foraging areas, or interference with established wildlife movement patterns on or between habitat areas. Projects, which create long-term or episodic impacts to natural areas -- such as by generating toxic fumes or fugitive dust -- could also result in degradation or destruction of a natural habitat. New development, construction, roadways, and agricultural use all have the potential to lower or remove natural resource values of natural open space systems.

Exhibit C-1 divides the City into five geographic zones for the purpose of identifying potential sensitive biological resources. Natural open space areas within the City's 11 Planning Subregions that may contain habitat for sensitive species are shown on Exhibits C-2 through C-5. These maps are based upon interpretation of aerial photography of the City dated November 1992¹. The maps include open space areas, as well as several areas that appear to be devoted to agriculture and mineral extraction. The latter areas are mapped because they are of substantial size and presently or potentially meet habitat needs for plants and animals. Urban parks, golf courses, and small reservoirs are excluded from this mapping unless they are physically contiguous with other habitats, such as at the Sepulveda and Hansen flood control basins. A few vacant lots within the City are also indicated on these maps by virtue of their size and present or future potential to support biological

¹ Areas that have been developed since November 1992 may be shown as open space habitat on these maps.

resources. Additionally, Significant Ecological Areas (SEAs), established by the County of Los Angeles through its General Plan, are shown. Exhibit C-6, describes the SEAs, open space habitats, and other potential/known sensitive resources in each planning subregion.

Both federal and state legislation calls for the protection of sensitive species, and the habitat that supports them, to reduce the chance that existing and future development will seriously endanger the continued existence of native biological resources. The presence of adequate habitat, including food and water, shelter, and nesting sites, is critical to a species' long-term survival. Exhibit C-7 provides a summary of existing known sensitive biological resources and classifications within the City of Los Angeles and vicinity, along with their federal and state listed status, habitat requirements, and the biological assessment zone (from Exhibit C-1) in which the species may exist. This exhibit also provides applicable classifications from the California Native Plant Society (CNPS).

The habitat types in the remaining natural open space areas are quite diverse. Chaparral, which supports a wide variety of wildlife, is most prevalent on the north slopes and higher-elevation south slopes of the Santa Monica and Verdugo Mountains. Open-structured coastal scrub and grassland are prevalent on the lower-elevation south slopes of these ranges, and also in the Simi Hills, Santa Susana and San Gabriel Mountains. Grasslands also occur in flood control basins and near reservoirs in various parts of the City. Along the coast, sandy beaches, rocky cliffs, headlands and promontories support marine invertebrates, fishes, mammals, birds and plants. In addition, coastal habitats, including the dunes, marshes and bluffs, support a number of unique, threatened and endangered plants and animals.

For the purposes of the *Thresholds Guide*, a sensitive biological resource is defined as follows:

- A plant or animal that is currently listed by a state or federal agency(ies) as endangered, threatened, rare, protected, sensitive or a Species of Special Concern or federally listed critical habitat;
- A plant or animal that is currently listed by a state or federal agency(ies) as a candidate species or proposed for state or federal listing; or
- A locally designated or recognized species or habitat.

C. Screening Criteria

For projects proposed on sites within the City of Los Angeles that are located in Area 5 of Exhibit C-1, or **in the unshaded portions** of Exhibits C-2 through C-5:

- Do known individuals or populations of a sensitive species use or inhabit the site during one or more seasons of the year, according to readily available published accounts, the project proponent and/or property owner?
- Is the project site immediately adjacent to undeveloped natural open space containing native vegetation (such as the shaded areas on Exhibits C-2 through C-5) or does the site appear to serve as a buffer between existing development and more natural habitat areas? Could it be part of a movement corridor or habitat linkage system?
- Is a natural water source, such as a lake, river, vernal pool, ephemeral stream, marsh or the ocean present on or adjacent to the site?

A "yes" response to any of the preceding questions indicates further study in an expanded Initial Study, Negative Declaration, Mitigated Negative Declaration, or EIR may be required. Refer to the Significance Threshold for Biological Resources and review the associated Methodology to Determine Significance, as appropriate.

A "no" response to all of the preceding questions indicates that there would normally be no significant impact on Biological Resources from the proposed project.

For projects proposed on sites within the City of Los Angeles that are located **within a shaded open space area** as identified on Exhibits C-2 through C-5:

- Do known individuals or populations of a sensitive species use or inhabit the site during one or more seasons of the year, according to readily available published accounts, the project proponent and/or property owner?
- Does the project site contain natural open space and/or known native vegetation?
- Does the site serve as a buffer between existing development and more natural habitat areas?
- Does the site serve as a known wildlife movement corridor between habitat areas?

- Is a natural water source, such as a lake, river, vernal pool, ephemeral stream, marsh or the ocean present on, or immediately adjacent to, the project site?
- Is the project site relatively undisturbed or undeveloped, that is, free of structures, agricultural fields, pavement, etc.? Is it free of regular maintenance activities such as disking or clearing, maintenance and repair of linear utilities, maintenance or repair of roads, or maintenance and repair of municipal reservoirs and associated infrastructure?²

A "yes" response to any of the preceding questions indicates further study in an expanded Initial Study, Negative Declaration, Mitigated Negative Declaration, or EIR may be required. Refer to the Significance Threshold for Biological Resources and review the associated Methodology to Determine Significance, as appropriate.

A "no" response to each of the previous questions indicates that there would normally be no significant impact on Biological Resources from the proposed project.

D. Evaluation of Screening Criteria

Locate the proposed project site on the appropriate map presented in Exhibits C-1 through C-5. Determine the existing conditions on the project site and surrounding area, including whether existing vegetation is native, urbanized, or ruderal (i.e, weedy or introduced plants where native vegetation has been disturbed).

If the site is located in an unshaded portion of Exhibits C-2 through C-5, review the first set of screening questions. Look for evidence that a sensitive species outside of the normal range, or an urban migratory species, uses or inhabits the site during one or more seasons. Look for unmanaged vegetation, cave-like areas, evidence of nesting, hunting, tracks or droppings, and review readily available published accounts of such sightings. Also, confer with the property owner and project proponent. Check for natural sources of water on or adjacent to the site as well as proximity of the site to areas of undeveloped open space to determine whether the site could serve as a buffer or wildlife movement corridor.

If the site is located within a shaded portion of Exhibits C-2 through C-5, review the second set of questions. Review Exhibits C-1 and C-7 to assist in identifying which species may potentially be located on the project site. If the project site has been developed or substantially disturbed since these maps were prepared in November 1992, use the questions for sites within the unshaded

² *Natural surface disturbances, such as fire or flood, are not considered to be resource-degrading.*

portions of the maps. The federal and state species lists change periodically; always compare with the most recent edition.

2. DETERMINATION OF SIGNIFICANCE

A. Significance Threshold

A project would normally have a significant impact on biological resources if it could result in:

- The loss of individuals, or the reduction of existing habitat, of a state or federal listed endangered, threatened, rare, protected, or candidate species, or a Species of Special Concern or federally listed critical habitat;
- The loss of individuals or the reduction of existing habitat of a locally designated species or a reduction in a locally designated natural habitat or plant community;
- Interference with wildlife movement/migration corridors that may diminish the chances for long-term survival of a sensitive species;
- The alteration of an existing wetland habitat; or
- Interference with habitat such that normal species behaviors are disturbed (e.g., from the introduction of noise, light) to a degree that may diminish the chances for long-term survival of a sensitive species.

B. Methodology to Determine Significance

Environmental Setting

In a description of the environmental setting, include the following information:

- A physical description of the project site, including acreage, topography, presence of sensitive features (e.g., wetlands, flowing, standing or ephemeral water sources, rock outcroppings, caves, etc.), major habitats and vegetation communities present, potential presence of wildlife populations, sensitive resources, migration corridors, and relationship to the surrounding land;

- In marine environments, describe the presence or absence of tidal wetlands, the bottom topography and depth, access to open ocean systems, information on existing biota, and the existence of movement or migration corridors of marine mammals; and
- A statement of the potential for existing sensitive resources, based upon review of Exhibit C-7, and other biological reference documents, including the California Natural Diversity Database (CNDDDB), federal and state agency lists, regulatory statutes, and applicable City documents.
- A review of local, state, and federal regulations that apply to the project site.

Prepare or reference baseline assessments of potential occurrence of sensitive resources (from literature and existing resource data bases) and conduct a field reconnaissance survey, as needed. Surveys should be performed during appropriate seasons, and should include all significant biotic elements, including corridor and habitat linkages, with an assessment of the nature of their occurrence (e.g., resident, transient, migratory, etc.). Species inventories should include organisms observed during surveys, along with those reasonably expected to occur over time, with a listing of sensitive biological elements and their agency status. See Exhibit C-7 for a list of sensitive resources potentially present within the City, and Exhibits C-1 through C-5 for habitat maps for various areas of the City.

Project Impacts

Prepare a biological assessment of the site, based on the known and potential biological resources on and adjacent to the site. Determine the actual presence or absence within project boundaries or on adjacent lands of sensitive plants, animals or habitats listed as "potentially present" in resource databases. Also, note the quality of existing vegetation.

Review the project description, including site preparation, construction and operational plans, to identify which biological resources could be lost or degraded by project implementation, if any, including habitats, shelter, movement corridors, foraging grounds, and nesting areas. Professional assistance may be required. Compare the results to the Significance Threshold. Incremental loss of areas used seasonally may be significant depending upon the value of the habitat that remains.

Cumulative Impacts

Review the list of related projects and identify those that, in combination with the proposed project, could impact sensitive biological resources. Consider especially impacts to the same species, habitat, or open space area as those affected by the proposed project. Include site preparation and construction activities as well as operational activities. Note whether the projects could combine to obstruct wildlife movement corridors, contribute to habitat fragmentation, or affect sensitive plants or animals. Assess the incremental losses to habitat, foraging areas, wintering grounds, nesting sites, etc., and any potential takings of sensitive species.

Also, evaluate the impact of cumulative project operational activities on sensitive species and habitats. Consider effects such as increased traffic, noise, fumes, general human activity, ambient lighting, fencing, fugitive dust pollution, infiltration of herbicides or industrial waste chemicals, and harassment of wildlife by domestic pets.

Sample Mitigation Measures

Specific project mitigation measures should be based on recommendations in the biological assessment and involve consultation with appropriate resource protection agencies. Potential mitigation measures include the following:

- Revise project construction plans to avoid grading or excavation during sensitive seasons (e.g., rain, nesting, etc.);
- Design the project such that the most biologically-sensitive portions of the site are preserved for natural habitat;
- Block human and domestic animal access to sensitive habitats adjacent to the project site;
- Provide for revegetation/restoration after project construction; and
- Mitigation banking: Compensate (to the satisfaction of resource agencies) for the loss of habitat values in one area by purchasing or deed-restricting similar or better habitat systems on other sites. These areas would be high value ecosystems, preferably containing viable populations of sensitive resources.

3. DATA, RESOURCES, AND REFERENCES

Los Angeles County Department of Regional Planning; Telephone: (213) 974-6411. SEA information. <http://planning.co.la.ca.us>.

Exhibit C-8 contains general references regarding biological resources in the Los Angeles area.

USFWS, Ecological Services, Carlsbad Field Office, 6010 Hidden Valley Road, Carlsbad, California, 92009; Telephone: (760) 431-9440. The USFWS can provide information regarding the Endangered Species Act, federally listed species, and federal wildlife resources and their protection.

Selected Legislation

Federal

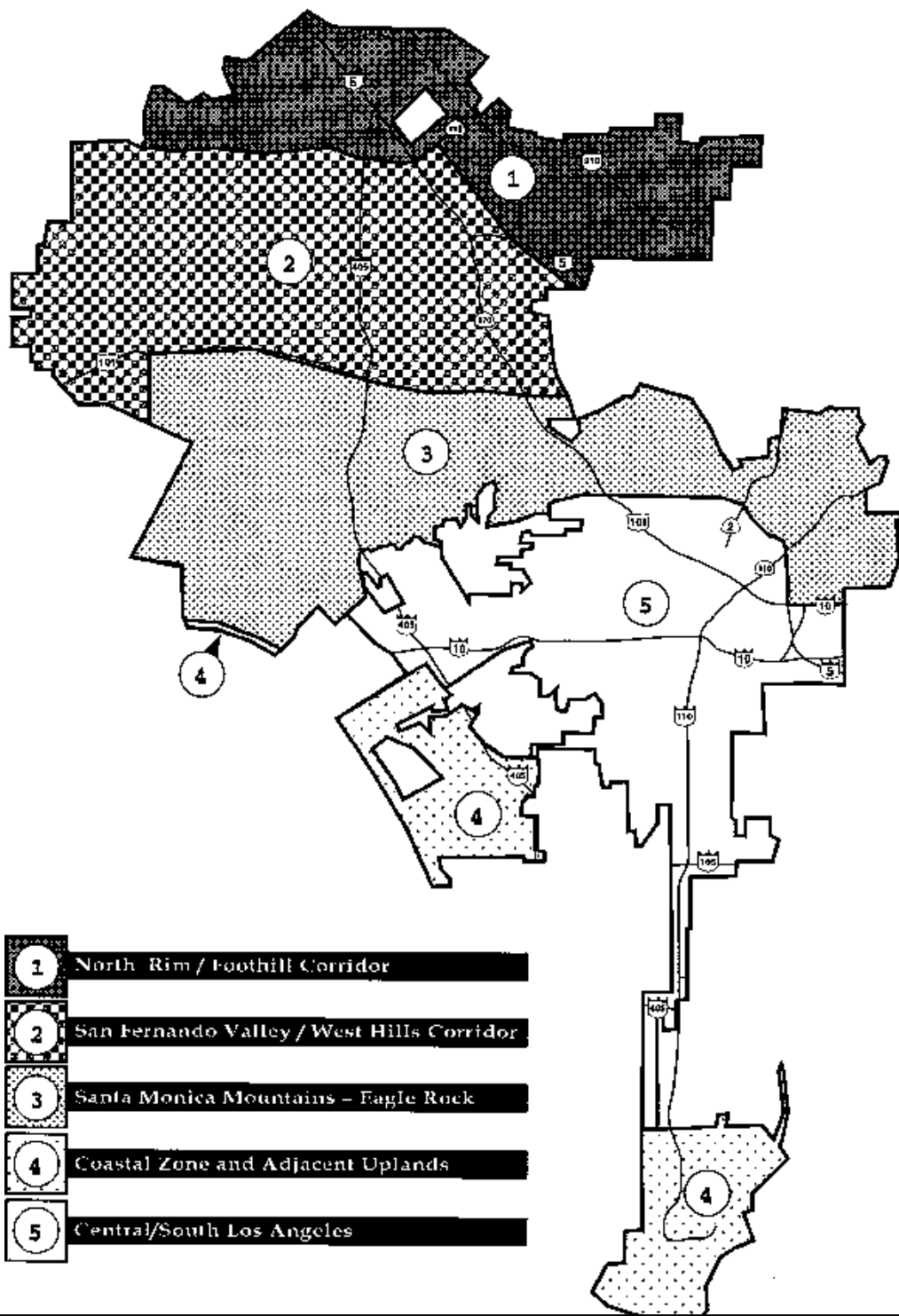
Endangered Species Act of 1973, PL 93-205 (16 U.S.C. 1531)

Purpose is to provide a means whereby the ecosystems upon which endangered species and threatened species depend may be conserved, to provide a program for the conservation of such endangered species and threatened species, and to take such steps as may be appropriate to achieve the purposes of the treaties and conventions set forth.

State

California Endangered Species Act, Fish and Game Code, Division 3, Chapter 1.5.

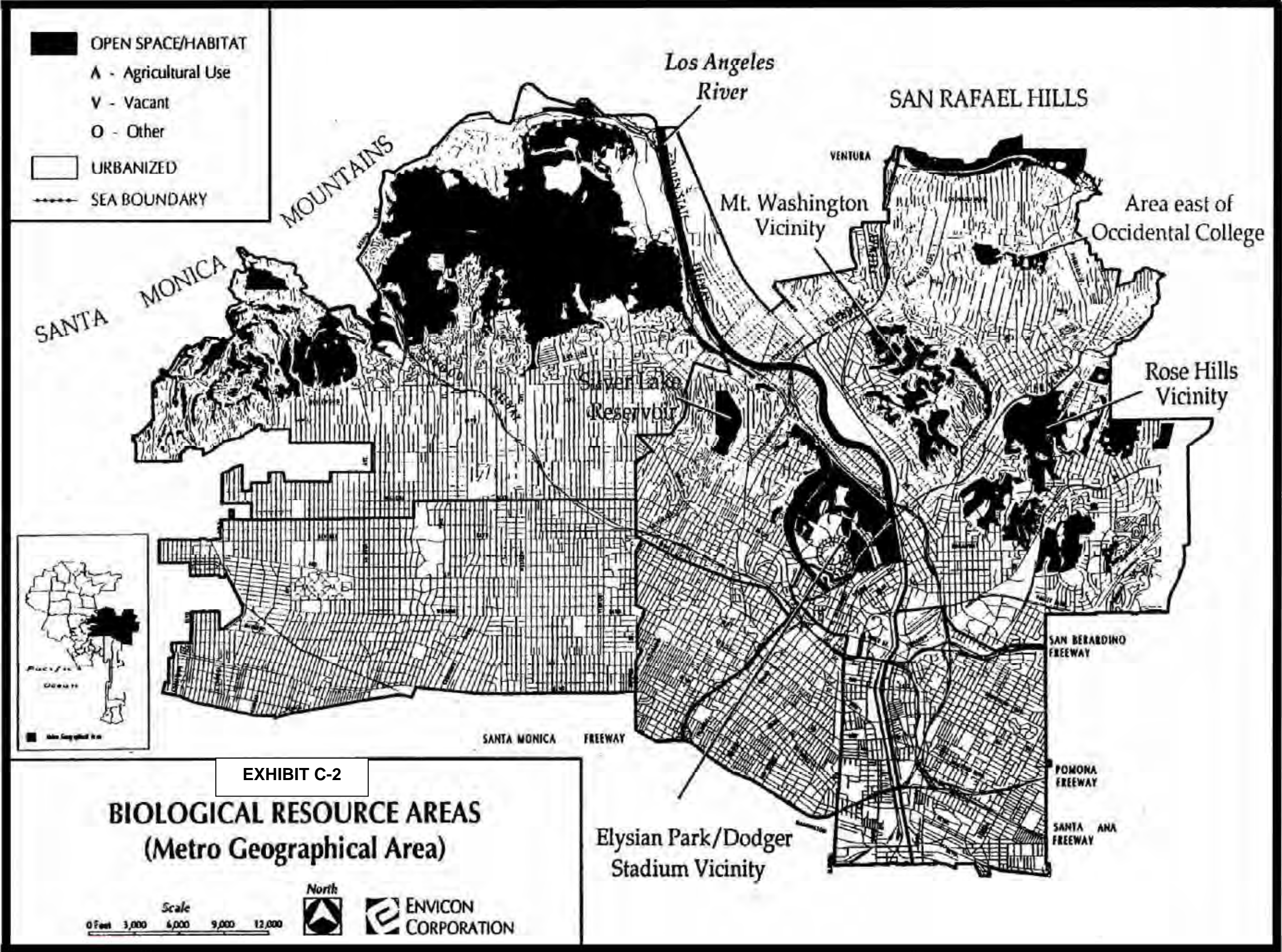
Declares that these species of fish, wildlife, and plants are of ecological, educational, historical, recreational, esthetic, economic, and scientific value to the people of this state, and the conservation, protection, and enhancement of these species and their habitat is of statewide concern. Provides for a state list of endangered and threatened species by the Fish and Game Commission and restricts activities that may impact these species.



Planning
Consultants
Research

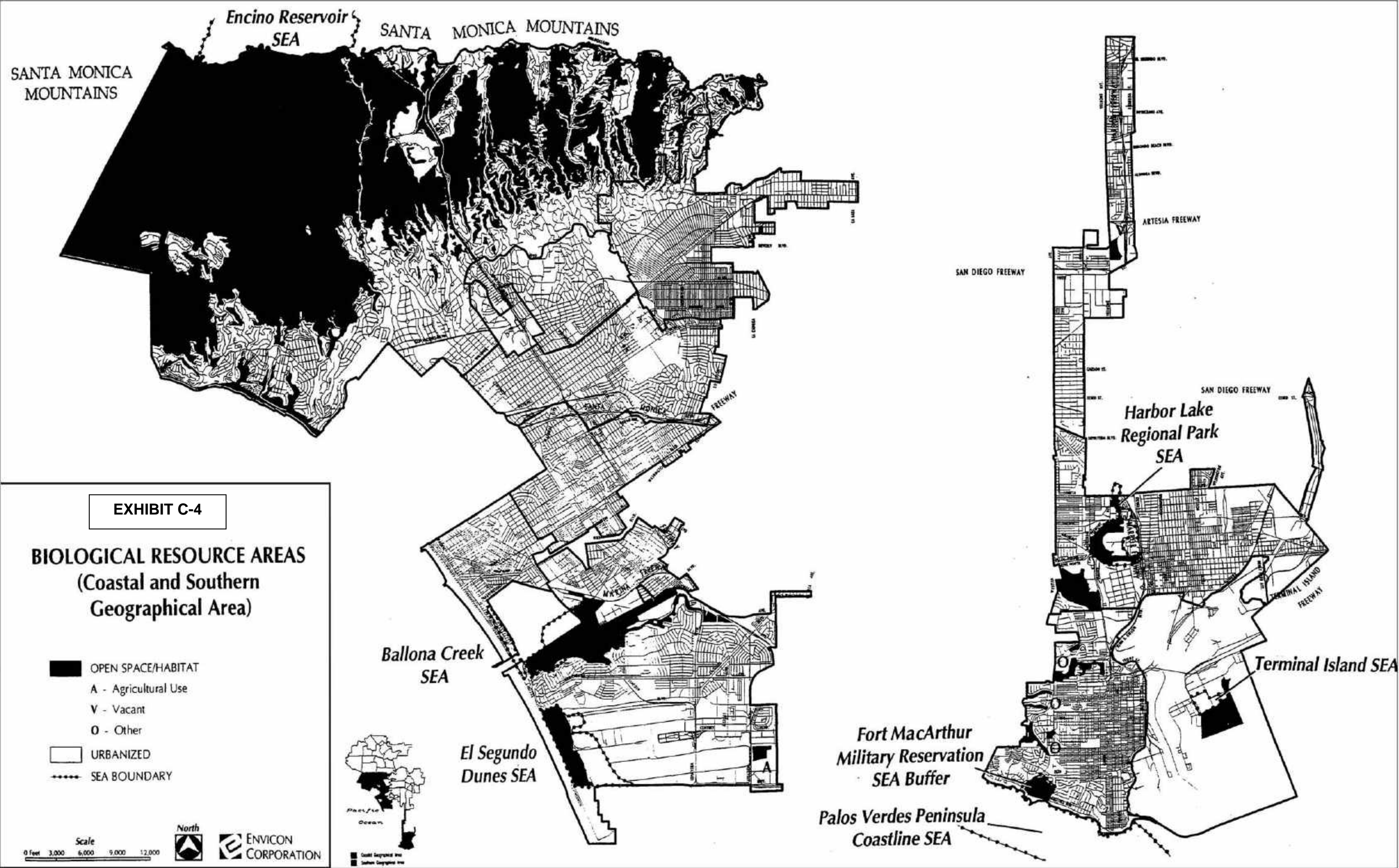
Exhibit C-1
**Habitat-Oriented Biological
Assessment Planning Zones**

This page intentionally left blank.

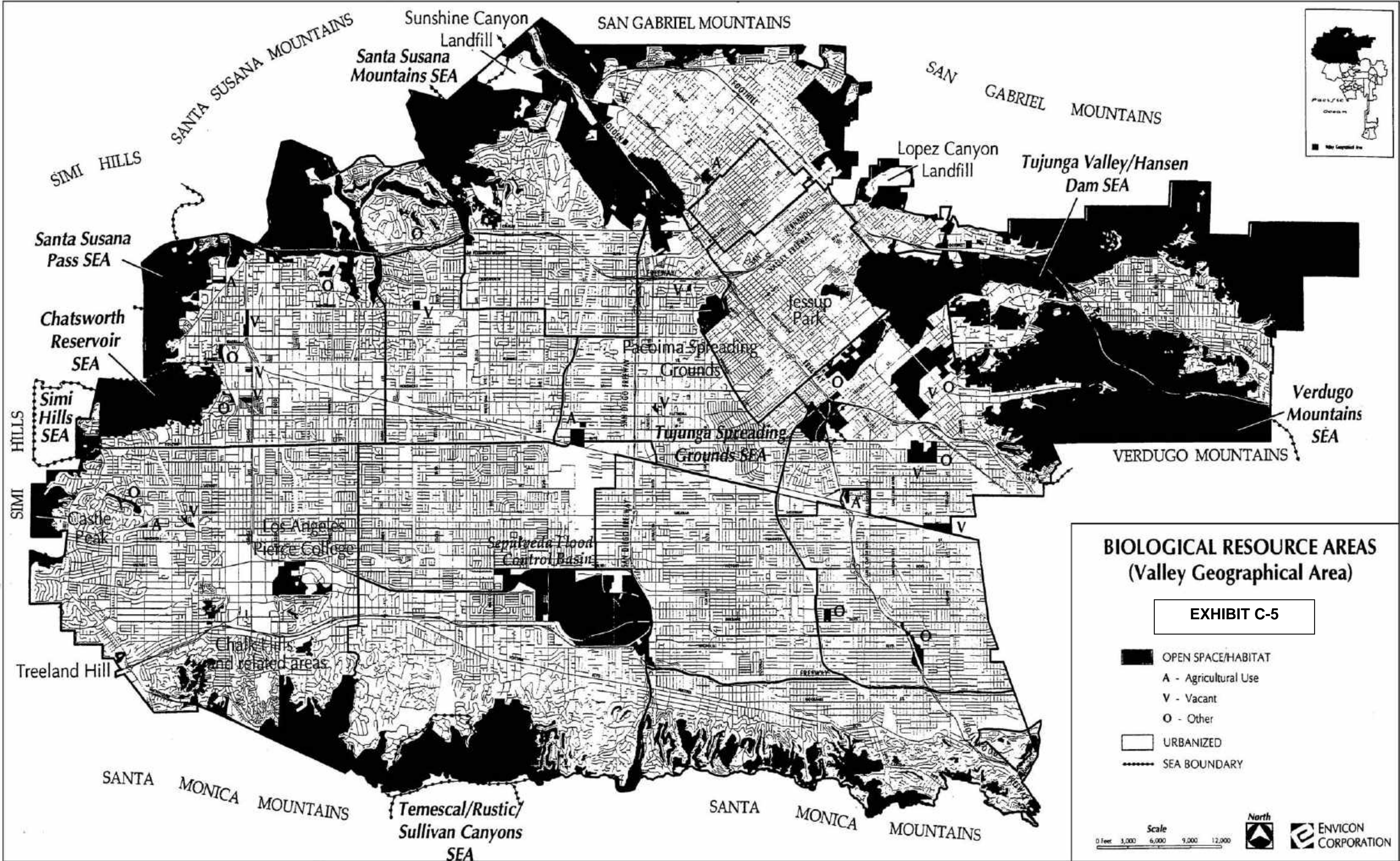


This page intentionally left blank.

This page intentionally left blank.



This page intentionally left blank.



This page intentionally left blank.

Exhibit C-6
NATURAL HABITATS AND SIGNIFICANT ECOLOGICAL AREAS (SEAs)
WITHIN THE CITY OF LOS ANGELES¹

The following discusses the open space resources and SEAs in each of the eleven Planning Subregions of the City, starting in the north and proceeding generally south. Within each subregion, the mapped open spaces and habitats they contain are briefly discussed, and the reader is referred to those general and site-specific accounts of biological resources that were found applicable to each subregion. Often, an open space area occurs in more than one subregion (e.g. Santa Monica Mountains). Such occurrences are discussed separately in each case, but in greatest detail when first encountered in the discussion. Therefore, the reader may find reference in the discussion to a prior description of an open space area in an earlier subregion. There is additional information about SEAs at the end of this section.²

Northwest Valley Planning Subregion

Chatsworth Reservoir SEA. The Chatsworth Reservoir is owned by the Los Angeles Department of Water and Power, and abuts the foot of the Simi Hills in the Western San Fernando Valley. A variety of habitats are present here, including grassland, oak woodland and savannah, freshwater marsh and open water, which offer important wintering and breeding grounds for songbirds and waterfowl (England and Nelson, 1976). The Chatsworth reservoir is one of five areas in the San Fernando Valley that is used regularly by wintering Canada Geese (*Branta canadensis*). Many-stemmed dudleya (*Dudleya multicaulis*) is reported in rocky areas on the south side of the reservoir (NDDB, 1994).

Simi Hills and Simi Hills SEA, and Santa Susana Pass SEA. The Simi Hills are generally located north of the Ventura Freeway (US 101), south of the Simi Valley Freeway (SR 118), and west of the San Fernando Valley. As such, they lie largely outside of the City boundary, and are mostly within Ventura County. However, portions of its eastern flank bordering the western San Fernando Valley from the vicinity of Castle Peak to Santa Susana Pass lie within the City. Wieslander (1934) mapped the vegetation of this region between 1927 and 1933. Wiekell (1983) has prepared a biological inventory and mapping for this area, although additional specific biological resource inventories of the Simi Hills within the City and County of Los Angeles are generally lacking. A survey over the areas of Dayton and Woolsey Canyons (Envicom Corp., 1990) in the Simi Hills just east of the Chatsworth Reservoir is the best representative inventory available for the eastern Simi Hills. Habitats present include grassland, coastal scrub, chaparral, riparian and oak woodland, and limited areas of walnut woodland. The state-listed Rare Santa Susana tarplant

¹ Reprinted from the EIR for the Framework Element.

² SEA boundaries are established by Los Angeles County. The current legal boundaries and status should be verified.

Exhibit C-6, continued
NATURAL HABITATS AND SIGNIFICANT ECOLOGICAL AREAS (SEAs)
WITHIN THE CITY OF LOS ANGELES¹

(*Hemizonia mint Jionii*) is prevalent in the sandstone outcrops, and Humboldt lily (*Lilium humboldtii ocellatum*) occurs in the under story of riparian woodland in upper Dayton Canyon.

The Simi Hills SEA is almost entirely within the unincorporated area of Los Angeles County, with only a small fraction extending into the City. The remaining portions of this SEA are located west of Chatsworth Reservoir and Valley Circle Boulevard, and north and south of Lakeside Park (a residential community). Santa Susana tarplant occurs adjacent to Valley Circle Boulevard in the northern area (Wishner, personal observation, 1990). The Simi Hills SEA contains representative examples of chaparral, coastal scrub, southern oak woodland and riparian woodland, and the area also serves as a wildlife corridor for movement between the Chatsworth Reservoir SEA and the large, undeveloped portions of the Simi Hills in Ventura County to the west (England and Nelson, 1976).

The southern portion of the Santa Susana Pass SEA that is located south of the Simi Valley Freeway (SR 118) is actually located in the Simi Hills, within the City of Los Angeles (the remainder of the SEA north of the freeway is in the Santa Susana Mountains, and outside the City boundary). The Santa Susana Pass SEA is an important wildlife movement zone between the Santa Susana Mountains and the Simi Hills (England and Nelson 1976), which is referred to as the "primary Simi Valley Freeway habitat linkage" by Edelman (1991). Intact crossings for large mammals include the Rocky Peak Road freeway overpass (just outside City/County line). Habitats encompassed by the Santa Susana Pass SEA (within the City) include chaparral, coastal scrub, grassland, oak woodland, and riparian woodland. The SEA also contains concentrations of Santa Susana tarplant, which is associated with sandstone outcrops in chaparral and coastal scrub habitats.

Discrepancies between the original boundaries recommended (England and Nelson, 1976) and adopted by the County of Los Angeles and the extent of open space habitat for plants and animals shown on Exhibits C-2 through C-5, are the result of "deletions" of areas from the SEA as they have become developed.

Santa Susana Mountains and Santa Susana Mountains SEA. The Santa Susana Mountains form an open-space link between the San Gabriel Mountains (northeast) and the Simi Hills and Santa Monica Mountains (southwest). With the exception of a resource inventory and mapping prepared by Wiekell (1983) and bird lists for O'Melveny Park (Martin, 1992), specific biological resource accounts of the Santa Susana Mountains are generally lacking. The range does support grassland, chaparral, oak woodland and savanna, riparian woodland, and big-cone spruce woodland (latter on the north slope only).

Exhibit C-6, continued
NATURAL HABITATS AND SIGNIFICANT ECOLOGICAL AREAS (SEAs)
WITHIN THE CITY OF LOS ANGELES¹

A small, eastern extension of the Santa Susana Mountains SEA is located within the City boundary, although much of the former SEA here is occupied by the Sunshine Canyon Sanitary Landfill.³ Habitats of the Santa Susana Mountains SEA include grassland, coastal sage scrub, chaparral, oak woodland and savannah, and riparian woodlands (England and Nelson, 1976). Porter Ranch is also included in this geographic region.

Van Norman Reservoir and vicinity. This large open space area in the northern San Fernando Valley receives water via aqueduct over the San Fernando Pass--the divide between the Santa Susana and San Gabriel Mountains. The size of the reservoir containing open water was substantially reduced following the Sylmar earthquake in 1971, when the lower dam was drained. As a result, portions of that area have recovered to form willow forest habitat. Upland portions of the reservoir area support grassland and coastal scrub vegetation. The area is one of five, which are regularly used by wintering Canada geese. To the south and adjacent to the reservoir are agricultural lands, a cemetery, a parcel containing remnant grassland, coastal scrub and oak woodland, and several vacant lots. These form a cohesive unit, which offers resources for plants and animals as an adjunct to the reservoir site. Across the Golden State Freeway (I-5) from the Van Norman Reservoir (in the Northeast Valley subregion) is a substantial area of grassland, coastal scrub, and small open water habitat, which adds to the effective size and resource value of the reservoir site.

Pacoima Spreading Grounds. This area of storm water runoff collection located southwest of the junction of the Golden State Freeway (I-5) and the Simi Valley Freeway (SR 118) is divided approximately in half between the Northwest and Northeast Valley Planning Subregions. It supports marsh-like habitat when ponding occurs (City of Los Angeles, 1989), and offers opportunities for migrating waterfowl and shorebirds.

Northeast Valley Planning Subregion

San Gabriel Mountains. This subregion contains portions of the foothills of the San Gabriel Mountains bordering the San Fernando Valley and extending from the western end of the range eastward to Pacoima Canyon, Lopez Canyon, Little Tujunga Canyon and Big Tujunga Canyon. From there, the City includes the foothills of the range bordering on the San Gabriel Valley eastward to approximately Hines Canyon, and extending upward into the mountains to the vicinity of Mount Lukens. Biological resources of the San Gabriel Mountains are discussed generally (Hanes, 1976; Schoenherr, 1976 and 1992; USDA:FS, 1987; Long, 1994), but specific biological accounts of areas

³ *The footprint of the landfill shown in Exhibit C-2 is as of November 1992, and does not reflect the expansion which has occurred since that date.*

Exhibit C-6, continued
NATURAL HABITATS AND SIGNIFICANT ECOLOGICAL AREAS (SEAs)
WITHIN THE CITY OF LOS ANGELES¹

within the City [with the exception of detailed vegetation maps prepared by Wieslander (1934)] are limited to project-related environmental impact reports and sensitive species records in the Natural Diversity Data Base. Habitats evident in the City boundary on aerial photographs include primarily coastal scrub and chaparral, and limited areas of oak and riparian woodlands, and grasslands.

Verdugo Mountains and Verdugo Mountains SEA. The City includes the entire northwestern end of this mountain range bordering the San Fernando Valley and the San Gabriel Valley. This geographic location makes the Verdugo Mountains an important habitat linkage between the San Gabriel Mountains to the north, and the Santa Monica Mountains to the south (England and Nelson, 1976). Both general and specific accounts of biological resources therein are lacking or limited to project-related environmental impact reports or accounts of sensitive species, and the detailed vegetation maps of the area prepared by Wieslander in 1934. As shown on aerial photographs, habitats present in these mountains include grassland, coastal scrub, chaparral, riparian and oak woodlands.

A substantial portion of the Verdugo Mountains SEA lies within the City, while the remainder is within the corporate boundaries of Burbank and Glendale. Although England and Nelson (1976) indicate "considerable information exists on the area," this information was not available for preparation of the General Plan Framework EIR.

Tujunga Valley/Hansen Dam Park SEA. The Tujunga Valley occupies the floodplain of Big Tujunga Canyon. Hansen Dam is a flood control basin receiving stream discharge from Lopez, Kagel, Little Tujunga, and Big Tujunga Canyons. The floodplain behind Hansen Dam (Hansen Dam Park) supports one of the last examples of alluvial scrub vegetation in the freshwater marsh, willow forest and scrub. Alluvial scrub is habitat for the state-listed Endangered Nevin's barberry (*Berberis nevinii*) and the state- and federally-listed Endangered slender-horned spineflower (*Dodecahema leptoceras*), which have been found here (England and Nelson, 1976; City of Los Angeles, 1989a). Long (1994) has prepared a list of plants and birds occurring at the Tujunga Ponds. The park reportedly (City of Los Angeles 1989) supports a south coast minnow/sucker stream which sustains native populations of arroyo chub (*Gila orcutti*) and Santa Ana sucker (*Catostomus santaanae*). Swift et al. (1993) report that arroyo chub remains common in Big Tujunga, whereas Pacific speckled dace (*Rhinichthys oscrilus*) and Santa Ana sucker have become scarce and perhaps extirpated. Areas to the southwest (below the dam) are used as a spreading ground for groundwater

Exhibit C-6, continued
NATURAL HABITATS AND SIGNIFICANT ECOLOGICAL AREAS (SEAs)
WITHIN THE CITY OF LOS ANGELES¹

recharge, which has created several freshwater marsh areas used by marsh birds, migratory waterfowl, and shorebirds (England and Nelson, 1976).⁴

Jessup Park. A small area of chaparral, coastal scrub and grassland habitats (as evident on aerial photographs) occurs just west of Hansen Dam Park--No specific details of biological resources present could be found in the available literature.

Tujunga Spreading Grounds SEA. This SEA is located in the Tujunga Wash downstream from Hansen Dam, at the juncture of the Golden State Freeway (I-5) and the Hollywood Freeway (SR 170). Although it contains little natural vegetation, it is an area of ponded water serving as an important nesting, feeding and resting ground for many migrating, resident and wintering bird species (England and Nelson, 1976).

Pacoima Spreading Grounds. This area of storm water runoff collection located southwest of the junction of the Golden State Freeway (I-5) and the Simi Valley Freeway (SR 118) is divided approximately in half between the Northwest and Northeast Valley Planning Subregions. It supports "marsh-like habitat" when ponding occurs (City of Los Angeles, 1989), and offers opportunities for migrating waterfowl and shorebirds

Van Norman Reservoir vicinity. Across the Golden State Freeway (I-5) from the Van Norman Reservoir (in the adjacent Northeast Valley subregion) is a substantial area of grassland, coastal scrub, and small open water habitat, which adds to the effective size and resource value of the reservoir site.

Southwest Valley Planning Subregion

Santa Monica Mountains and Encino Reservoir SEA. The biological resources of the Santa Monica Mountains are considered in general (Raven et al., 1986; Othmer, 1980; USDI:NPS, 1982; De Lisle et al., 1986). Wielander (1934) mapped the vegetation in detail between 1927 and 1933. Aside from project-related environmental impact reports and accounts of sensitive species, specific details are generally lacking. The subregion includes portions of the north slope of the range from the vicinity of Topanga Canyon Boulevard (south of US 101) eastward to the Sepulveda Pass (San Diego Freeway; I-405). As evidenced on aerial photographs, habitats in the area include mostly chaparral, but also oak and riparian woodland, and small amounts of grassland, coastal scrub and

⁴ *The SEA boundary shown on Exhibit C-2 is as originally proposed by England and Nelson (1976). A portion of the area was "redesignated to open space," therefore, not adopted as SEA under the Los Angeles County General Plan.*

Exhibit C-6, continued
NATURAL HABITATS AND SIGNIFICANT ECOLOGICAL AREAS (SEAs)
WITHIN THE CITY OF LOS ANGELES¹

walnut woodland. A small portion of Topanga State Park is included in upper Caballero (Reseda) Canyon, with the bulk occurring in the West Los Angeles subregion.

The Encino Reservoir SEA contains "the best stand of inland chaparral, coastal scrub and streamside vegetation remaining on the inland slope of the Santa Monica Mountains" (England and Nelson, 1976). In addition, the reservoir itself is an open, fresh water habitat. Along with Chatsworth Reservoir, the Sepulveda Basin, Van Norman Reservoir, and Los Angeles Pierce College, the Encino Reservoir is an important wintering ground for Canada geese.

Simi Hills and Simi Hills SEA. The Simi Hills are represented in this subregion by small areas at the western end of the San Fernando Valley, with the majority occurring in the Northwest Valley subregion. As discussed for that subregion, with the exception of an inventory and mapping by Weikel (1983), general and specific accounts of biological resources of the range are lacking. As evidenced by aerial photographs, the area within the City and subregion support grassland, chaparral, coastal scrub, oak and riparian woodland, and walnut woodland. Castle Peak⁵ is a prominent rocky peak that is a major roosting site for great horned (*Bubo virginianus*) and barn owls (*Tyto alba*), and probably a hibernaculum for one or more species of bats (Wishner, personal observation, 1987). None of the Simi Hills SEA occurs in the Southwest Valley subregion.

Los Angeles Pierce College. The campus of the former Clarence W. Pierce School of Agriculture retains a substantial amount of agricultural open space that is attractive to wintering Canada geese. As such, it is one of only five areas in the San Fernando Valley where Canada geese can forage. The recently-graded (fall 1993) Warner Ridge property adjacent to the west side of the Campus was also used by geese in the winter of 1994, since the area supported a dense growth of young grasses following the grading (Wishner, personal observation, 1994). In addition to the agricultural lands at Pierce College, the campus also contains an outdoor Nature Center with a pond and surrounding hillsides supporting grassland, and an arboretum. A number of sensitive or unusual bird species occur on the campus, especially in winter, and it is a popular location during the annual Christmas Bird Count conducted by the Audubon Society. The hilly portions of the campus represent an extension of the Chalk Hills discussed below.

Chalk Hills and related areas. The Chalk Hills in Woodland Hills are a privately-owned, small island of grassland vegetation south of the Ventura Freeway (US 101) in the foothills of the Santa Monica Mountains. Close proximity to these mountains enables this area to support wildlife species

⁵ Castle Peak is located west of Valley Circle Boulevard between Vanowen St. and Bell Canyon Rd.

Exhibit C-6, continued
NATURAL HABITATS AND SIGNIFICANT ECOLOGICAL AREAS (SEAs)
WITHIN THE CITY OF LOS ANGELES¹

including coyote (*Canis latrans*), bobcat (*Felis rufes*), western harvest mouse (*Reithrodontomys megalotis*), and California quail (*Callipepla californica*). Barn owls, great horned owls, red-tailed hawks (*Buteo jamaicensis*) and American kestrel (*Falco sparverius*) are resident in the trees of the surrounding neighborhood and forage in the grassland. The site is the only location of square-stemmed buckwheat (*Eriogonum angulosum*) in the Santa Monica Mountains zone. Similar, geologically-related areas occur between the Chalk Hills and Pierce College, and to the west of Topanga Canyon Boulevard both to the north and south of the Ventura Freeway (US 101), and again on the western edge of the subregion at Boething's Treeland Nursery.

Sepulveda Flood Control Basin. The Los Angeles River and tributaries draining the western San Fernando Valley discharge into the Sepulveda Basin. A variety of open space land uses occur here including agriculture, wastewater treatment, outdoor recreation, and an outdoor nature center. The area is one of only five areas of the San Fernando Valley that is regularly used by wintering Canada geese. The area also includes grassland and open water habitats, as well as two lakes (one is concrete lined), and a segment of riparian woodland on the river. The basin is a popular location for the annual Christmas Bird Count conducted by the Audubon Society. A portion of the Sepulveda Basin has been restored to attract migratory waterfowl and other wildlife.

Southeast Valley Planning Subregion

No substantial areas of natural habitat for plants and animals are evident on aerial photographs covering this subregion. Although the Los Angeles River passes through this area, it is a vertical-walled, concrete-lined segment of the stream.

Metro Center Planning Subregion

Santa Monica Mountains and Griffith Park SEA. Griffith Park, located at the east end of the Santa Monica Mountains, supports coastal scrub, chaparral, riparian and oak woodland habitats. The area also includes the Hollywood Reservoir. England and Nelson (1976) consider Griffith Park an important "island" rest stop for migrating birds, as well as a "reservoir for native species" and "corridor" for wildlife movement between the Santa Monica Mountains and San Gabriel Mountains, via the Verdugo Mountains. The Department of Recreation and Parks manages a portion of the Park as a bird sanctuary.

Exhibit C-6, continued
NATURAL HABITATS AND SIGNIFICANT ECOLOGICAL AREAS (SEAs)
WITHIN THE CITY OF LOS ANGELES¹

Central Los Angeles Planning Subregion

No substantial areas of natural habitat for plants and animals are evident on aerial photographs covering this subregion. Although the Los Angeles River passes through this area, it is a vertical-walled, concrete-lined segment of the stream.

Northeast Los Angeles Planning Subregion

Los Angeles River. The river in this subregion is a concrete-lined conveyance channel, although a five-mile stretch of the river from Griffith Park to the Golden State (I-5) and Pasadena (SR 11) Freeway interchange contains a natural bottom (City of Los Angeles, 1991). The river is perennial below the Sepulveda Basin since 1985 as a result of the discharge of tertiary-treated wastewater from the Tillman Reclamation Plant. A limited amount of riparian scrub vegetation is present in the bed of the river, subject to scouring and reappearance elsewhere in the shifting bottom sediments.

Elysian Park/Dodger Stadium. Undeveloped portions of this area support chaparral and oak woodland vegetation, as evident on aerial photography. No specific details of biological resources present there could be found in the literature.

Mount Washington and vicinity. In the area east of the Golden State Freeway (I-5) and between the Glendale (SR 2) and Pasadena (SR 11) Freeways, there occurs a number of small pockets of grassland and coastal scrub habitat in the mountainous area in the vicinity of Mount Washington. No specific details of biological resources present there could be found in the literature.

Areas east of Occidental College. Small pockets of grassland and coastal scrub habitats remain in the mountainous area just to the east of Occidental College. No specific details of biological resources present there could be found in the literature.

Rose Hill/Arroyo Seco Parks and Vicinity. Areas of remnant grassland habitat occur at Rose Hill Park and Arroyo Seco Park, and in the mountainous terrain to the south and east. Included here is also the open water habitat of Ascot Reservoir. No specific details of the biological resources present there could be found in the literature.

Silverlake and Ivanhoe Reservoirs. These reservoirs located west of the Golden State (I-5) and Glendale (SR 2) freeway interchanges are concrete-lined open water habitats with some waterfowl use.

Exhibit C-6, continued
NATURAL HABITATS AND SIGNIFICANT ECOLOGICAL AREAS (SEAs)
WITHIN THE CITY OF LOS ANGELES¹

San Rafael Hills. The San Rafael Hills represent a southeastward extension of the Verdugo Mountains. A small portion of the foothills on the southern flank of these mountains and on both sides of the Foothill Freeway (I-210) occurs within this subregion. As evident on aerial photographs, the primary habitat type present is chaparral.

South Los Angeles Planning Subregion

No substantial areas of natural habitat for plants and animals are evident on aerial photographs covering this subregion.

Southwest Los Angeles Planning Subregion

El Segundo Dunes SEA. Located west of the runways of the Los Angeles International Airport, the El Segundo Dunes SEA is the last remnant of a coastal dune system that once stretched several miles in each direction from here (England and Nelson, 1976). A substantial portion of the original SEA has been deleted due to airport expansion. The present SEA borders a portion of Dockweiler Beach State Park. The vegetation found here, referred to as coastal dune scrub, occurs nowhere else in the County. The dunes support the entire world population of the El Segundo Blue butterfly (*Euphilotes battoides allyni*), a federally listed endangered species. Much of the area has been disturbed by a former residential development, but the area is currently undergoing restoration. The specific biological resources of the El Segundo Dunes are discussed by Mattoni (1990).

Ballona Wetlands and Ballona Creek SEA. The Ballona Wetlands, located just north of the El Segundo Dunes, are privately owned and subject to a future restoration (ca. 280 acres) of the area to tidally influenced coastal saltmarsh under the Playa Vista Plan (City of Los Angeles, 1992; Mattoni, 1990a). The specific biological resources of the Ballona region have been investigated in some detail (Dailey et al., 1974; Envicom Corp., 1979; Schreiber, 1981; Jones and Stokes Associates 1981; Corey, 1990; Corey and Massey, 1990; Allen, 1991; Carter, 1991; Henrickson, 1991; Mattoni, 1991; Soltz, 1991). Habitats present include coastal saltmarsh willow woodlands, freshwater marsh, coastal dunes, and coastal scrub. The Ballona Creek SEA, generally encompassing the Ballona Wetlands, is one of two remaining remnants of coastal saltmarsh habitat in Los Angeles County (England and Nelson, 1976), and is used as a breeding ground for several state-listed Endangered species including Belding's savanna sparrow (*Passerculus sandwichensis beldingi*), California least tern (*Sterna antillarum browni*), saltmarsh skipper (*Panoquina errans*), and saltmarsh harvest mouse (*Sorex ornatus salicornicus*).

Exhibit C-6, continued
NATURAL HABITATS AND SIGNIFICANT ECOLOGICAL AREAS (SEAs)
WITHIN THE CITY OF LOS ANGELES¹

Baldwin Hills. The Baldwin Hills support coastal scrub and grassland communities, reportedly containing plant species now found only at the edge of the Los Angeles Metropolitan area and on the desert side of the San Gabriel Mountains (England and Nelson, 1976)⁶. According to these authors, they are "one of the last remaining open spaces in the western portion of the Los Angeles Basin."

West Los Angeles Planning Subregion

Santa Monica Mountains including Topanga State Park. The largest portions of the Santa Monica Mountains that are contained within the City occur in this subregion. The biological resources of the Santa Monica Mountains are considered in general (Raven et al., 1986; Othmer, 1980; USDI:NPS, 1982; De Lisle et al., 1986). Wieslander (1934) mapped the vegetation in detail between 1927 and 1933. Muns (1983) has compiled a flora for Topanga State Park. Aside from project-related environmental impact reports and accounts of sensitive species, specific details are generally lacking. The subregion includes the south slopes of the range from Topanga State Park eastward to Laurel Canyon. As evidenced on aerial photographs, habitats in the area include mostly chaparral, but also coastal scrub, oak and riparian woodland, and small amounts of grassland.

Will Rogers State Park Beach coastline. In the Pacific Palisades, sandy beach as well as rocky and sandy intertidal zones offer habitat for shorebirds.

Stone Canyon Reservoir. There are actually two reservoirs here. The upper reservoir is concrete-lined, and the lower one is larger, with natural banks. The area provides habitat for waterfowl, and also support a small area of walnut woodland.

Harbor Planning Subregion

Palos Verdes Peninsula Coastline SEA. The City includes the eastern portion of this SEA from near Cabrillo Beach Park/Point Fermin westward to the City boundary. The Fort MacArthur Military Reservation is included as a buffer for the SEA. The shoreline encompasses headlands, rocky shoreline, sandy beaches, intertidal areas, kelp beds, coastal strand, and coastal scrub vegetation (England and Nelson, 1976). The coastal cliffs and offshore rocks offer roosting and feeding sites for shorebirds, gulls and other seabirds including the state- and federally-endangered brown pelican. The state- and federally-listed Endangered peregrine falcon (*Falco peregrinus*

⁶ This area was originally considered as a potential SEA in 1976, however, most of the area was "redesignated to open space", and has subsequently been incorporated into the Kenneth Hahn State Recreation Area (Koutnik, personal communication, Oct. 6, 1994).

Exhibit C-6, continued
NATURAL HABITATS AND SIGNIFICANT ECOLOGICAL AREAS (SEAs)
WITHIN THE CITY OF LOS ANGELES¹

anatum), and Species of Special Concern prairie falcon (*Falco mexicanus*) are reported to winter along bluff tops in this area.

Harbor Lake Regional Park SEA. Harbor Lake Regional Park, located northwest of the junction of the Harbor Freeway (SR 110) and Anaheim Boulevard, supports one of two remaining wetland areas that once covered the South Bay area (the other area is Madrona Marsh, outside the City) (England and Nelson, 1976). Habitats present include willow forest, freshwater marsh and open water habitats, which support frogs, toads, water-dependent birds, and migratory birds. The Harbor Lake area is noted for the number of songbirds found there during migration, including many which are outside their normal ranges (so-called “vagrants”).

San Pedro Harbor. This area is heavily used for shipping traffic and recreational activities (i.e., jet skis and boating). Some biological value does remain in the harbor, particularly along the northern part of the jetty separating the harbor from the open ocean. Of special interest is the sandy beach on the ocean-side of the jetty adjacent to Cabrillo Park, where grunion (*Leuresthes tenuis*) spawn in spring on nights of high tides following a full moon. The harbor also provides habitat for fish and water birds. The heavy human activity in the area has reduced the value of the harbor to wildlife.

Significant Ecological Areas (SEAs)

The County of Los Angeles, through its General Plan, established 61 Significant Ecological Areas (SEAs), which represent a wide variety of biological communities within the County. The SEAs function to preserve this variety and to provide a level of protection to the resources within them. These SEAs are living laboratories containing examples of the County’s diverse ecological heritage. SEAs are intended to be preserved in an ecologically viable condition for the purposes of public education, research, and other non-disruptive outdoor uses but do not preclude limited compatible development. The County General Plan outlines a process to regulate land uses in these areas and creates an advisory committee of scientists appointed to oversee the regulation of these policies.

A conditional use permit is required for development in SEAs in order to protect resources contained in SEAs from incompatible development, which may result in or have potential for environmental degradation⁷. A biological constraints analysis is required to describe in a general manner the extent, location, and sensitivities of ecological resources found within an SEA.

⁷ Section 22.56.215 of the County Code.

Exhibit C-6, continued
NATURAL HABITATS AND SIGNIFICANT ECOLOGICAL AREAS (SEAs)
WITHIN THE CITY OF LOS ANGELES¹

Development proposed within a designated SEA is subject to review based on design compatibility criteria provided to guide specific land use decisions.

The SEAs are classified into the following eight categories:

Class 1 - The habitat of state and federally listed endangered, rare, or threatened plants and animals

Class 2 - Biotic communities, vegetative associations, and habitats of plants and animal species that are either one of a kind, or are restricted in distribution on a regional basis.

Class 3 - Biotic communities, vegetative associations, and habitats of plants and animal species that are either one of a kind, or are restricted in distribution in Los Angeles County.

Class 4 – Habitat that serves, at some point in the life cycle of a species or group of species, as a concentrated breeding, feeding, resting, or migrating grounds, and is limited in availability.

Class 5 - Biotic resources that are of scientific interest because they either are at an extreme in the physical or geographic range of a population of community, or they represent an unusual variation in a population or community.

Class 6 – Areas important as game habitat or fisheries resources.

Class 7 - Areas that would preserve relatively undisturbed examples of natural biotic communities in Los Angeles County.

Class 8 - Special areas, not meeting the above criteria, but that have some notable biological features (such as a wildlife corridor) can also be designated as SEAs.

Exhibit C-7
SENSITIVE SPECIES COMPENDIUM - CITY OF LOS ANGELES¹

KEY

| State Status - California Department of Fish and Game (CDFG) | |
|--|---|
| SE | State Listed Endangered |
| ST | State Listed Threatened |
| CSC | Species of Special Concern ² |
| SCE | State Candidate Endangered |
| SCT | State Candidate Threatened |
| SFP | State Fully Protected |
| SP | State Protected |
| SR | State Listed Rare |
| | |
| Federal Status - U.S. Fish and Wildlife Service (USFWS) | |
| FE | Federally Listed Endangered |
| FT | Federally Listed Threatened |
| FCH | Federally Listed Critical Habitat |
| FPE | Federally Proposed Endangered |
| FPT | Federally Proposed Threatened |
| FPCH | Federally Proposed Critical Habitat |
| FPD | Federally Proposed Delisting |
| FC | Federal Candidate Species |
| EXT | Extinct |
| <p>¹ This list is current as of January 2001. Check the most recent state and federal lists for updates and changes, or consult the CDFG's California Natural Diversity Database.</p> <p>² CSC - California Special Concern species. The Department has designated certain vertebrate species as "Species of Special Concern" because declining population levels, limited ranges, and/or continuing threats have made them vulnerable to extinction. The goal of designating species as "Species of Special Concern" is to halt or reverse their decline by calling attention to their plight and addressing the issues of concern early enough to secure their long term viability. Not all "Species of Special Concern" have declined equally; some species may be just starting to decline, while others may have already reached the point where they meet the criteria for listing as a "Threatened" or "Endangered" species under the State and/or Federal Endangered Species Acts.</p> | |

Exhibit C-7, continued
SENSITIVE SPECIES COMPENDIUM - CITY OF LOS ANGELES

KEY (continued)

| California Native Plant Society (CNPS) | |
|---|---|
| 1A | Plants presumed extinct in California ³ |
| 1B | Plants that are rare, threatened, or endangered in California or elsewhere ³ |
| 2 | Plants that are rare, threatened, or endangered in California, but more common elsewhere ³ |
| 3 | Plants about which more information is needed - a review list ⁴ |
| 4 | Plants of limited distribution - a watch list ⁵ |
| Habitat Code Designations - California Natural Diversity Database (CNDDB) | |
| AF | Alluvial Fan Sage Scrub |
| BW | Brackish Water |
| CB | Coastal Bluff Scrub |
| CD | Coastal Dunes |
| CH | Chaparral |
| CL | Coastal Lagoon |
| <p>³ All of the plants constituting Lists 1A, 1B, and 2 meet the definitions of Section 1901, Chapter 10 (Native Plant Protection Act) or Sections 2062 and 2067 (California Endangered Species Act) of the California Department of Fish and Game Code, and are eligible for listing. According to the DFG, if the taxa on List 1A are rediscovered, they should be fully considered during preparation of environmental documents relating to CEQA. List 1B and 2 plants should be fully considered during preparation of environmental documents relating to CEQA.</p> <p>⁴ Some of the plants constituting List 3 meet the definitions of Section 1901, Chapter 10 (Native Plant Protection Act) or Sections 2062 and 2067 (California Endangered Species Act) of the California Department of Fish and Game Code, and are eligible for listing. The DFG recommends that List 3 plants be evaluated for consideration during preparation of environmental documents relating to CEQA.</p> <p>⁵ Very few of the plants constituting List 4 meet the definitions of Section 1901, Chapter 10 (Native Plant Protection Act) or Sections 2062 and 2067 (California Endangered Species Act) of the California Department of Fish and Game Code, and few, if any, are eligible for listing. Nevertheless, many of them are significant locally, and the DFG recommends that List 4 plants be evaluated for consideration during preparation of environmental documents relating to CEQA. This may be particularly appropriate for the type locality of a List 4 plant, for populations at the periphery of a species' range or in areas where the taxon is especially uncommon or has sustained heavy losses, or for populations exhibiting unusual morphology or occurring on unusual substrates.</p> | |

Exhibit C-7, continued
SENSITIVE SPECIES COMPENDIUM - CITY OF LOS ANGELES

KEY (continued)

| Habitat Code Designations - California Natural Diversity Database (CNDDB) (Con't) | |
|--|---|
| CM | Coastal Salt Marsh |
| CO | Coastal Habitats |
| CP | Chenopod Scrub |
| CS | Coastal Sage Scrub |
| DR | Desert Riparian |
| DW | Desert Wash |
| ES | El Segundo Dunes |
| ET | Estuary |
| FM | Freshwater Marsh |
| GL | Grassland (native or introduced) |
| MF | Montane Forest (mixed hardwood, coniferous) |
| OW | Oak Woodland (coast live, valley, canyon or scrub oaks) |
| PJ | Pinyon-Juniper Woodland |
| PL | Playa Habitats, coastal or inland |
| RP | Riparian Scrub |
| RV | Rivers (open water or aquatic habitats) |
| RW | Riparian Woodland |
| SG/S
J | San Gabriel/San Jacinto Mountains |
| VP | Vernal Pools |
| WA | Water (general open water habitats) |

Exhibit C-7, continued
SENSITIVE SPECIES COMPENDIUM - CITY OF LOS ANGELES

| SCIENTIFIC NAME | COMMON NAME | STATUS | ZONE * | HABITAT |
|---|--|-------------------|---------|----------------|
| Invertebrates | | | | |
| <i>Euphilotes battoides allyni</i> | El Segundo blue butterfly | FE | 4 | CD |
| <i>Glaucopsyche lygdamus palosverdesensis</i> | Palos verdes blue butterfly | FE, FCH | 4 | CS |
| <i>Raphiomidas t. terminatus</i> | El Segundo flower-loving fly | EXT | 4 | ES |
| <i>Streptocephalus woottoni</i> | Riverside fairy shrimp | FE, FPCH | 4 | CH |
| Fish | | | | |
| <i>Catostomus santaanae</i> | Santa Ana sucker | CSC, FT | 1,3 | RV |
| <i>Eucyclogobius newberryi</i> | tidewater goby | CSC, FE, FPD, FCH | 4 | BW |
| <i>Gasterosteus aculeatus williamsoni</i> | unarmored threespine stickleback | FE, FPCH, SE, SFP | Unknown | |
| <i>Gila orcutti</i> | arroyo chub | CSC | 1,2,3,4 | RV |
| <i>Onchorhynchus mykiss</i> | southern steelhead | FE, FCH, CSC | Unknown | |
| <i>Rhinichthys osculus</i> ssp. 3 | Santa Ana speckled dace | CSC | 1 | RV |
| Amphibians | | | | |
| <i>Bufo microscaphus californicus</i> | arroyo southwestern toad | CSC, SP, FE, FCH | 1,2,3,4 | RV, DR |
| <i>Rana aurora draytoni</i> | California red-legged frog | FT, FPCH, CSC, SP | 1,2,3,4 | |
| <i>Rana muscosa</i> | So. California population of mountain yellow-legged frog | FPE, CSC, SP | 1,2,3,4 | |
| <i>Scaphiopus hammondi</i> | western spadefoot toad | CSC, SP | 1 | VP, RV, CS, CH |
| Reptiles | | | | |
| <i>Anniella p. pulchra</i> | silvery legless lizard | CSC | 1,2,3,4 | CH, OW, CS |
| <i>Clemmys marmorata pallida</i> | southwestern pond turtle | CSC, SP | 1,2,3,4 | RV |
| <i>Lampropeltis zonata pulchra</i> | San Diego mountain kingsnake | CSC, SP | 1,2,3 | CH, CS, OW |
| <i>Phrynosoma coronatum blainvillei</i> | San Diego horned lizard | CSC, SP | 1,2,3,4 | CS, CH, AF |
| <i>Salvadora hexalepis virgulata</i> | coast patch-nosed snake | CSC | 1,2,3,4 | CS, CH, OW |
| <i>Thamnophis (Nerodia) hammondi</i> | two-striped garter snake | CSC, SP | 1,2,3,4 | RV, FM |
| <i>Xantusia riversiana</i> | island night lizard | FT, SP | 1,2,3,4 | |

* Refer to Exhibit C-1.

Exhibit C-7, continued
SENSITIVE SPECIES COMPENDIUM - CITY OF LOS ANGELES

| SCIENTIFIC NAME | COMMON NAME | STATUS | ZONE * | HABITAT |
|---|------------------------------------|-------------------------------|---------|----------------|
| Birds | | | | |
| <i>Accipiter cooperii</i> | Cooper's hawk (nest) | CSC | 1,2,3,4 | RW, OW |
| <i>Accipiter striatus</i> (migrant) | sharp-shinned hawk (nest) | CSC | 1,2,3,4 | RW |
| <i>Aimophila ruficeps canescens</i> | So. Cal.rufous-crowned sparrow | CSC | 1,2,3,4 | CS, CH |
| <i>Amphispiza b. belli</i> | Bell's sage sparrow | CSC | 1,2,3,4 | CS, CH |
| <i>Asio flammeus</i> | short-eared owl | CSC | 3,4 | CM, FM |
| <i>Asio otus</i> | long-eared owl | CSC | 1,2,3,4 | OW, RP |
| <i>Athene cunicularia hypugea</i> | burrowing owl | CSC | 1,2,3,4 | GL, DW, CS, CB |
| <i>Charadrius alexandrinus nivosus</i> | western snowy plover | FT, FCH, CSC | 4 | PL, ET, CD |
| <i>Charadrius montanus</i> | mountain plover | FPT, CSC | 1,2,3 | |
| <i>Chlidonias niger</i> | black tern | CSC | 4 | PL, CO, ET |
| <i>Circus cyaneus</i> | northern harrier (nest) | CSC | 1,2,3,4 | FM, ET, CM |
| <i>Coccyzus americanus occidentalis</i> | western yellow-billed cuckoo | SE | 1,2,3,4 | RW |
| <i>Cypseloides niger</i> (migrant) | black swift (nest) | CSC | 1,2,3,4 | RV, waterfalls |
| <i>Dendroica petechia brewsteri</i> | yellow warbler (nest) | CSC | 1,2,3,4 | RP, RW, CH |
| <i>Elanus leucurus</i> | white-tailed kite | SFP | 1,2,3,4 | GL, ET, FM, OW |
| <i>Epidonax traillii</i> | willow flycatcher (all subspecies) | SE | 1,3 | RW, RP |
| <i>Epidonax traillii extimus</i> | Southwestern willow flycatcher | FE, FCH, SE | 1,3 | RW, RP |
| <i>Eremophila alpestris actia</i> | California horned lark | CSC | 1,2,3,4 | GL, CS |
| <i>Falco columbarius</i> (migrant) | Merlin | CSC | 1,2,3,4 | gen. Flyover |
| <i>Falco mexicanus</i> | prairie falcon (nest) | CSC | 1,2,3,4 | DR, DW, CH |
| <i>Falco peregrinus anatum</i> | American peregrine falcon | (FE delisted 8/25/99) SE, SFP | 1,2,3,4 | CO, PL, ET |
| <i>Icteria virens</i> | yellow-breasted chat (nest) | CSC | 1,2,3,4 | RP, RW |
| <i>Ixobrychus exilis hesperis</i> (migrant) | western least bittern | CSC | 1,2,3,4 | RP, ET, FM, SM |
| <i>Lanius ludovicianus</i> | Loggerhead shrike | CSC | 1,2,3,4 | CS, CH, CP, DW |

* Refer to Exhibit C-1

Exhibit C-7, continued
SENSITIVE SPECIES COMPENDIUM - CITY OF LOS ANGELES

| SCIENTIFIC NAME | COMMON NAME | STATUS | ZONE * | HABITAT |
|--|------------------------------------|--------------|---------|--------------|
| Birds (cont'd.) | | | | |
| <i>Laterallus jamaicensis coturniculus</i> | California black rail | ST, SFP | 4 | FM, CM |
| <i>Numenius americanus</i> | long-billed curlew (nest) | CSC | 4 | CO, WA |
| <i>Pandion haliaetus</i> (migrant) | osprey (nest) | CSC | 1,2,3,4 | CO, WA, RV |
| <i>Passerculus sanwichensis beldingi</i> | Belding's savannah sparrow | SE | 4 | CM |
| <i>Pelecanus occidentalis californicus</i> | California brown pelican | SE, FE, SFP | 4 | CO |
| <i>Phalacrocorax auritus</i> | double-crested cormorant (rookery) | CSC | 1,2,3,4 | CO, WA, RV |
| <i>Piranga rubra</i> (migrant) | summer tanager | CSC | 1,4 | RW |
| <i>Poliophtila c. californica</i> | California gnatcatcher | FT, FCH, CSC | 1,4 | CS, CH |
| <i>Rallus longirostris levipes</i> | light-footed clapper rail | SE, FE, SFP | 4 | CM |
| <i>Riparia riparia</i> (migrant) | bank swallow | ST | 1,2,3 | CO, RP, RV |
| <i>Sterna antillarum browni</i> | California least tern | SE, FE, SFP | 4 | CD, ET, PL |
| <i>Vermivora virginiae</i> (migrant) | Virginia's warbler | CSC | 3 | CH, OW, RW |
| <i>Vireo bellii pusillus</i> | least Bell's vireo | SE, FE, FCH | 1,2,3 | RP, RW |
| Mammals | | | | |
| <i>Antrozous pallidus pacificus</i> | pallid bat | CSC | 1,2,3,4 | CS,CH,GL |
| <i>Eumetopias jubatus</i> | northern sea lion | FT | 4 | CO |
| <i>Eumops perotis californicus</i> | California mastiff bat | CSC | 1,2,3,4 | general |
| <i>Lepus californicus bennettii</i> | San Diego blacktailed jackrabbit | CSC | 1,2,3,4 | CS,CP,CH, DW |
| <i>Macrotus californicus</i> | California leaf-nosed bat | CSC | 1 | general |
| <i>Microtis californicus stephensii</i> | Stephen's California vole | CSC | 4 | FM,GL |
| <i>Neotoma lepida intermedia</i> | San Diego desert woodrat | CSC | 1,2,3,4 | CS,CH,DW |
| <i>Onychomys torridus ramona</i> | southern grasshopper mouse | CSC | 1,3 | CL,CS,CH, DW |
| <i>Perognathus longimembris brevinasus</i> | Los Angeles pocket mouse | CSC | 1,4 | CS,CH,DW |
| <i>Perognathus longimembris pacificus</i> | Pacific pocket mouse | CSC, FE | 4 | CS |
| <i>Plecotus townsendii pallescens</i> | pale big-eared bat | CSC | 1,2,3,4 | DW,CH,OW |
| <i>Sorex ornatus salicornicus</i> | southern Calif. saltmarsh shrew | CSC | 4 | CM |

* Refer to Exhibit C-1

Exhibit C-7, continued
SENSITIVE SPECIES COMPENDIUM - CITY OF LOS ANGELES

| SCIENTIFIC NAME | COMMON NAME | STATUS | ZONE* | HABITAT |
|---|---------------------------------|-------------|---------|-----------------|
| Plants | | | | |
| <i>Abronia maritima</i> | red sand-verbena | 4 | 4 | CD |
| <i>Acanthomintha obovata cordata</i> | heart-leaved thorn-mint | 4 | unknown | CH,OW,PJ, GL |
| <i>Androsace elongata acuta</i> | California androsace | 4 | unknown | CH,OW,CS |
| <i>Aster greatae</i> | Greata's aster | 1B | unknown | CH |
| <i>Astragalus brauntonii</i> | Braunton's milk vetch | FE, 1B | 2,3 | MF,CH,CS, GL |
| <i>Astragalus pycnostachyus</i> v. <i>lanosissimus</i> | Ventura marsh milk-vetch | SE, FPE, 1B | 3,4 | CM |
| <i>Astragalus tener</i> v. <i>titi</i> | coastal dunes milk-vetch | SE, FE, 1B | 4 | CB,CD |
| <i>Atriplex pacifica</i> | south coast saltscale | 1B | 4 | CB,CS,PL |
| <i>Atriplex parishii</i> | Parish's brittlescale | 1B | 1 | CS,VP,PL |
| <i>Atriplex serenana</i> v. <i>davidsonii</i> | Davidson's saltscale | 1B | unknown | CBS,CS |
| <i>Baccharis malibuensis</i> | Malibu baccharis | 1B | 3 | CS,CH,OW |
| <i>Baccharis p. plummerae</i> | Plummer's baccharis | 4 | 3 | MF,CH,OW,CS |
| <i>Berberis nevinii</i> | Nevin's barberry | SE, FE, 1B | 1,2,3 | CH,AF,CS |
| <i>Calandrinia breweri</i> | Brewer's calandrinia | 4 | unknown | CH,CS |
| <i>Calandrinia maritima</i> | seaside calandrinia | 4 | 4 | CBS,GL |
| <i>Calochortus catalinae</i> | Catalina mariposa lily | 4 | 1,2,3 | CH,OW,CS, GL |
| <i>Calochortus c. v. clavatus</i> | club-haired mariposa lily | 4 | 1,3 | CH,OW,GL |
| <i>Calochortus plummerae</i> | Plummer's mariposa lily | 1B | 3 | CH,OW,CS, GL,MF |
| <i>Calystegia peirsonii</i> | Peirson's morning-glory | 4 | 1 | CH,CS,OW, CS,MF |
| <i>Calystegia sepium binghamiae</i> | Santa Barbara morning-glory | 1A | 4 | CM |
| <i>Camissonia lewisii</i> | Lewis's evening-primrose | 3 | unknown | CB,OW,CD, CS,GL |
| <i>Castilleja plagiota</i> | Mojave Indian paintbrush | 4 | 1 | PJ,GB |
| <i>Centromadia parryi</i> ssp. <i>australis</i> (<i>Hemizonia minthornii</i>) | Santa Susana tarplant | SR, 1B | 1,2,3 | CH, CS |
| <i>Cercocarpus betuloides</i> v. <i>blancheae</i> | island mountain-mahogany | 4 | 3 | CH |
| <i>Chorizanthe parryi</i> v. <i>fernandina</i> | San Fernando Valley spineflower | SCE, FC, 1B | 1,3 | CS |
| <i>Chorizanthe p. v. parryi</i> | Parry's spineflower | 3 | 3 | CS,AF,CH, OW |
| <i>Chorizanthe spinosa</i> | Mojave spineflower | 4 | 1 | CS,DW |
| <i>Convolvulus simulans</i> | small-flowered morning-glory | 4 | unknown | CS,GL |
| <i>Cordylanthus m. maritimus</i> | salt marsh bird's-beak | SE, FE, 1B | 4 | CM |
| <i>Crossosoma californicum</i> | Catalina crossosoma | 1B | 4 | CS |

Refer to Exhibit C-1

Exhibit C-7, continued
SENSITIVE SPECIES COMPENDIUM - CITY OF LOS ANGELES

| SCIENTIFIC NAME | COMMON NAME | STATUS | ZONE * | HABITAT |
|---|-----------------------------|------------|---------|--------------|
| Plants (Con't) | | | | |
| <i>Deinandra minthornii</i> (<i>Hemizonia parryi australis</i>) | southern tarplant | 1B | Unknown | ET, GL, VP |
| <i>Dichondra occidentalis</i> | western dichondra | 4 | 4 | CH,OW,CS, GL |
| <i>Dithyrea maritima</i> | beach spectaclepod | ST, 1B | 4 | CD,CS |
| <i>Dodecahema leptoceras</i> | slender-horned spineflower | SE, FE, 1B | 1 | AF,CH |
| <i>Dudleya b. blochmaniae</i> | Blochman's dudleya | 1B | 3 | CS,CB,CH, GL |
| <i>Dudleya cymosa marcescens</i> | marcescent dudleya | SR, FT, 1B | 3 | CH |
| <i>Dudleya cymosa ovatifolia</i> | Santa Monica Mtns. dudleya | FT, 1B | 3,4 | CH,CS |
| <i>Dudleya multicaulis</i> | many-stemmed dudleya | 1B | 2 | CH,CS,GL |
| <i>Dudleya virens</i> | bright green dudleya | 1B | 4 | CH,CS |
| <i>Erysimum insulare suffrutescens</i> | suffrutescent wallflower | 4 | unknown | CB,CD,CS |
| <i>Fremontodendron mexicanum</i> | Mexican flannelbush | SR, FE, 1B | 1,2,3 | MF,CH,OW |
| <i>Galium angustifolium gabrielense</i> | San Antonio Canyon bedstraw | 4 | 1 | MF |
| <i>Galium cliftonsmithii</i> | Santa Barbara bedstraw | 4 | 2,4 | OW |
| <i>Galium johnstonii</i> | Johnston's bedstraw | 4 | unknown | MF |
| <i>Goodmania luteola</i> | golden goodmania | 4 | Unknown | DW,PL,GL |
| <i>Helianthus nuttallii parishii</i> | Los Angeles sunflower | 1A | 3 | CM,FM |
| <i>Heuchera abramsii</i> | Abram's alumroot | 4 | Unknown | MF |
| <i>Heuchera elegans</i> | urn-flowered alumroot | 4 | Unknown | MF |
| <i>Hulsea vestita gabrielensis</i> | San Gabriel Mtns. sunflower | 4 | 1 | MF |
| <i>Juglans c. v. californica</i> | So.Cal. black walnut | 4 | 1,2,3 | CH,OW,AF |
| <i>Juncus acutus leopoldii</i> | southwestern spiny rush | 4 | 4 | CD,CM |
| <i>Juncus duranii</i> | Duran's rush | 4 | Unknown | MF |
| <i>Lasthenia glabrata coulteri</i> | Coulter's goldfields | 1B | Unknown | CM,PL,VP |
| <i>Lepechinia fragrans</i> | fragrant pitcher sage | 4 | 3 | CH |
| <i>Lilium humboldtii ocellatum</i> | ocellated Humboldt lily | 4 | 1,2,3 | CH,OW,CO |
| <i>Linanthus orcuttii</i> | Orcutt's linanthus | 1B | Unknown | CH,MF |
| <i>Lupinus elatus</i> | silky lupine | 4 | Unknown | MF |
| <i>Lupinus excubitus v. johnstonii</i> | interior bush lupine | 4 | Unknown | MF |
| <i>Lupinus peirsonii</i> | Peirson's lupine | 1B | Unknown | CH,CS,RW |
| <i>Malacothamnus davidsonii</i> | Davidson's bush mallow | 1B | 1,3 | CS,RW |
| <i>Microseris douglasii v. platycarpha</i> | small-flowered microseris | 4 | Unknown | OW,CS,GL |
| <i>Monardella cinerea</i> | gray monardella | 4 | Unknown | MF |

Refer to Exhibit C-1

Exhibit C-7, continued
SENSITIVE SPECIES COMPENDIUM - CITY OF LOS ANGELES

| SCIENTIFIC NAME | COMMON NAME | STATUS | ZONE * | HABITAT |
|--|---------------------------|------------|---------|--------------|
| Plants (Con't) | | | | |
| <i>Monardella viridis saxicola</i> | rock monardella | 4 | Unknown | CH,MF |
| <i>Mucronea californica</i> | California spineflower | 4 | Unknown | CH,CD,CS, GL |
| <i>Muilla coronata</i> | crowned muilla | 4 | Unknown | DW |
| <i>Nama stenocarpum</i> | mud nama | 2 | Unknown | FM |
| <i>Nemacaulis d. v. denudata</i> | coast woolly-heads | 2 | 4 | CD |
| <i>Nemacladus gracilis</i> | slender nemacladus | 4 | Unknown | OW,GL |
| <i>Orcuttia californica</i> | California Orcutt grass | SE, FE, 1B | 1,4 | VP |
| <i>Oreonana vestita</i> | woolly mountain-parsley | 1B | Unknown | MF |
| <i>Oxytheca caryophylloides</i> | chickweed oxytheca | 4 | Unknown | MF |
| <i>Pentachaeta lyonii</i> | Lyon's pentachaeta | SE, FE, 1B | 3,4 | CH,GL |
| <i>Perideridia g. gairdneri</i> | Gairdner's yampah | 4 | Unknown | CH,GL,VP,MF |
| <i>Perideridia pringlei</i> | adobe yampah | 4 | Unknown | CH,OW,CS |
| <i>Phacelia exilis</i> | Transverse Range phacelia | 4 | Unknown | MF |
| <i>Phacelia mohavensis</i> | Mojave phacelia | 4 | Unknown | OW,MF |
| <i>Phacelia stellaris</i> | Brand's phacelia | 1B | Unknown | CD,CS |
| <i>Polygala cornuta v. fishiae</i> | Fish's milkwort | 4 | 4 | CH,OW,RW |
| <i>Quercus engelmannii</i> | Engelmann oak | 4 | Unknown | CH,OW,RW,GL |
| <i>Ribes divaricatum v. parishii</i> | Parish's gooseberry | 1B | 2 | RW |
| <i>Romneya coulteri</i> | Coulter's matilija poppy | 4 | Unknown | CH,CS |
| <i>Scutellaria bolanderi austromontana</i> | southern skullcap | 1B | Unknown | CH,OW,MF |
| <i>Selaginella asprella</i> | bluish spike-moss | 4 | Unknown | MF |
| <i>Senecio ionophyllus</i> | Tehachapi ragwort | 4 | Unknown | MF |
| <i>Suaeda esteroa</i> | estuary seablite | 1B | 4 | CM |
| <i>Suaeda taxifolia</i> | woolly seablite | 4 | 4 | CB,CM |
| <i>Swertia neglecta</i> | pine green-gentian | 4 | Unknown | MF |
| <i>Syntrichopappus lemmonii</i> | Lemmon's syntrichopappus | 4 | Unknown | CH |
| <i>Thermopsis californica v. argentata</i> | silvery false lupine | 4 | Unknown | MF |

Refer to Exhibit C-1

Exhibit C-7, continued
SENSITIVE SPECIES COMPENDIUM - CITY OF LOS ANGELES

| NDDB Highest Inventory Priority Plant Communities of Los Angeles City | |
|--|---|
| Community | Mapping Zone of Occurrence (NDDB data) |
| Walnut Forest | 3 |
| California Walnut Woodland | 1,2 |
| Valley Oak Woodland | 1,2 |
| Southern Willow Scrub | 1 |
| Southern Sycamore Alder Riparian Woodland | 1,2,3 |
| Southern Mixed Riparian Forest | 1 |
| Southern Cottonwood Willow Riparian Forest | 1,3 |
| Southern Coast Live Oak Riparian Forest | 1,2,3 |
| Riversidian Alluvial Fan Sage Scrub | 1 |
| Valley Needlegrass Grassland | 2 |
| Southern Dune Scrub | 1 |
| Southern Coastal Bluff Scrub | 4 |
| Coastal Salt Marsh | 3 |

Source: Frank Hovore & Associates, December 1995; Environmental Affairs Department, 2001.

Exhibit C-8
GENERAL REFERENCES

- Allen, L.W., and K. Garrett 1995. Atlas handbook, Los Angeles County breeding bird atlas. Los Angeles Audubon Society. Special Publication, 57 pp.
- CNPS 1991. Mitigation guidelines regarding impacts to rare, threatened, and endangered plants. Pamphlet, 17 pp.
- DFG 1983 (revised May 8, 2000). Guidelines for assessing effects of proposed developments on rare and endangered plants and plant communities, 2 pp.
- DFG 1991. Informational leaflet; California's fully protected birds, mammals, reptiles, amphibians and fish, 3 pp.
- DFG 1992. Annual report on the status of California state-listed Threatened and Endangered animals and plants, 193 pp.
- DFG 1992. Natural communities. 9 pp.
- DFG August 1994. Wildlife Management Division, Nongame Bird and Mammal Sect., "Special Animals," 28 pp.; *ibid.*, November 1994. "Special Plants," 74 pp.
- DFG 1995. Endangered and Threatened Animals of California, 13 pp.
- DFG 2001. Habitat Conservation Division, California Natural Diversity Database (CNDDB printouts, Rarefind 2)
- DFG 1995. Natural Heritage Division, Endangered, Threatened and Rare Plants of California, 27 pp.
- DFG 1995. Sensitivity rankings for natural communities in California, 7 pp.
- DFG 1995, Non-Game Heritage, Natural Diversity Data Base (NDDB printouts, Calabasas and Malibu Beach quadrangles).
- De Lisle, H. et al., 1987. The distribution and present status of the herpetofauna of the Santa Monica Mountains. Southwestern Hep. So.c., Special Publ. #2, 94 pp.

Exhibit C-8, continued
GENERAL REFERENCES

- Faber, P.A., E. Keller, A. Sands, and B.M. Massey. 1989. The Ecology of Riparian Habitats of the Southern California Coastal Region: a Community Profile. USFWS Biol. Rep. 85(7.27). 152 pp.
- Garrett, K. and J. Dunn. 1981. Birds of Southern California, status and distribution. Los Angeles Audubon Society publ. 408 pp.
- Grinnell, J. and A.H. Miller. 1944. The distribution of the birds of California. Cooper Ornith. Club, Pacific Coast Avifauna, #27, reprinted 1986, Artemisia Press, D. Gaines, ed. 615 pp.
- Hickman, J.C., ed. 1993. The Jepson Manual, Higher Plants of California. UC Press, 1400 pp.
- Hogue, C.L. 1993. Insects of the Los Angeles Basin. Natural History Museum Foundation, 446 pp.
- Jameson, E.W. Jr. & H.J. Peeters 1988. California Mammals. California Natural History guides: 52, University of California press, 402 pp.
- Jennings, M.R. and M.P. Hayes 1994. Amphibian and reptile species of special concern in California. CDFG Special Report, #8023, 255 pp.
- Los Angeles County Museum of Natural History, Mammalogy Section, 1992, 1993; computerized print out, all specimen data, Los Angeles County.
- Mattoni, R. 1990. Butterflies of greater Los Angeles. Foldout, 20 section pamphlet, illus.
- Mayer, K.E. and W.F. Laudenslayer, Jr., eds. A guide to wildlife habitats of California. California Department of Forestry and Fire Protection. Spec. Publ., 166 pp.
- Moyle, P.B., J.E. Williams and E.D. Wikramanayake. 1989. Fish species of special concern of California. Spec. Rept. 7337, DFG.
- Page, L.M. and B.M. Burr. 1991. A field guide to freshwater fishes, North America north of Mexico. Peterson Field Guide Series #42. 432 pp.
- Peterson, R.T. 1990. A Field Guide to Western Birds, 3rd edition. Houghton Mifflin Co., 432 pp.

Exhibit C-8, continued
GENERAL REFERENCES

- Powell, J.A. and C. H. Hogue. 1979. California Insects. California Natural History Guides, vol. 388 pp.
- Recon Consultants. 1990. Draft Comprehensive Species Management Plan for the least Bell's vireo. San Diego Association of Governments, 243 pp., appendix.
- Remsen, J. V. Jr. 1978. Bird species of special concern in California. DFG, Wildlife Management Branch Administration Report 78-1, 54 pp.
- Schoenherr, A.A. 1976. The herpetofauna of the San Gabriel Mountains, Los Angeles County, California. Spec. Pub. Southwestern Herp. Soc., 95 pp.
- Small, A. 1994. California birds: their status and distribution. Ibis Publ., 342 pp.
- Skinner, M.W. and B.M. Pavlik. 1994. California Native Plant Society's inventory of rare and endangered vascular plants of California. CNPS Spec. Publ., #1, 5th ed. 338 pp.
- Stebbins, R.C. 1985. A field guide to western reptiles and amphibians, 2nd ed. Peterson field guide series, Houghton Mifflin Co. 336 pp.
- Swift, C. C., T.R. Haglund, M. Ruiz and R.N. Fisher. 1993. The status and distribution of the freshwater fishes of southern California. Bull. So. Calif. Acad. Sci., 92(3): 101 - 167.
- Thelander, C.G., ed. Life on the Edge: a guide to California's endangered natural resources wildlife. Biosystems Books. 550 pp.
- USFWS, Fed. Reg., May 12, 1993; Endangered and Threatened species; policy on candidate categories relative to petition findings. 2 pp.
- USFWS, Fed. Reg., July 23, 1993; 50 CFR Part 17, Endangered and Threatened Species; Proposed rule to list the Southwestern Willow Flycatcher as Endangered with critical habitat. 27 pp.
- USFWS, Fed. Reg., Aug. 11, 1993; 50 CFR Part 17, Endangered and Threatened Wildlife and Plants; Notice of 1-year Petition Finding, western pond turtle. 2 pp.

Exhibit C-8, continued
GENERAL REFERENCES

- USFWS, Fed. Reg., Sept. 30, 1993; 50 CFR Part 17, Plant taxa for listing as Endangered or Threatened species; Notice of review. 46 pp.
- USFWS, Fed. Reg., Dec. 9, 1993; 50 CFR Part 17, Endangered and Threatened Species; Petition Findings for 990 Spp., Proposed Rule. 17 pp.
- USFWS, Fed. Reg., Feb. 2, 1994; 50 CFR Part 17, Endangered and Threatened Species; Designation of critical habitat for the Least Bell's Vireo. 22 pp.
- USFWS July, 1994. California Federally listed Endangered and Threatened species by county. Internal document, 26 pp.
- USFWS, Fed. Reg., Aug. 20, 1994; 50 CFR Part 17.11 and 17.12, Endangered and Threatened Wildlife and Plants, 42 pp.
- USFWS, Fed. Reg., Nov. 15, 1994; 50 CFR Part 17, Endangered and Threatened wildlife and plants; animal candidate review for listing as Endangered or Threatened species. 46 pp.
- USFWS, pers comm., Feb. 16, 2001; Listed, Proposed, and Candidate Species that may Occur in the Los Angeles County, California. 2 pp.
- Williams, D.F. 1986. Mammalian species of special concern in California. DFG, Wildlife Management Division Admin. Rpt., 86-1, 112 pp.
- Zeiner, D.C., Laudenslayer, W.F. Jr., Mayer, K.E. and M. White, eds. 1990. California's Wildlife, Vol. 3, mammals. Calif. Statewide Wildlife Habitat Relationships System. DFG. Vol. 1 Amphibians and Reptiles. Vol. 2 Birds. Vol. 3 Mammals.

D. CULTURAL RESOURCES

D.1. PALEONTOLOGICAL RESOURCES

1. INITIAL STUDY SCREENING PROCESS

A. Initial Study Checklist Question

V.c): Would the project directly or indirectly destroy a unique paleontological resource or site or unique geologic feature?

B. Introduction

Paleontological resources are the fossilized remains of organisms that have lived in the region in the geologic past and the accompanying geologic strata. Because the majority of species that have existed on Earth are extinct, the fossil record represents the primary source of data on ancient life forms. In addition, the fossil record is finite, and many scientists feel that no single species is sufficiently understood or represented in research as to preclude further need for specimens. Paleontological resources are considered non-renewable and important.

Paleontological resources occur throughout the City of Los Angeles. They are not evenly distributed; the potential for fossil occurrence depends on the rock type exposed at the surface in a given area. Rocks are classified into three principal types: igneous, metamorphic and sedimentary. Sedimentary rocks contain the bulk of fossils in the City, although metamorphic rocks may also contain fossils. Igneous rocks do not contain fossils. In addition to igneous and most metamorphic rocks, areas of artificial landfill, streambeds and beach sand do not contain fossils.

The older sedimentary rocks are exposed in the hills and mountains, while younger rock units are present in low-lying and flat valley and basin floors. The majority of igneous rocks in the region are found in the Santa Monica Mountains and the northern San Fernando Valley. Within the City of Los Angeles, metamorphic rocks are found mostly in the Santa Monica Mountains and within scattered exposures around the region.

Direct destruction of fossils within fossil-bearing rock units may result from grading or excavation associated with a project, particularly during the construction phase. Indirect destruction or loss of fossils exposed at the surface may result from increased erosion, human access, or other activity in a project area. Increased access could result from the opening of private or otherwise closed lands, new access routes through sensitive areas, or through excavation or the removal of

vegetation.

Paleontological resources are protected by state and federal legislation. State regulations mandate protection of paleontological resources on public lands and CEQA requires evaluation of impacts to paleontological sites. Paleontological resources are also subject to certain state regulations for historical resources.¹ City guidelines for the protection of paleontological resources are specified in Section VIII of the Conservation Element, and for public works projects, Standard Specifications for Public Works Construction, Section 6-3.2. Information on rock types can be found in 3. Data, Resources, and References.

C. Screening Criteria

- Could implementation of the project result in the disturbance of surface or subsurface fossils, either through site preparation, construction or operational activities, or through an increase in human activities at or near the fossil site?

A "yes" response to the preceding question indicates further study in an expanded Initial Study, Negative Declaration, Mitigated Negative Declaration, or EIR may be required. Refer to the Significance Threshold for Paleontological Resources and review the associated Methodology to Determine Significance, as appropriate.

A "no" response to the preceding question indicates that there would normally be no significant impact on Paleontological Resources from the proposed project.

D. Evaluation of Screening Criteria

Assess the potential for discovery of paleontological resources. The following sources are available: existing paleontological surveys for the project site; Los Angeles County Natural History Museum; Environmental and Public Facilities Maps - Vertebrate Paleontological Resource Sensitivity Areas in the City of Los Angeles and Invertebrate Paleontological Resource Sensitivity Areas in the City of Los Angeles; Exhibit D.1-1; or other appropriate resources.

Evaluate the degree of disturbance to the project site. Consider whether the site has been vacant or covered by surfaces that required little or no excavation or grading, such that there has been little surface or subsurface disturbance. Sites from which native topsoil has been removed, such as

¹ *The California Office of Historic Preservation (OHP) has jurisdiction over projects that may impact historic resources. For regulation of historic resources, see Exhibits D.3-1 to D.3-3.*

landfills, are unlikely to retain paleontological resource potential.

Review the description of the project and the construction/operation activities. Assess the amount of grading, excavation, erosion, and increased human activity (e.g., opening of previously closed lands, new access routes through sensitive areas, or removal of vegetation that could disturb surface and subsurface fossils). Compare this information to the Screening Criteria.

2. DETERMINATION OF SIGNIFICANCE

A. Significance Threshold

The determination of significance shall be made on a case-by-case basis, considering the following factors:

- Whether, or the degree to which, the project might result in the permanent loss of, or loss of access to, a paleontological resource; and
- Whether the paleontological resource is of regional or statewide significance.

B. Methodology to Determine Significance

Environmental Setting

In a description of the environmental setting, include the following information:

- Description of the physical setting, paleontology, and geology of the project site and surrounding area;
- Summary of surveys and research for the project site; and
- Summary of requirements and/or policies for paleontological resources that apply to the project. (See 3. Data, Resources, and References.)

Project Impacts

Using the information from the Evaluation of Screening Criteria, Environmental Setting, and project description, estimate the extent and importance of paleontological resources likely to be contained on the site and the consequences that would likely result from the project. Consider

compliance with guidelines and regulations such as the California Public Resources Code, Federal Antiquities Act, Conservation Element, and, for public works projects, Standard Specifications for Public Works Construction. Regional or statewide significance may be based on the quality and integrity of the resource, remaining supply, feasibility of recovery, or scientific or public importance. Assistance from the Los Angeles County Museum of Natural History or a professional consultant may be required.

Determine whether excavation, grading, or operational activities would impact to the depth of the subsurface rock units containing the fossils. Evaluate the potential destruction of fossils exposed on the surface by considering the increased human activity generated by the project, including potential for soil erosion, construction traffic in sensitive areas, and increased human access to sensitive areas after project completion. If the area has been disturbed through previous grading or excavation or installation of subsurface utilities, it is likely that fossils would have been discovered at that time, have been destroyed, or are no longer in their original location (e.g., they have been brought in from other areas with fill).

Cumulative Impacts

Review the list of related projects and estimate the extent of paleontological resources likely to be contained on the sites and the consequences that would likely result from these related projects. Determine the cumulative impact to fossils of regional or statewide significance from the related projects combined with the proposed project. In particular, consider cumulative impacts to fossils from the same time period. Evaluate the destruction of fossils by considering the cumulative increase in human activity, excavation, grading, or operational activities.

Sample Mitigation Measures

Potential mitigation measures include the following:

- Revise the proposed project to avoid excavation or grading in areas with known or potential surface exposures of fossils, or within rock units with a high potential for paleontological resources;
- Provide erosion protection (e.g., retaining walls, drainage channels) to protect surface resources;
- Restrict or prevent access to sensitive resource areas on site;

- Retain a qualified paleontologist to monitor, and, if necessary, salvage scientifically significant fossil remains. Ensure scientific specimens become the property of a public, nonprofit educational institution, such as the Los Angeles County Museum of Natural History or similar institution;
- Protect subsurface fossils in place, through covering with appropriate soil materials; and
- Divert grading efforts in the area of an exposed fossil to allow evaluation and, if necessary, salvage of exposed fossils.

3. DATA, RESOURCES, AND REFERENCES

Los Angeles County Museum of Natural History, Department of Vertebrate Paleontology: 900 Exposition Boulevard, Los Angeles, California 90007; Telephone: (213) 763-3489, Lawrence G. Barnes Ph.D.; 213-763-3329. The Museum of Natural History does not maintain records of paleontological surveys or studies, but does perform record checks to determine if fossil resources are present within or near a project area, provides technical assistance, and acts as a repository for salvage fossils.

California Office of Historic Preservation: P.O. Box 942896, Sacramento, California 94296-0001; Telephone: (916) 653-6624. OHP has legal jurisdiction over projects, which may impact historic resources, which include certain paleontological resources. OHP can provide guidance as to the evaluation of significance of historic resources.

Conservation Element provides guidelines for the preservation of paleontological resources.

City Planning Department, Environmental and Public Facilities Maps (1997):

- Vertebrate Paleontological Resources Sensitivity Areas in the City of Los Angeles
- Invertebrate Paleontological Resources Sensitivity Areas in the City of Los Angeles

These maps were based on information prepared by the County of Los Angeles Natural History Museum in 1993 and delineate areas of similar paleontological sensitivity within the City. These sensitivity zones may contain several different rock units that share a common history of production of paleontological resources.

California Division of Mines and Geology (CDMG), 655 S. Hope St. Rm 700, Los Angeles, California 90017-2321; Telephone: (213) 239-0878. The following documents are available

from CDMG:

- CDMG Geologic Atlas Sheets of California - Los Angeles: These maps show the geologic formations underlying the City of Los Angeles in a single map, at a scale of 1:250,000.
- Dibblee Geological Foundation Maps - applicable United States Geological Survey (USGS) topographic quadrangle: Dibblee maps show geologic information in greater detail than Geologic Atlas Sheets, at a scale of 1:24,000, corresponding to 7½ minute USGS topographic quadrangles.

The Society of Vertebrate Paleontology, an international association of professional paleontologists, has developed guidelines for protection and preservation of paleontological resources, as well as mitigation standards for impacts to paleontological resources, in response to CEQA.

Rock Types

Sedimentary rocks are usually layered or bedded and formed from cemented accumulations of sand, silt or mud. The sedimentary rocks in the City range in age from the Cretaceous (100 million years before present) to the Recent periods. Intrusive igneous rocks, formed at depth from molten magma and intruded into other rock bodies, tend to be homogeneous masses, such as granite, and do not contain fossils. Extrusive igneous rocks, such as volcanic rocks, very rarely contain plants or animal fossils. Metamorphic rocks, products of modifications to igneous or sedimentary rocks by heat, pressure or fluids, may or may not contain fossils, depending on the degree of alteration and the original rock type.

Selected Legislation

Federal

Federal Antiquities Act of 1906 (P. L. 59-202; 32 Stat. 225)

This act forbids, and establishes criminal sanctions for, the disturbance of any object of antiquity on federal land without obtaining a permit from an authorizing authority.

Federal Land Management and Policy Act of 1976 (FLMPA) (P.L. 94-579, 43 U.S.C. 1701-1782)

FLMPA provides authority for the Bureau of Land Management (BLM) to regulate lands under its jurisdiction, to be managed in a manner to "protect the quality of scientific, scenic, historic,

ecological, environmental...and archaeological values.” Authority is given to establish Areas of Critical Concern (ACEC).

National Environmental Policy Act (NEPA) of 1969 (P. L. 91-190; 83 Stat. 852, 42 U.S.C. 4321-3427)

With regard to paleontological resources, NEPA mandates the evaluation of impacts in order to "preserve important historic, cultural and natural aspects of our national heritage" (Section 101b.4).

State

Public Resources Code, Section 5097.5 (Stats. 1965, c. 1136, p. 2792)

This section prohibits “the excavation or removal of any vertebrate paleontological site...or any other archaeological, paleontological or historical feature, situated on public lands, except with the express permission of the public agency having jurisdiction over such lands.”

CEQA (13 PRC, 21000 et seq)

According to CEQA, "historical resource" includes, but is not limited to, any object, building, structure, site, area, place, record or manuscript which is historically or archaeologically significant, or is significant in the architectural, engineering, scientific, economic, agricultural, educational, social, political, military or cultural annals of California (Div. 1, PRC 5020.1) (*italics added*). This has been subsequently interpreted as requiring identification of potential adverse impacts of a project to any object or site of scientific importance.

Guidelines for the Implementation of CEQA, as amended May 10, 1980 (14 Ca. Admin. Code: 15000 et seq)

The CEQA Guidelines authorize the Lead Agency to require mitigation to reduce and avoid significant effects on the environment. CEQA, Appendix G, subsection J, states, "A project will normally have a significant effect on the environment if it will disrupt or adversely affect a prehistoric or historic archaeological site or a property of historic or cultural significance to a community or ethnic or social group; or a paleontological site except as a part of a scientific study.”

California Administrative Code, Title 14, Section 4307

States, “no person shall remove, injure, disfigure, deface, or destroy any object of paleontological, archaeological, or historical interest or value.”

Local

Standard Specifications for Public Works Construction, Section 6-3.2

Requires that grading, excavation, or other ground disturbing activities for a public project be halted in the area of a paleontological or archaeological find, until such time as a resource expert can review the find, determine its significance, and if required, determine appropriate mitigation measures.

Exhibit D.1-1
PALEONTOLOGICAL POTENTIAL BY ROCK UNIT/GEOLOGIC FORMATION

| Formation/Rock Unit | Paleontological Potential | Fossils Present |
|--|----------------------------------|-------------------------------|
| Palos Verdes Sand | High | Vertebrates and Invertebrates |
| San Pedro Sand | High | Vertebrates and Invertebrates |
| Lomita Marl | High | Vertebrates |
| Timms Point Silt | High | Vertebrates and Invertebrates |
| Fernando Formation or Reppeto Formation | High | Vertebrates and Invertebrates |
| Pico Formation | High | Vertebrates and Invertebrates |
| Monterey Formation | High | Vertebrates |
| Altamira Shale | High | Vertebrates |
| Model Formation | High | Vertebrates |
| Topanga Formation | High | Vertebrates and Invertebrates |
| Santa Suzana Formation ^a | High | Invertebrates |
| Chico Formation and/or Tuna Canyon Formation | High | Vertebrates and Invertebrates |
| Quaternary Alluvium | Low to High ^b | Vertebrates |
| Las Virgenes Sandstone ^a | Low | Invertebrates |
| Simi Conglomerate ^a | Low | none reported |
| Trabucco Formation | Low | none reported |
| Santa Monica Slate | Low | Invertebrates |

^a These rock units are grouped together as the Martinez Formation in the older literature on the region.

^b Potential for discovery of resources in Quaternary deposits increases with increased depth of excavations.

NOTE: "Low," "High" and "Undetermined" potential are scientifically recognized terms identifying the chance of fossil discovery during excavation into a given geologic unit. It is not uncommon for low potential deposits to overlay or otherwise cover more rock units with a high potential for discovery. Information on rock units on a particular site may be obtained from existing geotechnical studies prepared for the project site or from maps, such as the CDMG Geologic Atlas Sheets of California or the Dibblee Geological Foundation Maps.

Source: RMW Paleo Associates, 1995, based on literature, published and unpublished records of discovery of fossils in each geologic unit, the relative abundance of fossils at past discovery sites and the depositional environment associated with individual geologic units.

D.2. ARCHAEOLOGICAL RESOURCES

1. INITIAL STUDY SCREENING PROCESS

A. Initial Study Checklist Questions

- V.b): Would the project cause a substantial adverse change in the significance of an archeological resource pursuant to §15064.5?
- V.d): Would the project disturb any human remains, including those interred outside of formal cemeteries?

B. Introduction

Archaeology involves the physical, structural, and documentary evidence of past human endeavors. Such cultural resources may or may not be visible on the surface, and may be of either prehistoric or historic origin. Because of its climate, topography, and natural resources, the greater Los Angeles area is known to have supported prehistoric and historic cultures. The location of known archaeological sites is confidential to prevent scavenging of artifacts. Artifacts are considered finite and non-renewable resources.

Construction or operation activities, which affect the surface or subsurface of the ground at or near archaeological resources, can disturb or destroy them. Artifacts may be lost or destroyed through grading, crushing, scattering, or removal from the ground. In addition, scattering or otherwise taking the artifacts out of their original placement may result in the loss of important information about the relationship of artifacts to each other. With archaeological resources, the relationship of materials to each other in the ground is more informative than the same artifacts removed to a laboratory for study. Impacts may also occur through the alteration or destruction of a physical landscape with special values to Native Americans. The Native American Graves and Repatriation Act of 1990 protect Native American remains (see 3. Data, Resources, and References).

The California state inventory of known, documented archaeological resources for the Los Angeles area is maintained at the South Central Coastal (Regional) Information Center, at the Institute of Archaeology of the University of California at Los Angeles (UCLA) (known as the Information Center). All resources on this inventory should be evaluated for potential impacts in CEQA documentation. In addition, federal standards for eligibility to the National Register of

Historic Places¹ (National Register) may be used to determine whether known or potential resources should be examined under CEQA. Archaeological resources may be present on the grounds of historic sites or districts.

C. Screening Criteria

- Would the proposed project occur in an area with archaeological resources, human remains having archaeological associations, an archaeological study area, or a Native American sacred place, and involve grading, excavation, accelerated erosion, or other activities or changes to the site that could affect archaeological resources?

A "yes" response to the preceding question indicates further study in an expanded Initial Study, Negative Declaration, Mitigated Negative Declaration, or EIR may be required. Refer to the Significance Threshold for Archaeological Resources, and review the associated Methodology to Determine Significance, as appropriate.

A "no" response to the preceding question indicates that there would normally be no significant impact on Archaeological Resources from the proposed project.

D. Evaluation of Screening Criteria

The following sources may provide assistance in identifying the presence or potential presence of archaeological resources: existing archaeological surveys and documented historical accounts; the Information Center at the UCLA Institute of Archaeology; the Native American Heritage Commission; California Department of Transportation (Caltrans); the Army Corps of Engineers (ACOE); State Park Service; National Register; local, county, and state landmarks lists; Sanborn Fire Insurance maps; the Environmental and Public Facilities Map, Prehistoric and Historic Archaeological Sites and Survey Areas; and other appropriate resources.

Where sufficient information or research is not available to determine the presence or absence of archaeological resources, consider the following:

- Presence of elements or features that are historically or culturally important to a significant earlier community.

¹ For federal eligibility criteria regarding listing of archaeological resources in the National Register, see Exhibit D.3-1 in D.3. HISTORICAL RESOURCES.

- Features of the area that would create a favorable environment for prehistoric or historical use, such as:
 - A water source, travel corridor, native plants or animals, or sources of rock for construction, making tools, or artwork; or
 - Location in an area with unusual views, a defensive position or other values for ceremonial, ritual or astronomical observances.

Evaluate the degree of disturbance to the project site. Consider if the site has been vacant or covered by surfaces that required little or no excavation or grading, such that there has been little surface or subsurface disturbance (sites from which native topsoil has been removed, such as landfills, are unlikely to retain archaeological resource potential). Compare this information to the Screening Criteria.

2. DETERMINATION OF SIGNIFICANCE

A. Significance Threshold

A project would normally have a significant impact upon archaeological resources if it could disturb, damage, or degrade an archaeological resource or its setting that is found to be important under the criteria of CEQA because it:

- Is associated with an event or person of recognized importance in California or American prehistory or of recognized scientific importance in prehistory;
- Can provide information which is both of demonstrable public interest and useful in addressing scientifically consequential and reasonable archaeological research questions;
- Has a special or particular quality, such as the oldest, best, largest, or last surviving example of its kind;
- Is at least 100-years-old² and possesses substantial stratigraphic integrity; or

²

Although the CEQA criteria state that "important archaeological resources" are those which are at least 100-years-old, the California Register provides that any site found eligible for nomination to the National Register will automatically be included within the California Register and subject to all protections thereof. The National Register requires that a site or structure be at least 50-years-old.

- Involves important research questions that historical research has shown can be answered only with archaeological methods.

B. Methodology to Determine Significance

Environmental Setting

In a description of the environmental setting, include the following information:

- Description of the physical setting, archaeology, and geology of the project site and surrounding area;
- Summary of surveys and research for the project site; and
- Summary of requirements and/or policies for archaeological resources that apply to the project. (See 3. Data, Resources, and References).

Project Impacts

If the project site is located in an area with known or potential presence of an archaeological resource, archaeological study area, or human remains having archaeological associations, reviews the description of the project and construction/operation activities. Assess the amount of grading, excavation, erosion and increased human activity (e.g., opening of previously closed lands, new access routes through sensitive areas, or through removal of vegetation) that would occur with project implementation.

Estimate the importance of archaeological resources likely to be contained on the site and the consequences that would likely result from the project. The significance of a site is measured by eligibility of the resource to the California Register of Historical Resources (California Register) or the National Register. Criteria for listing in the National Register include association with events, persons, history or prehistory or embodiment of distinctive characteristics. These criteria are based on context (theme, place, and time), integrity (location, design, setting, materials, workmanship, feeling), and association. The California Register uses the National Register criteria for listing resources significant at the national, state, or local level.

Consider compliance with guidelines and regulations such as the California Public Resources Code, Federal Antiquities Act (and subsequent federal legislation), Conservation

Element, and, for public projects, Standard Specifications for Public Works Construction. Assistance from the Information Center or a professional consultant may be required.

Most existing archaeological site records, information about what areas have already been surveyed, information concerning sites that have been tested or evaluated, and a library of excavation reports, are maintained as part of the State Inventory at the Information Center. The most immediate and complete source of updated site information is a "Quick Check" conducted by the Information Center. Under new directives, the Information Center is beginning to gather information about designated landmarks, historical sites, and historical maps, but this archive is not yet complete. The Information Center maintains a list of qualified archaeological consultants which is made available on request.

Determine whether construction or operational activities would disturb, damage, or degrade an important resource or its setting. Consider excavation and grading that directly impacts a resource; construction of permanent buildings that result in loss of access to buried resources; added human activity that may lead to scavenging or uncovering of resources; and increases in soil erosion. If the area has been disturbed through previous grading or excavation or installation of subsurface utilities, it is likely that resources would have been discovered at that time or have been destroyed.

Cumulative Impacts

Review the list of related projects and identify those in areas with known or the potential presence of archaeological resources. In the same manner as for project impacts, estimate the extent and importance of archaeological resources likely to be contained on the sites and the consequences that would likely result from these related projects. Determine the cumulative impact from the related projects combined with the proposed project. In particular, consider cumulative impacts to the population of resources which would remain and impacts to groupings (e.g., same camp, village, or settlement). Evaluate the destruction of resources exposed on the surface by considering the cumulative increase in human activity and soil erosion.

Sample Mitigation Measures

Potential mitigation measures include the following:

- Cover archaeological sites with a layer of fill before building surface facilities such as tennis courts, parking lots, or gardens above them, when the following

conditions can be met:

- The underlying site will not be seriously compacted;
 - The fill will not be chemically active;
 - The site is protected against natural deterioration; and
 - The site has been recorded and tested, and full parameters are known, i.e., horizontal extent, depth, age, cultural complexity, etc;
-
- Deed archaeological sites into permanent conservation easements;
 - Undertake data recovery. Data recovery requires the preparation of an excavation plan³ which sets forth the size of the sample to be acquired, the methods and techniques of excavation, methods and techniques of laboratory studies to be conducted, documentation procedures, and the place where all materials and documentation will be curated; and
 - Conduct resource recovery. Some features or objects (rock rings, rock art, structural elements, architectural elements, etc.) can be documented in place, and then either relocated for public interpretation on the subject property, or removed to a museum or other institution for safekeeping and display.

³

Archaeological Resource Management Reports (ARMR): Recommended Contents and Format. Preservation Planning Bulletin No. 4 (a).

3. DATA, RESOURCES, AND REFERENCES

Information Center: UCLA Institute of Archaeology, Fowler Museum of Cultural History, Los Angeles, California 90095; Telephone: (310) 825-4361.

California Office of Historic Preservation (OHP), P.O. Box 942896, Sacramento, California 94296-0001; Telephone: (916) 653-6624. Maintains many publications, including Instructions for Recording Historical Resources, 1995, and California Register: Proposed Guidelines for the Nomination of Properties, 1995.

The Cultural Heritage Commission (CHC), Los Angeles Conservancy, Natural History Museum of Los Angeles County, and the Community Redevelopment Agency (CRA) of the City of Los Angeles, have limited inventories of historical landmarks, but their data do not include archaeological sites and should be augmented by consultation with the Information Center.

CEQA, Appendix K, Archaeological Resources, contains standards for review and mitigation.

Archaeological Resource Management Report (ARMR): Recommended Contents and Format, OHP, 1989. Contains a useful checklist and guidelines for reviewing the adequacy of the preparation and organization of archaeological reports.

CEQA and Archaeological Resources, 1994. Governor's Office of Planning and Research (OPR).

Conservation Plan Element: Section II-3, Preservation of Archaeological Sites and Paleontological Findings, 2001.

City of Los Angeles -- Archaeological Resources Information:

In a comprehensive review of the City's archaeological resources completed in August 1993, the Information Center, which assigns site numbers and curates site records, estimated that only two percent of the City's approximately 800 square miles has been surveyed for archaeological resources. At that time, however, 196 prehistoric sites, 50 historical sites, and 10 undefined isolated occurrences had already been recorded. Of these, at least 26 sites were known to contain human burials, and 10 sites had both prehistoric and historic components. The prehistoric sites include named Native American villages, buried deposits and features, pit houses, occupied caves and rockshelters, bedrock mortars, camp sites, cemeteries and rock art. Historical sites were distinctly underrepresented in the records, since standing historic structures have not been regularly assigned archaeological site numbers or assessed for the potential existence of associated buried features until

recent state guidelines advised that this should be done. The historical sites already recorded are as varied as pre-1830s limekilns, stage stops, mission structures and dams, a log cabin, many adobes, quarries, oil exploration and development features, a submerged ship, a Civil War asphalt mine, aspects of the Pueblo and early water canal features, Chinatown, and a Japanese labor camp.

Selected Legislation

Federal

Federal Antiquities Act of 1906 (P. L. 59-209; 16 U.S.C. 431-433)

Basis for all following legislation. The government, acting for the people, should protect archaeological and historical sites and "any object of antiquity," and preserve them for public availability. Forbids disturbance of said objects of antiquity on federal lands without a permit issued by the responsible agency. Establishes criminal sanctions for unauthorized use or destruction of antiquities.

Historic Sites Act of 1935 (P. L. 74-292, 16 U.S.C. 461-467, 49 Stat. 666)

Declares, "it to be national policy to preserve for public use historic sites, properties, buildings, and objects of national significance." Gives the National Park Service (NPS) (through the Secretary of the Interior) broad powers to execute this policy, including criminal sanctions, on both federal and non-federal lands. It also sets up an advisory board to aid the Secretary of the Interior in implementing this Act.

Reservoir Salvage Act of 1960 (P. L. 86-523; 74 Stat. 220)

Requires Secretary of the Interior to institute an archaeological salvage program in connection with federally funded reservoir programs requiring the responsible agencies to comply with this program.

Historic Preservation Act of 1966 (P. L. 89-665; 80 Stat. 915)

Expansion of the National Register to include sites of not only national, but local significance; authorizes program of matching funds for their acquisition and preservation; and establishes the Advisory Council on Historic Preservation to help implement and monitor this Act.

National Environmental Policy Act (NEPA) of 1969 (P. L. 91-190; 83 Stat. 852)

Requires that cultural resources be considered in assessing the environmental impact of proposed federal projects.

Executive Order 11593 of May 13, 1971: "Protection and Enhancement of the Cultural Environment" Richard M. Nixon (36 F.R. 8921)

States that the federal government shall provide leadership in preserving, restoring and maintaining the historic and cultural environment; specifies that all federal agencies shall institute inventories for historic and archaeological sites, and shall provide for their protection as specified by P. L. 89-665.

Archaeological and Historical Preservation Act of 1974 (P. L. 93-291, U.S.C. 469-469c; 88 Stat. 174)

Amends the Reservoir Salvage Act of 1960 to include all federal programs which may impact cultural resources; authorizes expenditure of program funds for salvage projects; and requires Secretary of the Interior to report annually to Congress on the effectiveness of the program.

Federal Land Policy and Management Act of 1976 (P. L. 94-579; 90 Stat. 2743)

Directs the Bureau of Land Management (BLM) to manage lands on the basis of multiple use in a manner that will protect the quality of scientific, historical, and archaeological values. It provides the guidelines for the acquisition and management of these resources.

American Indian Religious Freedom Act of 1978 (P. L. 95-341; 92 Stat. 469)

States that it is the policy of the United States to protect and preserve for Native Americans their inherent right of freedom to believe, express, and exercise the traditional religions of the American Indian including access to sites, use and possession of sacred objects, and the freedom to worship through ceremonial and traditional rites.

Native American Heritage Bill - Chapters 1492 (1984) and 370 (1992)

Policy to protect Native American remains and maintain integrity of their archaeological database; and to establish guidelines for recordation of reburial of human remains and grave goods.

Native American Graves Protection and Repatriation Act of 1990 (NAGPRA) - (P. L. 101-601; 104 Stat. 3048, 25 U.S.C. 3001)

Conveys to Native Americans, of demonstrated lineal descent, human remains and funerary or religious items that are held by federal agencies and federally-supported museums, or that have been recovered from federal lands. Also makes the sale or purchase of Native American human remains, "whether or not they derive from federal or Indian lands, illegal."

State

California Public Resources Code

Section 5097.5 (Stats. 1965, C. 11362792)

Defines as a misdemeanor the unauthorized disturbance or removal of archaeological, historical, or paleontological resources located on public lands. Prohibits the knowing destruction of objects of antiquity without a permit (expressed permission) on public lands, and provides for criminal sanctions. Amended in 1987 to require consultation with the California Native American Heritage Commission whenever Native American graves are found. Violations for taking or possessing remains or artifacts are felonies.

Chapter 1332, Section 5097.9

Establishes the California Native American Heritage Commission to make recommendations to encourage private property owners to protect and preserve sacred places in a natural state and to allow appropriate access to Native Americans for ceremonial or spiritual activities. The Commission is authorized to assist Native Americans in obtaining appropriate access to sacred places on public lands, and to aid state agencies in any negotiations with federal agencies for the protection of Native American sacred places on federally administered lands in California.

Section 5097.98-99 (Stats. 1982, C. 1492. Amended 1987)

Requires that the Governor's California Native American Heritage Commission be consulted whenever Native American graves are found. Makes it illegal to take or possess remains or artifacts taken from Native American graves. Does not apply to materials taken before 1984. Violations occurring after January 1, 1988, become felonies.

CEQA (P. R. C. Section 21001)

Requires that cultural resources be considered in assessing the environmental impact of proposed projects.

California Register (1993, AB 2881, Chapter 1075)

Amends the Public Resources Code as it affects historical resources. Purpose is to develop and maintain, "an authoritative guide to be used by state and local agencies, private groups, and citizens to identify the state's historical resources and to indicate which properties are to be protected, to the extent prudent and feasible, from substantial adverse change." Sites, places, or objects which are eligible to the National Register (50-years-old or more) are automatically included in the California Register.

California Penal Code, Title 14, Part 1, Section 622.5

Provides that any person, not the owner thereof, who willingly destroys or injures objects of archaeological or historical value, whether on public or private land, is guilty of a misdemeanor.

California Administrative Code, Title 14, Section 4307

States, "no person shall remove, injure, disfigure, deface or destroy any object of paleontological, archaeological, or historical interest or value."

Local

Standard Specifications for Public Works Construction, Section 6-3.2

Requires that grading, excavation, or other ground disturbing activities for a public project be halted in the area of a paleontological or archaeological find, until such time as a resource expert can review the find, determine its significance, and if required, determine appropriate mitigation measures.

D.3. HISTORICAL RESOURCES

1. INITIAL STUDY SCREENING PROCESS

A. Initial Study Checklist Question

V.a): Would the project cause a substantial adverse change in the significance of a historical resource as defined in §15064.5?

B. Introduction

Historical resources are found throughout the City of Los Angeles and are reminders of the City's historical and cultural development. Resources include, for example, buildings, structures, street lighting systems, spaces, sites, or components thereof. Uses include residential, non-residential (e.g., commercial, industrial, institutional), and public facilities. Resources may be important individually or as part of a district or grouping of complementary resources.

Significant historical resources include those designated or eligible for designation in the National Register of Historic Places (National Register); the California Register of Historical Resources (California Register) or other state program; as a City of Los Angeles Historic Cultural Monument; or in a City of Los Angeles Historic Preservation Overlay Zone (HPOZ). Historical resources may also include resources listed in the State Historic resources Inventory as significant at the local level or higher and those evaluated as potentially significant in a survey or other professional evaluation.

Agencies with jurisdiction over historical resources include the National Park Service (NPS), the California Office of Historic Preservation (OHP), and the City of Los Angeles (see Exhibits D.3-1 to D.3-4 for additional information). The NPS maintains the National Register. Criteria for listing in the National Register include association with events, persons, history, or prehistory or embodiment of distinctive characteristics. These criteria are based on context (theme, place, and time), integrity (location, design, setting, materials, workmanship, feeling, and association), and, if a recent resource, exceptional importance.

OHP implements state preservation law and is responsible for the California Register. The California Register uses the National Register criteria for listing resources significant at the national, state, or local level.

Within the City of Los Angeles, the Cultural Heritage Commission (CHC) is responsible for designating resources as Historic-Cultural Monuments. Monuments, which must meet criteria similar to those for the National Register, are designated and protected. The City assigns an HPOZ to an area that meets certain criteria in order to preserve historical resources and ensure that new development is compatible with the area. Projects within an HPOZ are monitored by the City Planning Department in order to maintain the historic integrity of the area.

Projects that affect historical resources, such as by demolition, relocation, rehabilitation, conversion, alteration, or construction, may have a significant impact. The stock of significant historical resources cannot be replenished and is finite. Thus, the permanent loss of a resource is irreversible. While, in some circumstances, the resource's integrity can be maintained after rehabilitation, conversion, alteration, or construction, insensitive work also may result in a significant impact.

C. Screening Criteria

- Are there historical resources on the project site or in the vicinity, which would be adversely impacted by the project through, for example, demolition, construction, conversion, rehabilitation, relocation, or alteration?

A "yes" response to the preceding question indicates further study in an expanded Initial Study, Negative Declaration, Mitigated Negative Declaration or EIR may be required. Refer to the Significance Threshold for Historical Resources, and review the associated Methodology to Determine Significance, as appropriate.

A "no" response to the preceding question indicates that there would normally be no significant impact on Historical Resources from the proposed project.

D. Evaluation of Screening Criteria

Evaluate the historical significance of the resource by considering the following questions. In general, a "yes" response to any of the questions indicates an historical resource may be involved.

1. Has the site been coded by the Department of Building and Safety with a Zoning Instruction (ZI) number in the 145 series (which indicates prior identification of the property as historic)?
2. Has the resource been designated by the City of Los Angeles as an Historic-Cultural

Monument or as a contributor to an HPOZ?

3. Is the resource included within the California Register maintained by the OHP and ranked with an evaluation code of 1 (National Register listed resource) or 2 (determined eligible for listing in the National Register)?
4. Has the resource been classified as historic in an historical resources survey conducted as part of the updating of the Community Plan, the adoption of a redevelopment area or other planning project?
5. Is the resource subject to other federal, state, or local preservation guidelines or restrictions?
6. Does the resource have known associations with an architect, master builder or person or event important in history such that the resource may be of exceptional importance?
7. Is the resource over 50-years-old and a substantially intact example of an architectural style significant in Los Angeles? (Age is calculated from an original building permit or the Land Use Planning and Mapping System (LUPAMS) maintained by the City Planning Department. See Exhibit D.3-5 for significant architectural styles.)

Review the description of the proposed project and determine the type of activities proposed during site preparation, construction, and operation. Projects that affect historical resources, such as demolition, relocation, rehabilitation, conversion, alteration, or construction, may have a significant impact if the project results in a substantial adverse change which would impair historical significance. Insensitive rehabilitation, conversion, alteration or construction may also result in a significant impact. Compare this information to the Screening Criteria.

2. DETERMINATION OF SIGNIFICANCE

A. Significance Threshold

A project would normally have a significant impact on historical resources if it would result in a substantial adverse change in the significance of an historical resource.

A substantial adverse change in significance occurs if the project involves:

- Demolition of a significant resource;
- Relocation that does not maintain the integrity and significance of a significant resource;

- Conversion, rehabilitation, or alteration of a significant resource which does not conform to the Secretary of the Interior's Standards for Rehabilitation and Guidelines for Rehabilitating Historic Buildings; or
- Construction that reduces the integrity or significance of important resources on the site or in the vicinity.

B. Methodology to Determine Significance

Environmental Setting

In a description of the environmental setting, include the following information:

- Architectural description and condition of the resource(s);
- Listing, designation, or determination from city, state, or federal agency (e.g., listed or determined eligible for the National Register or California Register; designated as a City of Los Angeles Historic-Cultural Monument; included within an HPOZ as a contributor);
- Construction history (date of construction and major alterations, architect, builder and owner);
- Significance of owner, architect, builder, or architectural style in history; and
- Context of resource (population, district, grouping, etc.).

Project Impacts

Conduct an evaluation of the historical resource to determine its significance (based on listing or eligibility for listing). Field surveys and research, in addition to the review of the Initial Study screening process may be necessary to determine whether a resource is listed or eligible for listing. If a resource is not listed on the National Register, California Register, City of Los Angeles Historic-Cultural Monuments, or, if applicable, HPOZ, use the appropriate criteria for listing to determine whether it is eligible. Assistance is available from the agencies with jurisdiction over such resources and from the information included in 3. Data, Resources, and References. A professional consultant may be required.

Review the description of the proposed project and consider the potential impacts. When the demolition of an historical resource is proposed, weigh the impact given the significance of the resource and the population of similar resources which would remain. If the resource to be demolished is part of a district or grouping, also assess the impact to the listing or eligibility of the district or grouping.

When a significant historical resource is relocated, the ability to retain listing or eligibility depends upon individual circumstances. For example, relocation of a resource whose most significant feature is setting or position on a parcel would be more detrimental than if the key element is the architectural style and structural features. The style and feature would relocate with the building; however, the setting would not. Also, consider changes in the context (e.g., removal from a district).

Evaluate conversion, rehabilitation, or alteration to a significant historical resource in terms of the extent of the work and the impact on the listing or eligibility of the resource. Also, determine whether the work meets the standards for rehabilitation established by the Secretary of the Interior and the OHP (see Exhibits D.3-1 and D.3-4). Consider whether the conversion, rehabilitation, or alteration work would be compatible with the massing, size, scale, and architectural features of the resource. Projects more sensitive to historic integrity include minor repairs or temporary work that does not permanently affect significant elements and character.

If new construction is proposed, give key consideration to compatibility with the massing, size, scale, and architectural features of the historical resource(s). Determine the impacts to the setting and character of the area as well as whether the new construction might indirectly reduce the viability of a district or grouping of historical resources.

Cumulative Impacts

Review the list of related projects and identify those that:

- Are located within the same National Register district, HPOZ, general area, neighborhood, or community; or
- Involve resources with the same historical context or use (e.g., by the same architect or in the same period).

Determine the impact of the related projects. Consider the cumulative impacts of the proposed and related projects to the population of resources which would remain, and to districts and groupings.

Sample Mitigation Measures

Potential mitigation measures include the following:

- Prepare a preservation plan or element which provides guidelines to ensure that the project conforms to the standards for rehabilitation established by the Secretary of the Interior and the OHP;
- Require new construction to be compatible with historical resources on the site and in the vicinity (e.g., mass, height, materials, setback, retention of mature landscaping);
- Require the project sponsor to relocate the historical resource or offer it for relocation by another individual or organization (provided that eligibility will be maintained following the relocation);
- Require the project sponsor to adaptively reuse the historical resource or incorporate it into the project;
- Undertake documentation according to the requirements of the Historic American Building Survey (HABS) such as large format photography, measured drawings and written narrative. Make available copies of this documentation to the Los Angeles Public Library (LAPL) and local preservation organizations and historical societies; and
- Require the project sponsor to allow local preservation organizations and historical societies to document the resource and/or remove significant historic elements for archives.

3. DATA, RESOURCES, AND REFERENCES

NPS, Pacific Great Basin Support Office, 1111 Jackson St., Suite 700, Oakland, CA. 94607, Telephone: (510) 817-1396. NPS maintains the National Register.

OHP, P.O. Box 942896, Sacramento, California 94296-0001; Telephone: (916) 653-6624. OHP duties include: administration of National Register, California Register, State Historical Landmarks and State Points of Historical Interest programs, and State Historical resources Inventory; Section 106 process (National Historic Preservation Act); and Responsible Agency for CEQA review.

CHC and the Cultural Affairs Department, 433 South Spring Street, 10th Floor, Los Angeles, California 90013; Telephone: INFO Desk (213) 473-7700. Responsible for designation and monitoring of City of Los Angeles Historic-Cultural Monuments.

Department of Building and Safety. Customer Call Center (888)-LA4-BUILD or outside Los Angeles County: (213) 977-6941, 201 N. Figueroa Street, Los Angeles, CA 90012. Maintains ZI codes for property parcels. The ZI 145 series is currently used for historic buildings.

City Planning Department; Telephone: (213) 482-7077; Bureau of Engineering; Telephone: (213) 847-8704; and Community Redevelopment Agency (CRA) of the City of Los Angeles; Telephone: (213) 977-1600, maintain historical resources surveys.

Bureau of Street Lighting; 600 S. Spring St. 14th Floor, Los Angeles, CA 90013. Telephone: (213) 847-6400, is responsible for historic street lights in the City.

Los Angeles Conservancy, a regional non-profit preservation organization; 523 W. 6th St. Los Angeles, CA 90014, Telephone: (213) 623-2489. This organization's activities include:

- Historical resources surveys;
- Information regarding how to obtain the results of surveys; and
- Information regarding the significance of particular architects and buildings.

Recording Historic Structures, HABS/Historic American Engineering Record, John A. Burns, ed, Washington: American Institute of Architects Press, 1989.

References to other sources are included within HABS/Historic American Engineering Record, An Annotated Bibliography, compiled by James C. Massey, et al, NPS, 1992.

Exhibit D.3-1
NATIONAL CRITERIA AND STANDARDS

National Register

To be eligible for listing in the National Register, a resource must possess significance in American history and culture, architecture, or archaeology. These criteria are the Register's standards for determining the significance of properties. Buildings, sites, districts, structures, or objects of potential significance must possess integrity of location, design, setting, and materials and meet one or more of four established criteria:

- A. Are associated with events that have made a significant contribution to the broad patterns of our history;
- B. Are associated with the lives of persons significant in our past;
- C. Embody the distinctive characteristics of a type, period, or method of construction or that represent the work of a master, or that possess high artistic values, or that represent a significant and distinguishable entity whose components may lack individual distinction; or
- D. Yield, or may be likely to yield, information important in prehistory or history.

Secretary of the Interior's Standards for Rehabilitation and Guidelines for Rehabilitating Historic Buildings

- 1. A property shall be used for its historic purpose or be placed in a new use that requires minimal change to the defining characteristics of the building and its site and environment.
- 2. The historic character of a property shall be retained and preserved. The removal of historic material or alteration of features and spaces shall be avoided.
- 3. Each property shall be recognized as a physical record of its time, place and use. Changes that create a false sense of historical development, such as adding conjectural features or elements from other buildings, shall not be undertaken.
- 4. Most properties change over time; those changes that have acquired significance in their own right shall be retained and preserved.
- 5. Distinctive features, finishes and construction techniques or examples of skilled craftsmanship, which characterize an historic property, shall be preserved.
- 6. Deteriorated historic features shall be repaired rather than replaced. Where the severity of deterioration requires replacement of a distinctive historic feature, the new feature shall match

the old in design, color, texture, and other visual qualities, and where possible, materials. Replacement of missing features shall be substantiated by documentary, physical, or pictorial evidence.

7. Chemical or physical treatments, such as sandblasting, that cause damage to historic materials shall not be used. The surface cleaning of structures, if appropriate, shall be undertaken using the gentlest means possible.
8. Significant archeological resources affected by a project shall be protected and preserved. If such resources must be disturbed, mitigation measures shall be undertaken.
9. New additions, exterior alterations, or related new construction shall not destroy historic materials that characterize the property. The new work shall be differentiated from the old and shall be compatible with the massing, size, scale, and architectural features to protect the historic integrity of the property and its environment.
10. New additions and adjacent or related new construction shall be undertaken in such a manner that if removed in the future, the essential form and integrity of the historic property and its environment would be unimpaired.

Exhibit D.3-2
CALIFORNIA REGISTER CRITERIA AND EVALUATION SYSTEM

The evaluation instructions and classification system proscribed by OHP in its "Instructions for Completing the California Historical resources Inventory Form, June 1990" provide the following general categories of evaluation. Categories 1 through 4 involve various levels of National Register eligibility. The California Register may include surveyed resources ranked from 1 - 5.

1. Listed in the National Register.
2. Determined eligible for listing in the National Register in a formal process involving federal agencies.
3. Appears eligible for listing in the National Register in the judgment of the persons completing or reviewing the form.
4. May become eligible for listing in the National Register.
5. Ineligible for the National Register, but of local interest.
6. None of the above.
7. Undetermined.

Resources eligible to be nominated for listing in the California Register include:

- Individual historical resources;
- Historical resources contributing to the significance of an historic district under criteria adopted by the Commission;
- Historical resources identified as significant in historical resource surveys, if the survey meets the criteria listed in California Public Resources Code . 5024.1(g); and
- Locally designated resources if the criteria for local designation have been determined by the Commission to be consistent with California Register criteria adopted by the Commission.

Exhibit D.3-3

CITY OF LOS ANGELES CRITERIA

City of Los Angeles Historic-Cultural Monument Designation

In the City of Los Angeles, resources may be designated as Historic-Cultural Monuments under Sections 22.120, et seq., of the Los Angeles Municipal Code (LAMC). An historical or cultural monument is defined as:

"any site (including significant trees or other plant life located thereon), building or structure of particular historic or cultural significance to the City of Los Angeles, such as historic structures or sites in which the broad cultural, political, economic or social history of the nation, state or community is reflected or exemplified, or which are identified with historic personages or with important events in the main currents of national, state or local history, or which embody the distinguishing characteristics of an architectural-type specimen, inherently valuable for a study of a period style or method of construction, or a notable work of a master builder, designer, or architect whose individual genius influenced his age."

City of Los Angeles Historic Preservation Overlay Zones (HPOZs)

HPOZs are essentially locally designated historic districts or groupings of historical resources. Under the HPOZ ordinance (LAMC Section 12.20.3.), to be significant, structures, natural features or sites within the involved area or the area as a whole shall meet one or more of the following criteria:

- (A) has substantial value as part of the development, heritage or cultural characteristics of, or is associated with the life of a person important in the history of the city, state or nation;
- (B) is associated with an event that has made a substantial contribution to the broad patterns of our history;
- (C) is constructed in a distinctive architectural style characteristic of an era of history;
- (D) embodies those distinguishing characteristics of an architectural type or engineering specimen;
- (E) is the work of an architect or designer who has substantially influenced the development of the City;
- (F) contains elements of design, details, materials or craftsmanship which represent an important innovation;
- (G) is part of or related to a square, park or other distinctive area and should be developed or preserved according to a plan based on a historic, cultural, architectural or aesthetic motif;
- (H) owing to its unique location or singular physical characteristics, represents an established feature of the neighborhood, community or City; or
- (I) retaining the structure would help preserve and protect an historic place or area of historic interest in the City.

Exhibit D.3-4
STATE OFFICE OF HISTORIC PRESERVATION (OHP)
LIST OF NON-ADVERSE REPAIRS AND IMPROVEMENTS

According to the OHP and the Advisory Council on Historic Preservation, the following work does not usually involve adverse effect on historical resources:

1. Electrical work, limited to upgrading or in-kind replacement;
2. Plumbing work, limited to upgrading or in-kind replacement, with the exception of historic fixtures which shall be repaired when possible;
3. Installation of mechanical equipment, which does not affect the exterior of the building or require installation of new ductwork throughout the interior;
4. Repainting of existing painted surfaces if destructive surface preparation treatments are not used, including, but not limited to, water blasting, sandblasting, and chemical removal;
5. In-kind repair/partial replacement of porches, cornices, exterior siding, doors, balustrades, stairs, or other trim;
6. In-kind replacement of deteriorated windows;
7. Replacement of windowpanes in-kind or with double or triple glazing so long as glazing is clear and not colored and replacement does not alter existing window material and form;
8. Caulking and weather stripping with compatibly colored materials;
9. In-kind repair/replacement of roof materials;
10. Installation of insulation, with the exception of urea formaldehyde foam insulation or any thermal insulation with a water content into wall cavities, provided that decorative interior plaster or woodwork or exterior siding is not altered by this work item;
11. Installation of fire or smoke detectors;
12. Installation of security devices, including deadbolts, door locks, window latches, and door peepholes, and the installation of electronic security systems;
13. In-kind repair/replacement of driveway or walkways;
14. In-kind repair/replacement of fencing;

15. Floor refinishing;
16. In-kind repair/replacement of floors;
17. Installation of grab bars and minor interior modifications for handicap accessibility;
18. In-kind repair/replacement of signs and awnings; and
19. In-kind repair/replacement of interior stairs.

Exhibit D.3-5
ARCHITECTURAL STYLES AND PERIODS

The following architectural styles and related periods of significance are historically important in Los Angeles:

| | |
|--------------------------|-----------|
| Adobe | 1800-1870 |
| Monterey | 1840-1870 |
| Greek Revival | 1825-1860 |
| Classical Revival | 1840-1870 |
| Italianate | 1870-1900 |
| Gothic Revival | 1870-1900 |
| Eastlake | 1870-1900 |
| Second Empire | 1870-1885 |
| Queen Anne | 1880-1905 |
| Chateausque | 1890-1915 |
| American Foursquare | 1894-1908 |
| Turn of the Century | 1895-1905 |
| Beaux Arts | 1895-1930 |
| Mission Revival | 1890-1915 |
| Craftsman | 1895-1925 |
| Pueblo Revival | 1900-1930 |
| Commercial Vernacular | 1910-1925 |
| Spanish Colonial Revival | 1915-1930 |
| Modernism | 1920-1940 |
| Art Deco | 1920-1940 |
| Monterey Revival | 1925-1940 |
| Colonial Revival | 1930-1945 |
| Tudor Revival | 1930-1945 |
| Streamline Moderne | 1935-1945 |
| PWA Moderne | 1930-1940 |
| California Ranch House | 1935-1990 |
| Corporate International | 1945-1990 |

Source: Los Angeles Conservancy, 1995.

Exhibit D.3-5
ARCHITECTURAL STYLES AND PERIODS

The following architectural styles and related periods of significance are historically important in Los Angeles:

| | |
|--------------------------|-----------|
| Adobe | 1800-1870 |
| Monterey | 1840-1870 |
| Greek Revival | 1825-1860 |
| Classical Revival | 1840-1870 |
| Italianate | 1870-1900 |
| Gothic Revival | 1870-1900 |
| Eastlake | 1870-1900 |
| Second Empire | 1870-1885 |
| Queen Anne | 1880-1905 |
| Chateausque | 1890-1915 |
| American Foursquare | 1894-1908 |
| Turn of the Century | 1895-1905 |
| Beaux Arts | 1895-1930 |
| Mission Revival | 1890-1915 |
| Craftsman | 1895-1925 |
| Pueblo Revival | 1900-1930 |
| Commercial Vernacular | 1910-1925 |
| Spanish Colonial Revival | 1915-1930 |
| Modernism | 1920-1940 |
| Art Deco | 1920-1940 |
| Monterey Revival | 1925-1940 |
| Colonial Revival | 1930-1945 |
| Tudor Revival | 1930-1945 |
| Streamline Moderne | 1935-1945 |
| PWA Moderne | 1930-1940 |
| California Ranch House | 1935-1990 |
| Corporate International | 1945-1990 |

Source: Los Angeles Conservancy, 1995.

E. GEOLOGY

E.1. GEOLOGIC HAZARDS

1. INITIAL STUDY SCREENING PROCESS

A. Initial Study Checklist Questions

- VI.a.i): Would the project expose people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving rupture of a known earthquake fault, as delineated on the most recent Alquist-Priolo Earthquake Fault Zoning Map issued by the State Geologist for the area or based on other substantial evidence of a known fault?
- VI.a.ii): Would the project expose people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving strong seismic ground shaking?
- VI.a.iii): Would the project expose people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving seismic-related ground failure, including liquefaction?
- VI.a.iv): Would the project expose people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving landslides?
- VI.c): Would the project be located on a geologic unit or soil that is unstable, or that would become unstable as a result of the project, and potentially result in on- or off-site landslide, lateral spreading, subsidence, liquefaction or collapse?
- VIII.j): Would the project expose people or structures to potential substantial adverse effects, including the risk of loss, injury or death involving inundation by seiche, tsunami, or mudflow?

B. Introduction

Geologic processes that result in geologic hazards include: surface rupture, ground shaking, ground failure, tsunamis, seiches, landslides, mudflows, and subsidence of the land.¹ Because the region is generally considered to be geologically active, most projects will be exposed to some risk from geologic hazards, such as earthquakes. Thus, significant geologic impacts exceed the typical risk of hazard for the region.

¹ *Sediment and erosion are addressed in E.2. SEDIMENTATION AND EROSION.*

Surface ruptures are the displacement and cracking of the ground surface along a fault trace. Surface ruptures are visible instances of horizontal or vertical displacement, or a combination of the two, typically confined to a narrow zone along the fault. The effects of ground shaking, the actual trembling or jerking motion of the ground during an earthquake, can vary widely across an area and depend on such factors as earthquake intensity and fault mechanism, duration of shaking, soil conditions, type of building, and other factors. Ground failure results from the cyclical ground acceleration generated during an earthquake, producing landslides, ground cracking, subsidence and differential settlement. Liquefaction is a form of earthquake-induced ground failure that occurs primarily in relatively shallow, loose, granular, water-saturated soils.

Tsunamis are large ocean waves generated by large-scale, short-duration submarine earthquakes. Tsunami waves are capable of traveling great distances (over 1,000 miles) and damaging low-lying coastal regions. Seiches are waves formed from oscillations in enclosed or restricted bodies of water (i.e., harbors, lakes). Seiches can cause water to overtop reservoirs and lakes.

Mudflows and landslides are the downslope movement of soil and/or rock under the influence of gravity. Mudflow and landslide processes are influenced by factors such as thickness of soil or fill over bedrock, steepness and height of slope, physical properties of the fill, soil or bedrock materials and moisture content. These factors may increase the effective force of gravity upon a slope, decrease the ability of a slope to resist gravitational influence or a combination of the two, which can lead to mudflows and landslides.

Subsidence is a localized mass movement that involves the gradual downward settling or sinking of the Earth's surface, resulting from the extraction of mineral resources, subsurface oil, groundwater, or other subsurface liquids, such as natural gas. Settlement is the gradual downward movement of a structure due to compression of the soil below the foundation. The principal cause of subsidence is the extraction of subsurface liquids, whereas settlement results from the compression of soils due to the weight of the structure or by surcharging following the placement of fill.

Construction is regulated by the Los Angeles Building Code, Sections 91.000 through 91.7016 of the Los Angeles Municipal Code (LAMC). The Los Angeles Building Code provides requirements for construction, grading, excavations, use of fill, and foundation work including type of materials, design, procedures, etc., which are intended to limit the probability of occurrence and the severity of consequences from geological hazards. Necessary permits, plan checks, and inspections are also specified.

C. Screening Criteria

- Is the project located in an area susceptible to unusual geologic hazards considering the following:
 - Designation on official maps and databases;
 - Past episodes on-site or in the surrounding area; and
 - Physical properties of the site, including the topography, soil or underlying bedrock (including thickness of bedrock and soil compressibility, strength, moisture content, and distribution)?
- Would the project include any of the following:
 - Placement of structures designed for regular occupancy or infrastructure on fill; or
 - Active or planned extraction (removal) of mineral resources, groundwater, oil, or natural gas on-site or in the surrounding area?

A "yes" response to any of the preceding questions indicates further study in an expanded Initial Study, Negative Declaration, Mitigated Negative Declaration, or EIR may be required. Refer to the Significance Threshold for Geologic Hazards, and review the associated Methodology to Determine Significance, as appropriate.

A "no" response to all of the preceding questions indicates that there would normally be no significant Geologic Hazard impact from the proposed project.

D. Evaluation of Screening Criteria

Review the description of the proposed project, project site, and surrounding area. To assist in determining whether the project is located in an area of known or suspected geologic hazard, consult the following maps and databases:

- Environmental and Public Facilities Maps, including:
 - Alquist-Priolo Special Study Zones and Fault Rupture Study Areas,
 - Inundation and Tsunami Hazard Areas,

- Areas Susceptible to Liquefaction,
 - Landslide Inventory and Hillside Areas,
 - Areas Containing Significant Mineral Deposits, and
 - Oil Field and Oil Drilling Areas;
- ZIMAS (Zone Information & Map Access System): <http://zimas.lacity.org>
 - Navigate LA: <http://navigatela.lacity.org/>
 - Federal Emergency Management Agency (FEMA) Flood Insurance Rate Maps (FIRM) for tsunami hazards

Using the above information, field research, published reports, or other appropriate maps or studies, as available, assess whether the project is located in an area susceptible to geologic hazards. Consider past episodes on site or in the surrounding area; steepness/height of slopes; physical properties of the soil; the presence of fill; or extraction of resources below the surface. If necessary, consult with the Bureau of Engineering or Department of Building and Safety.

Compare this information to the Screening Criteria.

2. DETERMINATION OF SIGNIFICANCE

A. Significance Threshold

A project would normally have a significant geologic hazard impact if it would cause or accelerate geologic hazards, which would result in substantial damage to structures or infrastructure, or expose people to substantial risk of injury.

B. Methodology to Determine Significance

Environmental Setting

In a description of the environmental setting, include the following information:

- Description of the physical setting and geology, such as the topography, steepness and height of slopes or cliffs, physical properties of the soil and underlying bedrock, proximity to bodies of water, presence of fill, and extraction or mining activities;

- Identification of the geologic processes that may result in geologic hazards on the project site or in the surrounding area; and
- Summary of requirements and/or policies for geologic hazards that apply to the project site.

Project Impacts

Using the information from the Evaluation of Screening Criteria and the description of the proposed project, project site, and surrounding area, determine the geologic hazards that the project would cause or accelerate. Substantial damage to structures or infrastructure and exposure of people to substantial risk of injury is related to the probable frequency of potential geologic hazards (i.e., likely number of events per year or decade) and the probable severity of the consequences to people, property, or infrastructure that may result (i.e., injuries to people and the valuation of property damage). Consider that the geologically active nature of the region means that most projects will be exposed to geologic hazards, such as seismic activity. Significant impacts, as indicated by the significance threshold, exceed the typical risk of hazard for the region. Consider the type of uses that would be included in the project, the characteristics of the occupants of the project, and the change in risk of hazard or damage that would result from the project.

Cumulative Impacts

Review the description of the related projects. Identify those with elements, activities, or operations which would cause or accelerate geologic hazards that would extend off-site. Consider the impact from the combined effect of the related and proposed projects, in the same manner as described above for Project Impacts.

Sample Mitigation Measures

Potential mitigation measures include the following:

- Use interim precautionary steps during construction; and
- Use design and structural features that exceed the requirements of the Los Angeles Building Code and Planning and Zoning Code. (Chapter 1 of the Municipal Code).

3. DATA, RESOURCES, AND REFERENCES

Department of Building and Safety, 201 North Figueroa Street, 4th Floor, Construction Services Center, Los Angeles, California 90012; Telephone: (213) 833-8389.

Bureau of Engineering, Geotechnical Engineering Group, 650 S. Spring St., Suite 495, Los Angeles, CA 90014. (213) 847-4010.

Bureau of Engineering, Structural Engineering Group, 650 S. Spring St., Suite 400, Los Angeles, CA. 90014. (213) 847-8774.

City Planning Department, Environmental and Public Facilities Maps (1996):

- Alquist-Priolo Special Study Zones and Fault Rupture Areas illustrates the approximate locations of Alquist-Priolo Special Study Zones and fault rupture areas;
- Inundation and Tsunami Hazard Areas;
- Areas Susceptible to Liquefaction;
- Landslide Inventory and Hillside Areas illustrates the approximate locations of hillside areas, areas with known or probable bedrock landslides, and areas of surficial landslides larger than five acres;
- Areas Containing Significant Mineral Deposits identifies areas within a Mineral Resource Zone (MRZ) 2. Projects within this designation may experience subsidence/settlement where mineral extraction has occurred or is planned; and
- Oil Field and Oil Drilling Areas show areas known to have supported at least six months of oil production, indicating an increased risk for subsidence.
- ZIMAS (Zone Information & Map Access System) <http://zimas.lacity.org>
- Navigate LA <http://navigatela.lacity.org/>
- Federal Emergency Management Agency (FEMA) Flood Insurance Rate Maps.

Planning and Zoning code is available from the City Planning Department's Central Publications Unit at 200 N. Spring St., 5th Floor, Los Angeles, CA., 90012; Online at: http://amlegal.com/los_angeles_ca/.

Selected Legislation

Federal

Flood Insurance Rate Maps (FIRMs) (10 CFR Section 1022.11, 43 CFR Section 64.3)

FIRMs are prepared by the Federal Insurance Administration of the Department of Housing and Urban Development (HUD) after a risk study for a community has been completed and the risk premium rates have been established. The maps indicate the risk premium zones applicable in the community and when those rates are effective. They are used in making flood plain determinations and to determine if a proposed action is located in the base or critical action flood plain, as appropriate.

State

Alquist-Priolo Earthquake Fault Zoning Act (PRC Section 2621.5)

Provides policies and criteria to assist cities, counties, and state agencies in the development of structures for human occupancy across the trace of active faults. Intended to provide the citizens of the state with increased safety and to minimize the loss of life during and immediately following earthquakes by facilitating seismic retrofitting to strengthen buildings, including historical buildings, against ground shaking.

E.2. SEDIMENTATION AND EROSION

1. INITIAL STUDY SCREENING PROCESS

A. Initial Study Checklist Question

VI.b): Would the project result in substantial soil erosion or the loss of topsoil?

B. Introduction

Projects that change the natural ground surface may expose earth materials, which are subject to erosion from both wind and water forces. Impacts are related to the amount of land exposed to wind and water forces and the characteristics of the site. Such erosion affects not only the integrity of the ground surface, but also results in the transport and deposition of dust in the surrounding locale and/or sediments in downstream water bodies. Impacts of sediment runoff on water quality are addressed in G.2. SURFACE WATER QUALITY.

Construction is regulated by the Los Angeles Building Code (Sections 91.7000 through 91.7016 of the Los Angeles Municipal Code (LAMC)). The Los Angeles Building Code provides requirements for construction, grading, excavations, use of fill, and foundation work including type of materials, design, procedures, etc., which are intended to limit the probability of occurrence and the severity of consequences from sedimentation and erosion. Necessary permits, plan checks, and inspections are specified. Also included in these requirements is the provision that any grading work in excess of 200 cubic yards (cu.yd.) that will occur between November 1 and April 15 (the "rainy season") must include an erosion control system approved by the Department of Building and Safety.

Under the National Pollutant Discharge Elimination System (NPDES), the State Water Resources Control Board has issued two general stormwater discharge permits for Los Angeles County to cover industrial and construction activities. The permits are required for specific industry types based on standard industrial classification and for construction activities on five acres or more. The Regional Water Quality Control Board (RWQCB) oversees implementation and enforcement of the general permits, including Waste Discharge Requirements (WDR). The Public Works Department, Bureau of Engineering, Stormwater Management Division, is the agency responsible for overseeing implementation of permit responsibilities for the City. Presently, under the General

Construction Stormwater Permit, projects greater than five acres are required to incorporate, to the maximum extent possible, permanent or post-construction best management practices (BMPs) in project planning and design.

C. Screening Criteria

- Would the project result in grading, clearing or excavation of more than 20,000 cu.yd. on a slope of ten percent or more?
- Does the project include grading, clearing, or excavation activities in an area of known or suspected erosion hazard (based upon designation on official maps and databases)?

A "yes" response to any of the preceding questions indicates further study in an expanded Initial Study, Negative Declaration, Mitigated Negative Declaration, or EIR may be required. Refer to the Significance Threshold for Sedimentation and Erosion, and review the associated Methodology to Determine Significance, as appropriate.

A "no" response to all of the preceding questions indicates that there would normally be no significant Sedimentation and Erosion impact from the proposed project.

D. Evaluation of Screening Criteria

Review the description of the proposed project, project site, and surrounding area. To determine if the project is located in an area of known or suspected erosion hazard, consult the following maps and databases:

- Environmental and Public Facilities Maps, Landslide Inventory and Hillside Areas; and
- Zimas (Zone Information & Map Access System) <http://zimas.lacity.org/>
- Navagate LA <http://navagatela.lacity.org>

Indications of high and very high levels of erosion hazard indicate known or suspected erosion hazard. Determine whether the project includes grading, clearing or excavation activities that could result in sedimentation and erosion impacts. If necessary, use field research, published reports, or other appropriate studies, as available, or consult with the Bureau of Engineering or Department of Building and Safety. Compare this information to the Screening Criteria.

2. DETERMINATION OF SIGNIFICANCE

A. Significance Threshold

A project would normally have significant sedimentation or erosion impacts if it would:

- Constitute a geologic hazard to other properties by causing or accelerating instability from erosion; or
- Accelerate natural processes of wind and water erosion and sedimentation, resulting in sediment runoff or deposition which would not be contained or controlled on-site.

B. Methodology to Determine Significance

Environmental Setting

In a description of the environmental setting, include the following information:

- Description of the physical setting and geology, such as the topography of the site, steepness and height of slopes or cliffs, characteristics of the soil, and type and extent of vegetation;
- Identification of the erosion processes that may result in geologic hazards on the project site or in the surrounding area; and
- Summary of requirements and/or policies for erosion hazards that apply to project site.

Project Impacts

Using the information from the Evaluation of Screening Criteria and the description of the proposed project, project site, and surrounding area, determine the erosion hazards that the project would cause or accelerate. Assess the probable frequency of potential geologic hazards (i.e., likely number of events per year or decade) and the probable severity of the consequences to people, property, or infrastructure that may result (i.e., injuries to people and the valuation of property damage). Consider the type of uses that would be included in the project, the characteristics of the occupants of the project, and the change in risk of

hazard or damage that would result from the project. Determine whether sediment runoff would be contained or controlled on-site. Exposure between November 1 and April 15 (the "rainy season") and removal of vegetative cover are more likely to result in erosion and sedimentation. Conditions such as steep slopes and cliffs or impermeable soil can also exacerbate runoff.

Cumulative Impacts

Review the description of the related projects. Identify those with activities or operations which would cause or accelerate erosion hazards. Assess the probable frequency of potential geologic hazards and the probable severity of the consequences to people, property, or infrastructure that may result from the combined effect of the proposed and related projects, in the same manner as described above for Project Impacts.

Sample Mitigation Measures

Potential mitigation measures include the following:

- Establish an erosion control plan prior to construction;
- Revegetate cleared areas as soon as feasible after grading or construction with temporary seeding, permanent seeding, mulching, and stabilization, vegetative buffer strips, protection of trees, or other soil stabilization practices;
- Reduce sedimentation by using detention basins, straw bale dikes, silt fences, earth dikes, brush barriers, velocity dissipation devices, drainage swales, check dams, subsurface drains, pipe slope drains, level spreaders, storm drain inlet protection, rock outlet protection, sediment traps, temporary sediment basins, or other controls; and
- Incorporate permeable paving materials that permit water penetration.

3. DATA, RESOURCES, AND REFERENCES

Department of Building and Safety, 201 North Figueroa Street, 3rd Floor, Construction Services Center, Los Angeles, California 90012; Telephone: (888) 524-2845. Technical requirements for grading activities and grading plan submittals are contained in the Los Angeles Building Code, and are outlined in form B-164 of the Department of Building and Safety.

Environmental and Public Facilities Maps (1996) Landslide Inventory and Hillside Areas illustrates the approximate locations of hillside areas, areas of known or probable bedrock landslides, and areas of surficial landslides larger than five acres.

General Permit No. CA 5000002 - WDR for Stormwater Runoff Associated with Construction Activities (Requirements of the NPDES).

Navigate LA available online at: <http://navagate.la.lacity.org>.

Zone Information & Map Access System, (ZIMAS) available online at: <http://zimas.lacity.org>

See also E.1. GEOLOGIC HAZARDS.

E.3. LANDFORM ALTERATION

1. INITIAL STUDY SCREENING PROCESS

A. Initial Study Checklist Question

- I.b): Would the project substantially damage scenic resources, including, but not limited to, trees, rock outcroppings, and historic buildings within a state scenic highway?
- V.c): Would the project directly or indirectly destroy a unique paleontological resource or site or unique geologic feature?

B. Introduction

This section addresses the potential effects of a project on distinct and prominent geologic or physical features, such as hilltops, ridges, hillslopes, canyons, ravines, rock outcrops, water bodies, streambeds and wetlands. While some of the environmental impacts surrounding these resources are evaluated in other sections of this document (such as A.1. AESTHETICS), this section directly addresses the alteration of these landforms, which primarily occurs through grading and other earth moving activities. These activities may alter landforms in various ways, including lowering ridgelines, covering wetlands, filling canyons, or removing rock outcrops.

All grading in Los Angeles is regulated by the Los Angeles Building Code (Sections 91.7000 through 91.7016, of the Los Angeles Municipal Code (LAMC)), which includes requirements for excavations, fills, and the planting and irrigation of graded slopes. Grading may also be regulated by policies, which apply to specific geographic areas, such as those, which may be imposed by a specific plan, a local coastal program or the California Coastal Act, the Community Plan, or the General Plan and its elements.

Examples of specific policies that support the protection of distinct and prominent landforms include:

- Sections 30251 and 30253 of the California Coastal Act which require that activities within the coastal zone (generally includes land and water 1000 yards inland of the mean high tide line) minimize alteration of natural landforms and do not create or contribute to erosion, geologic instability, etc., in coastal areas;

- Several Community Plans encourage "cluster type" development in hillside areas in order to minimize the amount of grading and alteration of the natural landform; and
- The Mulholland Scenic Parkway Specific Plan includes policies, which regulate grading activities within the specific plan area. These policies are intended to minimize grading, preserve significant ridgelines, and minimize alteration of the natural landform characteristics of the Santa Monica Mountains through the use of grading standards set forth in the City Planning Department's Landform Grading Manual.

C. Screening Criteria

- Does the project site contain any distinct and prominent geologic or physical features that may be physically altered by project implementation?

A "yes" response to the preceding question indicates further study in an expanded Initial Study, Negative Declaration, Mitigated Negative Declaration or EIR may be required. Refer to the Significance Threshold for Landform Alteration, and review the associated Methodology to Determine Significance, as appropriate.

A "no" response to the preceding question indicates that there would normally be no significant impact on Landform Alteration from the proposed project.

D. Evaluation of Screening Criteria

Review the description of the proposed project, proposed grading plans and proposed project operations. Identify any distinct and prominent resources on the project site, which may include, but are not limited to, hilltops, ridgelines, hillslopes, canyons, ravines, rock outcrops, water bodies, streambeds, and wetlands. Determine whether the project activities could physically alter the identified landform(s) through, for example: lowering ridgelines; reducing wetlands or streambeds; filling canyons; or removing rock outcrops. Compare this information to the Screening Criteria.

2. DETERMINATION OF SIGNIFICANCE

A. Significance Threshold

A project would normally have a significant impact on landform alteration if one or more distinct and prominent geologic or topographic features would be destroyed, permanently covered or

materially and adversely modified. Such features may include, but are not limited to, hilltops, ridges, hillslopes, canyons, ravines, rock outcrops, water bodies, streambeds and wetlands.

B. Methodology to Determine Significance

Environmental Setting

In a description of the environmental setting, include the following information:

- Describe the existing slopes and topography of the site and surrounding areas, including any distinct or prominent geologic or physical features. Include a map, as appropriate;
- Identify any specific grading or landform alteration policies that apply to the project site as imposed by any specific plan, local coastal program or the California Coastal Act, the Community Plan, the General Plan and its elements, the Hillside Ordinance or other portions of the LAMC; and
- Describe any drainage and diversion structures, retaining walls, cribbing and other surface protection devices existing on the site or immediately adjacent.

Project Impacts

Review the grading and construction plans to identify which distinct and prominent geologic or physical features on the project site would be impacted by project construction or operation. Determine what type of impact the project would have on the resource(s), such as major changes to existing slopes or ridgelines, the filling of canyons, removal or destruction of rock outcrops, covering of wetland areas, etc. Determine whether these changes would destroy an existing prominent resource and/or whether other project activities would result in adverse modifications. Note how long modifications would last and whether the resource would be restored.

The project-grading plan may be used to determine grading amounts and other earth moving activities that may impact a landform. Identify the location and quantities of cut and fill areas, height of cut and/or fill slopes, steepness and stability of proposed slopes and structures, details and location of proposed drainage devices, and, if it would impact an identified landform, the location of disposal sites for excess materials.

Cumulative Impacts

Review the list of related projects. Identify those with distinct and prominent geologic or physical features that would be altered. Assess the impact on these features from implementation of the related projects in the manner described above in Project Impacts. Identify cumulative impacts that would occur and determine their significance. Consider multiple impacts on a single feature or the combined impact on a group of like features.

Sample Mitigation Measures

Potential mitigation measures include the following:

- the modification of grading or excavation plans to avoid a distinct landform; and
- a reduction in amount of grading to conform to natural contours.

3. DATA, RESOURCES, AND REFERENCES

Specific plans, Coastal Act, especially policies 30251 and 30253, for projects within the coastal zone, and various specific plans, which include hillside areas, such as the Mulholland Scenic Parkway Specific Plan. Available from the City Planning Department's Central Publications Unit (see address and telephone below).

Landform Grading Manual, available from the City Planning Department's Central Publications Unit at 200 N. Spring St. 5th Floor, Los Angeles, California 90012; Telephone: (213) 978-1255.

See also E.1. GEOLOGIC HAZARDS and E.2. SEDIMENTATION AND EROSION.

E.4. MINERAL RESOURCES

1. INITIAL STUDY SCREENING PROCESS

A. Initial Study Checklist Questions

- X.a): Would the project result in the loss of availability of a known mineral resource that would be of future value to the region and the residents of the state?
- X.b): Would the project result in the loss of availability of a locally-important mineral resource recovery site delineated on a local general plan, specific plan or other land use plan?

B. Introduction

Underlying the City of Los Angeles are finite deposits of non-renewable mineral resources, including petroleum and natural gas, limestone, and aggregate (e.g., rock, sand, and gravel). Development that includes placement of structures over resource areas or blocks access to a resource area results in the loss of availability of resources. Impacts are related to the characteristics of the resource and the degree of loss.

Federal, State and City agencies regulate or have documented the presence of mineral resources. The State Geologist, California Division of Mines and Geology (CDMG), and State Mining and Geology Board (SMGB) provide assistance and direction with regard to mineral resources. The SMGB uses a classification system that divides land into four Mineral Resource Zones (MRZ) based on quantity and significance of mineral resources. (See Exhibit E.4-1) Projects located within the MRZ-2 designation are subject to City policies established in Section VII, Mineral Resources, of the Conservation Element. The Bureau of Land Management (BLM) and the United States Forest Service (USFS) issue permits for mining activity on federal lands.

C. Screening Criteria

- Is the project located within, or would it block access to, a MRZ-2, or other known or potential mineral resource area (based upon designation on official maps and databases such as those identified below)?

A "yes" response to the preceding question indicates further study in an expanded Initial Study, Negative Declaration, Mitigated Negative Declaration, or EIR may be required. Refer to the Significance Threshold for Mineral Resources, and review the associated Methodology to Determine Significance, as appropriate.

A "no" response to the preceding question indicates that there would normally be no significant impact on Mineral Resources from the proposed project.

D. Evaluation of Screening Criteria

Review the description of the proposed project, project site, and surrounding area. To determine if the project is located in, or could block access to, a mineral resource area, consult the following maps:

- Environmental and Public Facilities Maps, including:
 - Areas Containing Significant Mineral Deposits; and
 - Oil Field and Oil Drilling Areas.

In addition, use field research, published reports, or other appropriate studies, as available, to assess whether the project is located in a MRZ-2 or other important mineral resource area. Consult with the CDMG as needed.

Compare this information to the Screening Criteria.

2. DETERMINATION OF SIGNIFICANCE

A. Significance Threshold

The determination of significance shall be made on a case-by-case basis, considering the following factors:

- Whether, or the degree to which, the project might result in the permanent loss of, or loss of access to, a mineral resource that is located in a MRZ-2 or other known or potential mineral resource area; and
- Whether the mineral resource is of regional or statewide significance, or is noted in the Conservation Element as being of local importance.

B. Methodology to Determine Significance

Environmental Setting

In a description of the environmental setting, include the following information:

- Description of the project site and surrounding area;
- Discussion of the mineral resource on the site, as well as within a regional and statewide context; and
- Summary of the requirements and/or policies for mineral resources that apply to the project site.

Project Impacts

Using the information from the Evaluation of Screening Criteria and the description of the proposed project, assess whether implementation of the project would result in a loss of, or loss of access to, the identified mineral resource. Determine whether alternative means of accessing the mineral resource exist and whether the loss of access would be permanent or temporary. Also, consider the importance of the mineral on a state, regional and local level, in terms of economic value, remaining supply, and feasibility of recovering the resource.

Cumulative Impacts

Review the description of the related projects. Identify those with activities and operations, which are within, or would block access to, a MRZ-2 or other important mineral resource area. Assess whether the related projects would result in the cumulative loss of, or loss of access to the mineral resource(s). Consider the importance of the resource and then consider the impact from the combined effect of the proposed and related projects, in the same manner as described above for Project Impacts.

Sample Mitigation Measures

Potential mitigation measures include the following:

- Design the project so that no or only nonpermanent structures are atop or blocking the mineral resource area; and
- Establish easements to preserve possible future use of the mineral resource.

3. DATA, RESOURCES, AND REFERENCES

CDMG, Southern California Regional Office located at 655 S. Hope St., #700, Los Angeles, California 90017-3231; Telephone: (213) 239-0878. CDMG prepares a Mineral Land Classification Report for the City of Los Angeles area. The criteria used in the classification reports are established by the SMGB and are contained in California Surface Mining and Reclamation Policies and Procedures, Special Publication 51, 1983.

City Planning Department, Environmental and Public Facilities Maps (1996):

- Areas Containing Significant Mineral Deposits illustrates the approximate locations of MRZ-2 areas within the City of Los Angeles; and
- Oil Field and Oil Drilling Areas shows areas known to have supported at least six months of oil production.

Conservation Element of the General Plan, available from the City Planning Department's Central Publications Unit at 200 N. Spring St. 5th Floor, Los Angeles, California 90012; Telephone: (213) 978-1255, Online at: <http://www.lacity.org/PLN/>.

Selected Legislation

State

Surface Mining and Reclamation Act of 1975

PRC Section 2711 declares that the extraction of minerals is essential to the continued economic well-being of the state and to the needs of the society, and that the reclamation of mined lands is necessary to prevent or minimize adverse effects on the environment and to protect the public health and safety.

Exhibit E.4-1
STATE MINING AND GEOLOGY BOARD (SMGB)
MINERAL RESOURCE ZONE (MRZ) CLASSIFICATIONS

The SMGB classification system divides land into four MRZs, reflecting varying degrees of significance. These categories are as follows:

- **MRZ-1:** Areas where available geologic information indicates there is little likelihood for the presence of significant mineral resources;
- **MRZ-2a:** Areas underlain by mineral deposits where geologic data indicate that significant measured or indicated resources are present, as determined by such evidence as drilling records, sample analysis, surface exposure, and mine information;
- **MRZ-2b:** Areas underlain by mineral deposits where geologic information indicates that significant inferred resources are present, as determined by limited data;
- **MRZ-3a:** Areas containing known mineral occurrences of undetermined mineral resource significance;
- **MRZ-3b:** Areas containing inferred mineral occurrences of undetermined mineral resource significance. Land classified MRZ-3b represents areas in geologic settings that appear to be favorable environments for the occurrence of specific types of mineral deposits; and
- **MRZ-4:** Areas of no known mineral occurrences where geologic information does not rule out either the presence or absence of significant mineral resources.

F. HAZARDS

F.1. RISK OF UPSET/EMERGENCY PREPAREDNESS

1. INITIAL STUDY SCREENING PROCESS

A. Initial Study Checklist Questions

- VII.a): Would the project create a significant hazard to the public or the environment through the routine transport, use, or disposal of hazardous materials?
- VII.b): Would the project create a significant hazard to the public or the environment through reasonably foreseeable upset and accident conditions involving the release of hazardous chemicals into the environment?
- VII.e): For a project located within an airport land use plan or, where such a plan has not been adopted, within two miles of a public airport or public use airport, would the project create a safety hazard for people residing or working in the project area?
- VII.f): For a project within the vicinity of a private airstrip, would the project result in a safety hazard for people residing or working in the project area?
- VII.g): Would the project impair implementation of or physically interfere with an adopted emergency response plan or emergency evacuation plan?

B. Introduction

Hazardous materials generally are chemicals, which have the capability of causing harm during an accidental release or mishap, and are characterized as being toxic, corrosive, flammable, reactive, an irritant or strong sensitizer. The term "hazardous substances" encompasses every chemical regulated by both the United States Department of Transportation's (DOT) "hazardous materials" regulations and the Environmental Protection Agency's (EPA) "hazardous waste" regulations, including emergency response. Hazardous wastes require special handling and disposal because of their potential to damage public health and the environment.

Activities and operations that use or manage hazardous or potentially hazardous or explosive substances could create a hazardous situation if an accidental explosion or release of these substances occurred. Individual circumstances, including the type of substance, quantity used or managed, and the nature of the activities and operations, affect the probable frequency and severity of consequences from a hazardous situation. Federal, state, and local laws regulate the use and management of hazardous or potentially hazardous or explosive substances. For example, the Clean Air Act Amendments (CAAA) of 1990 require facilities that exceed federal threshold levels of listed substances to prepare Risk Management Plans. State threshold levels have also been established.

Emergency response plans and emergency evacuation plans specify appropriate actions to be undertaken with regard to emergency situations such as warning systems, evacuation plans/procedures, and emergency action plans. These plans are required by state environmental and occupational health laws and regulations for businesses that use specified hazardous or extremely hazardous materials or involve a potential threatened release of acutely hazardous materials above certain threshold limits. Projects may require new or revised plans due to the construction or expansion of operations.¹

Creation of human health hazards or exposure of people to existing sources of potential health hazards, including asbestos, is addressed in F.2. HUMAN HEALTH HAZARDS. According to the federal Occupational Safety and Health Administration (OSHA), hazardous chemicals are chemicals that would be a risk to employees if there is exposure in the workplace. They are listed and regulated through OSHA and the California Occupational Safety and Health Administration (CalOSHA).

Toxic air emissions are addressed in B.3. TOXIC AIR CONTAMINANTS.

C. Screening Criteria

- Would the project use or manage hazardous or potentially hazardous or explosive substances (including, but not limited to, oil, pesticides, chemicals, or radiation)?
- Would the project require a new or revised risk management plan, emergency response, or emergency evacuation plan?

A "yes" response to any of the preceding questions indicates further study in an expanded Initial Study, Negative Declaration, Mitigated Negative Declaration, or EIR may be required. Refer to the Significance Threshold for Risk of Upset/Emergency Preparedness, and review the associated Methodology to Determine Significance, as appropriate.

A "no" response to all of the preceding questions indicates that there would normally be no significant impact on Risk of Upset/Emergency Preparedness from the proposed project.

D. Evaluation of Screening Criteria

Review the description of the proposed project. Determine whether operation or construction would involve the use, generation, disposal, transport, or management of potentially hazardous or explosive substances (including, but not limited to, oil, pesticides, chemicals, or radiation) in

¹ *Risks due to earthquake-related hazards are addressed in E.1. GEOLOGIC HAZARDS.*

sufficient quantities to cause a potential hazard. Emergency response and evacuation plans are required for businesses that use hazardous materials or involve a potential threatened release of acutely hazardous materials during operation or construction. Compare this information to the Screening Criteria.

2. DETERMINATION OF SIGNIFICANCE

A. Significance Threshold

The determination of significance shall be made on a case-by-case basis, considering the following factors:

- The regulatory framework;
- The probable frequency and severity of consequences to people or property as a result of a potential accidental release or explosion of a hazardous substance;
- The degree to which the project may require a new, or interfere with an existing, emergency response or evacuation plan, and the severity of the consequences; and
- The degree to which project design will reduce the frequency or severity of a potential accidental release or explosion of a hazardous substance.

B. Methodology to Determine Significance

Environmental Setting

In a description of the environmental setting, include the following information:

- Description of the project site, including any on-site activities or structures;
- Physical description of land uses and activities in the surrounding area and along appropriate transportation routes (generally, from the project site to the nearest designated truck route), including distance to sensitive receptors, such as schools, hospitals, or residential uses;
- Description of emergency response or evacuation plan(s) affecting the project and/or the surrounding area; and
- Summary of the regulatory framework.

Project Impacts

Review the description of the proposed project. Identify the activities and operations which would involve the use, generation, disposal, transport, or management of potentially hazardous or explosive substances (including, but not limited to, oil, pesticides, chemicals, or radiation) in sufficient quantities to cause a potential hazard. Estimate the probable frequency of a potential accidental release or explosion of a hazardous substance and the probable severity of the consequences to people or property that would result. Elements of individual projects, such as the type of substance, the quantity used or managed, and the nature of the activities and operations, affect the risk of accidental explosion or release of hazardous substances. Identify and evaluate project features or components that would reduce the risk associated with use or management of hazardous, potentially hazardous, or explosive substances. Consider the regulatory framework and determine the resulting risk.

Review applicable emergency response or evacuation plans. Determine the impact of the project on implementation of the plan(s) and whether the project would require new or expanded plans to be written, because of project activities or location.

Cumulative Impacts

Review the description of the related projects. Identify those with activities and operations which would involve the use, generation, disposal, transport, or management of potentially hazardous or explosive substances (including, but not limited to, oil, pesticides, chemicals, or radiation). Determine the combined impact from the related and proposed projects, in the same manner as described above for Project Impacts. Determine the cumulative impact on the implementation and adequacy of emergency response or evacuation plans due to increases in the amount of hazardous materials used or the location of the projects.

Sample Mitigation Measures

Potential mitigation measures include the following:

- Use non-toxic or less toxic substances in project construction or operation;
- Investigate opportunities and implement programs to reduce the amount of waste chemicals generated; and
- Redesign operations and or use alternate transportation routes.

3. DATA, RESOURCES, AND REFERENCES

Los Angeles Fire Department (LAFD), Bureau of Fire Prevention and Public Safety; 200 N. Main St., Room 1000, Los Angeles, CA. 90012; Telephone: Research Unit (213) 485-6021.

Los Angeles County Fire Department, Hazardous Materials Division; Telephone: (213) 890-4045.

CalOSHA Consultation Service; 10350 Heritage Park Dr., Suite 201, Santa Fe Springs, CA 90670. Telephone: (562) 944-9366, or Consultation Toll Free at (888) 963-9424.

Hazardous materials are defined and listed in various federal and state laws and regulations. These include, but are not limited to, 40 CFR 302 (hazardous substances), 40 CFR 261 (hazardous waste), 49 CFR 172.101 and appendices (hazardous materials), 22 CCR, Section 66261 (hazardous waste), 20 HSC, Chapter 6.5 (hazardous waste).

Requirements for emergency response plans, emergency evacuation plans, and emergency action plans can be found in numerous state and federal laws and regulations. A partial list includes, but is not limited to, the following: 29 CFR 1910.120; Title 8, CCR Sections 3215, 3220 and 5192; Title 22 CCR Section 66265.50-52; and 20 HSC Sections 25504 and 25534.

Risk Management Plans are required under certain conditions by federal and state laws and regulations. The regulations list substances and threshold levels that trigger preparation of Risk Management Plans. Some relevant federal regulations can be found in 40 CFR 68 et seq, which implement Section 112(r)(7) of the CAAA. Some State regulations are listed in Title 22 CCR Section 66261.113, 20 HSC Section 25531 et seq., Title 8 Section 5189, and Title 19 Sections 2510 and 2620 to 2732.

Work place operations and exposure are included in laws and regulations of OSHA and CalOSHA. See, for example, 29 CFR 1910 and Title 8, CCR, Section 5192(a)(3)(A) through (D) and Section 5155.

F.2. HUMAN HEALTH HAZARDS

1. INITIAL STUDY SCREENING PROCESS

A. Initial Study Checklist Questions

- VII.a): Would the project create a significant hazard to the public or the environment through the routine transport, use, or disposal of hazardous materials?
- VII.b): Would the project create a significant hazard to the public or the environment through reasonably foreseeable upset and accident conditions involving the release of hazardous chemicals into the environment?
- VII.c): Would the project emit hazardous emissions or handle hazardous or acutely hazardous materials, substances, or waste within one-quarter mile of an existing or proposed school?
- VII.d): Would the project be located on a site which is included on a list of hazardous materials sites compiled pursuant to Government Code Section 65962.5 and, as a result, would it create a significant hazard to the public or the environment?

B. Introduction

A variety of activities, operations, and projects can create human health hazards, or expose people to existing sources of potential health hazards. Impacts can result directly from a process or substance (e.g., removal of asbestos containing materials) or indirectly (e.g., transmission of a disease by rodents or insects). Individual circumstances, including the type of hazard and nature of the activities and operations, affect the probable frequency and severity of consequences from the health hazard. Federal, state, and local laws regulate these hazards.

Hazardous materials generally are substances which, by their nature and reactivity, have the capability of causing harm or a health hazard during normal exposure or an accidental release or mishap, and are characterized as being toxic, corrosive, flammable, reactive, an irritant or strong sensitizer. The term “hazardous substances” encompasses chemicals regulated by both the United States Department of Transportation's (DOT) "hazardous materials" regulations and the Environmental Protection Agency's (EPA) "hazardous waste" regulations, including emergency response. Hazardous wastes require special handling and disposal because of their potential to damage public health and the environment. A designation of “acutely” or “extremely” hazardous refers to specific listed chemicals and quantities.

A health hazard may also occur where there is contact with or contamination from asbestos-containing material (ACM), which includes both friable ACM and Class I nonfriable ACM. Friable asbestos is more easily airborne than non-friable asbestos. Actions which may cause ACM to be broken, crumbled, pulverized, or reduced to powder include physical wear and disturbance by mechanical force, such as, but not limited to, sanding, sand blasting, cutting or abrading, improper handling or removal, or leaching of matrix binders. Class I nonfriable ACM includes, but is not limited to, fractured or crushed asbestos cement products, transite materials, mastic, roofing felts, roofing tiles, cement water pipes and resilient floor covering. Friable ACM is material containing more than 1 percent asbestos that, when dry, can be crumbled, pulverized, or reduced to powder by hand pressure. California Occupational Safety and Health Administration (CalOSHA) defines asbestos-containing construction material as material which contains more than 1/10 of 1 percent asbestos by weight.

Risk of accidental explosion or release of hazardous substances and interference with an emergency response or evacuation plan is addressed in F.1. RISK OF UPSET/EMERGENCY PREPAREDNESS. According to the Occupational Safety and Health Administration (OSHA), hazardous chemicals are chemicals that would be a risk to employees if there were exposure above specified limits in the workplace. They are listed and regulated through OSHA and CalOSHA.

C. Screening Criteria

- Would the project create a health hazard, such as by introducing or directly modifying any of the following (or similar) facilities/activities:
 - Pipeline for hazardous or potentially hazardous or explosive substance which is:
 - More than eight miles in length; or
 - Less than eight miles in length with more than one-half mile subject to activity at any time;
 - Subterranean storage field or above ground tanks;
 - Solid waste facility;
 - Waste water treatment plant;
 - Major utility transmission or distribution facility;

- Land use or activity with recognized vector (e.g., rodents, insects, etc.) management problems; or
- Facility that uses or manages hazardous substances in sufficient quantities to cause a potential hazard?
- Would the project locate people adjacent to a health hazard, such as any of the above uses?
- Would the project create a health hazard through activities that involve the disturbance, removal, storage, or disposal of ACM or lead paints?

A "yes" response to any of the preceding questions indicates further study in an expanded Initial Study, Negative Declaration, Mitigated Negative Declaration, or EIR may be required. Refer to the Significance Threshold for Human Health Hazards, and review the associated Methodology to Determine Significance, as appropriate.

A "no" response to all of the preceding questions indicates that there would normally be no significant impact on Human Health Hazards from the proposed project.

D. Evaluation of Screening Criteria

Review the description of the proposed project, project site, and surrounding area. Determine whether any of the uses or activities listed would be part of the project or adjacent to the project site. Health hazards may be created by increasing the frequency or severity of consequences from human exposure to hazardous materials or conditions. Vector management issues may include conditions or activities that attract rodents, insects, or other vectors. Compare this information to the Screening Criteria.

2. DETERMINATION OF SIGNIFICANCE

A. Significance Threshold

The determination of significance shall be made on a case-by-case basis, considering the following factors:

- The regulatory framework for the health hazard;
- The probable frequency and severity of consequences to people from exposure to the health hazard; and

- The degree to which project design would reduce the frequency of exposure or severity of consequences of exposure to the health hazard.

B. Methodology to Determine Significance

Environmental Setting

In a description of the environmental setting, include the following information:

- Description of the project site and surrounding area, identifying potential health hazards and sensitive receptors; and
- Summary of applicable health and safety regulations.

Project Impacts

Review the description of the proposed project, project site, and surrounding area. Identify the activities and operations, which could create a health hazard. Specific circumstances, including the type of hazard, distance between the hazard and people, and the nature of the activities and operations, affect the probable frequency and severity of the consequences. Identify and evaluate project features or components that would reduce the human health risk below that typically associated with the proposed land use or activity. Considering this and the regulatory framework, determine the resulting hazard.

Cumulative Impacts

Review the description of the related projects. Identify those with activities or operations, which would create a health hazard, such as by introducing any of the uses or activities listed in the Screening Criteria to locations where people could be impacted. Determine the combined impact from the proposed and related projects, in the same manner as described above for Project Impacts.

Sample Mitigation Measures

Potential mitigation measures include the following:

- Relocate storage of hazardous substances away from site boundaries;
- Develop a community warning plan;

- Provide spill containment measures;
- Develop a health and safety plan;
- Provide barriers that contain hazards (e.g., appropriate buffers between land uses or air curtains of sufficient strength to control insect vectors); and
- Reduce or eliminate conditions that exacerbate the frequency or severity of occurrences (e.g., avoid landscaping, such as ivy, which can provide nesting areas for rodents; prevent ponding of water which can provide breeding areas for mosquitos).

3. DATA, RESOURCES, AND REFERENCES

Los Angeles County Department of Health Services; 313 N. Figueroa St., Los Angeles, CA 90012. Telephone: (213) 240-8144.

South Coast Air Quality Management District (SCAQMD), Rules and Regulations. Regulation X – Subpart M and Rules 470, 1108, 1108.1, 1120, 1403, and 1414. Information regarding a particular rule or regulation may be obtained by calling the SCAQMD at (909) 396-2000 or 1-800-CUT-SMOG.

Federal extremely hazardous substances and planning thresholds are listed in 40 CFR 355, Appendices A and B. State extremely hazardous substances and planning thresholds are referenced in 19 CCR 2729(a). State acutely hazardous materials and threshold quantities are listed in 8 CCR 5189, Appendix A and referenced in 20 HSC 25532.

State extremely hazardous wastes are asterisked in 22 CCR, Div. 4.5, Chapter 11, Appendix X and referred to in 22 CCR 66261.110 and 66261.113.

State and federal acutely hazardous wastes are listed in 22 CCR 66261.33(c) and 40 CFR 261. Subpart D, respectively.

Asbestos-containing construction material is defined in 8 CCR 1529(b), a CalOSHA regulation.

See also F.1. RISK OF UPSET/EMERGENCY PREPAREDNESS.

This page intentionally left blank.

G. WATER RESOURCES

G. WATER RESOURCES

G.1. SURFACE WATER HYDROLOGY

1. INITIAL STUDY SCREENING PROCESS

A. Initial Study Checklist Questions

- VIII.c): Would the project substantially alter the existing drainage pattern of the site or area, including through the alteration of the course of a stream or river, in a manner which would result in substantial erosion or siltation on- or off-site?
- VIII.d): Would the project substantially alter the existing drainage pattern of the site or area, including through the alteration of the course of a stream or river, or substantially increase the rate or amount of surface runoff in a manner which would result in flooding on- or off-site?
- VIII.e): Would the project create or contribute runoff water which would exceed the capacity of existing or planned storm water drainage systems, or provide substantial additional sources of polluted runoff?
- VIII.g): Would the project place housing within a 100-year flood hazard area as mapped on a federal Flood Hazard Boundary or Flood Insurance Rate Map or other flood hazard delineation map?
- VIII.h): Would the project place within a 100-year flood hazard area structures, which would impede or redirect flood flows?
- VIII.i): Would the project expose people or structures to a significant risk of loss, injury or death involving flooding, including flooding as a result of the failure of a levee or dam?
- XVI.b): Would the project result in the construction of new water or wastewater treatment facilities, the construction of which could cause significant environmental effects?
- XVI.c): Would the project require or result in the construction of new storm water drainage facilities or expansion of existing facilities, the construction of which could cause significant environmental effects?

B. Introduction

This section addresses the potential surface water hydrology impacts that may be associated with the implementation of a project, including flood hazard impacts and changes in the amount or movement of surface water. Surface water impacts may occur when a project results in either

increased on- or off-site storm water flows, changes in absorption rates, alterations to existing surface water flow patterns or directions (including the intake and use of water from a surface water body), or other factors which result in a changed rate of flow. Surface waters include lakes, rivers, streams, reservoirs, the ocean, and similar water bodies. Flood hazard is defined as flooding which occurs during a storm event, particularly the 50-year developed storm event.¹ Impacts may also occur when development of a project results in the depletion of natural flood plain values through development of land within a flood plain area, which is accounted for in the 50-year developed storm event. These impacts typically result in an increased potential for flood hazard.

C. Screening Criteria

- Is the project located within a 100-year flood plain, an area designated as hillside (as identified in the Los Angeles Municipal Code (LAMC) Section 91.7001), or other known flood-prone area?
- Would run-off from the project site drain onto an unimproved street or on to adjacent properties other than public right-of-way (ROW)?
- Would project implementation affect a surface water body such that the amount of surface water, current, course or direction of flow would change?
- Would the run-off factor for the developed project site exceed the percentage of imperviousness for the existing land use category, as contained in the Bureau of Engineering Manual, Part G, Storm Drain Design?

A "yes" response to any of the preceding questions indicates further study in an expanded Initial Study, Negative Declaration, Mitigated Negative Declaration, or EIR may be required. Refer to the Significance Threshold for Surface Water Hydrology, and review the associated Methodology to Determine Significance, as appropriate.

¹ *The 50-year developed storm event is the maximum predicted rainfall event used by the City and County of Los Angeles for determining storm water runoff quantities utilized in the design of the local storm drain system. This specification has been incorporated in the Bureau of Engineering Manual Part G, Storm Drain Design. The year refers to a calculated storm magnitude, which would occur with an approximate frequency of every 50 years. "Developed" refers to hydrology calculations, which assume that all land is developed according to its general plan/zoning designation. A "developed condition" permeability factor is assigned to each parcel, even if it is currently vacant, in order to design adequate storm drain facilities for future conditions.*

A "no" response to each of the preceding questions indicates that there would normally be no significant impact on Surface Water Hydrology from the proposed project.

D. Evaluation of Screening Criteria

Identify the location of the proposed project site using the Environmental and Public Facilities Maps (100 Year and 500 Year Flood Plains and Landslide Inventory and Hillside Areas) and/or relevant Federal Emergency Management Agency (FEMA) Flood Insurance Rate Maps (FIRM). In addition, use the United States Geological Survey (USGS) topographic map(s) for the site and any available project or field study information to determine the potential for flooding.

Determine whether changes to the project site would cause run-off to drain on to an unimproved street or on to adjacent properties other than public ROW. Review the proposed activities and geological conditions of the project site and surrounding area to determine the project's potential to affect the existing current, direction of flow, or amount of water in a surface water body, including lakes, rivers, streams, or the ocean. Consult the Department of Public Works Bureau of Engineering, Los Angeles County Flood Control District and the Army Corps of Engineers (ACOE), as necessary.

Review the project plans and identify the percentage of imperviousness for the site, after project completion. Compare to the percentage for the existing zoning classification reproduced in Exhibit G.1-1. See the Bureau of Engineering Storm Drain Manual if assistance is needed.

Compare this information to the Screening Criteria.

2. DETERMINATION OF SIGNIFICANCE

A. Significance Threshold

A proposed project would normally have a significant impact on surface water hydrology if it would:

- Cause flooding during the projected 50-year developed storm event, which would have the potential to harm people or damage property or sensitive biological resources;
- Substantially reduce or increase the amount of surface water in a water body; or

- Result in a permanent, adverse change to the movement of surface water sufficient to produce a substantial change in the current or direction of water flow.

B. Methodology to Determine Significance

Environmental Setting

Describe the project site, including the topography, soil types, location and size of impermeable surfaces (buildings, paving, hardscape, parking lots), location within a flood plain, and the size and location of drainage facilities. Note the existing direction of flow of surface water runoff from the site. Identify storm drains and surface water bodies to which the runoff drains directly or eventually.

Project Impacts

Determine whether the project would result in a change in water flows during a projected 50-year developed storm event that would flood the site or off-site properties, upstream or downstream and cause harm to people or damage to property or sensitive biological resources (see C. BIOLOGICAL RESOURCES for a definition of sensitive biological resources). Consider topography, soil types, location and size of impermeable surfaces, the size and location of drainage facilities, and flood control facilities. Mechanisms of flood control include, but are not limited to: dams, flood control basins, levees, channelization, pumping stations, upstream retention, diversion of run-off, and spreading grounds. Also, consider the nature of the land uses involved when determining the likelihood of harm or damage. (The City has designated certain land uses as appropriate to locate within a defined flood plain.)

Determine whether the project would result in an increase or decrease of water in a surface water body during project construction or operation, and whether project-related changes in the current or direction of flow of water would be permanent and adverse. Consult with the Bureau of Engineering, the Los Angeles County Flood Control District, or the ACOE, as appropriate.

Cumulative Impacts

Identify the related projects that could affect the same surface water body or flood plain as the proposed project. Using the methodology identified in Project Impacts, determine the combined effect of the proposed and related projects. Consult with the Bureau of Engineering and other flood control agencies, as appropriate.

Sample Mitigation Measures

Potential mitigation measures include the following:

- Construct new or improved existing storm water management facilities to reduce or retard the amount of peak runoff from the project site. Such measures may include the construction of detention basins or other structures that will slow down or delay the peak flow of storm water runoff from the site;
- Redesign the project such that structures and other important facilities that would be adversely affected by flooding are no longer located within flood hazard areas or so that the floodway open space is preserved;
- Raise the building pad or ground floor of proposed structures to an elevation above flood prone areas; and
- Reduce impervious surfaces and materials. Maximize landscaped and natural areas.

3. DATA, RESOURCES, AND REFERENCES

Bureau of Engineering Public Counters. Construction Services Center, 4th Floor, 201 North Figueroa Street, Los Angeles, California 90012; Telephone: (213) 977-6032. Valley District, Van Nuys Municipal Building, 14410 Sylvan Street, 2nd Floor, Van Nuys, California 91401; Telephone: (818) 756-8421. Harbor District, San Pedro Municipal Building, 638 South Beacon Street, Room 400, San Pedro, California 90731; Telephone: (310) 732-4677. West Los Angeles District, 1828 Sawtelle Boulevard, 3rd Floor, Los Angeles, CA 90025-5516; Telephone: (310) 575-8384.

Bureau of Engineering, Structural and Technical Engineering, 650 South Spring Street, Room 400, Los Angeles, California 90014-1913; Telephone: (213) 847-4010.

Department of Building and Safety, Construction Services Center, 201N. Figueroa St., 4th Floor, Los Angeles, California 90012; Telephone: (213) 847-8774.

Los Angeles County Flood Control District, 900 South Fremont, Alhambra, California 91803; Telephone: (626) 458-5100.

ACOE, 911 Wilshire Boulevard, #1525, Los Angeles, California 90017; Telephone: (213) 452-3908.

Bureau of Engineering Manual, Part G, Storm Drain Design.

Flood Insurance Rate Maps (FIRMs) (10 CFR Section 1022.11, 43 CFR Section 64.3). FIRMs are prepared by the Federal Insurance Administration of the Department of Housing and Urban Development (HUD) after a risk study for a community has been completed and the risk premium rates have been established. The maps indicate the risk premium zones applicable in the community and when those rates are effective. They are used in making flood plain determinations and to determine if a proposed action is located in the base or critical action flood plain, as appropriate.

USGS topographic maps.

City Planning Department, Environmental and Public Facilities Maps (1996):

- 100 Year and 500 Year Flood Plains; and
- Landslide Inventory and Hillside Areas.

Exhibit G.1-1
DEVELOPMENT CLASSIFICATIONS
(Typical Percentage of Imperviousness, by Zone)

| Zoning Classification | Type of Development | I_d |
|---|---|----------------------|
| | Park (lawn areas only)..... | 15 |
| | Undeveloped Hillside or Mountainous Areas ^a | 35 |
| A1, A2, RA | Agricultural and One-Family Dwelling..... | 35 |
| RE11, RE15, RE20, RE40 | One-Family Dwelling - Level Area..... | 35 |
| | - Hillside Area..... | 50 |
| R1, RD1.5, RD2 | One-Family Dwelling - Large Hillside Lot..... | 50 |
| RS, R1, RE9 | One-Family Dwelling - Level Area..... | 40 |
| | - Hillside Area..... | 70 |
| R2, RW1, RW2, RD3, RD4, RD5, RD6 | Multiple Dwelling..... | 60 |
| R3 | Multiple Dwelling..... | 70 |
| R4, R5, P, PB, CR, C1, C2, C4, C5, CM, MR1, MR2, M1, M2, M3 | Multiple Dwelling, Parking, All Commercial and Manufacturing..... | 100 |
| | Playgrounds, Schools..... | 100 |
| RPD ^b | ¾ of land area with I _d per development above; ¼ of land area with I _d for park | |

Notes:

I_d is the percentage of imperviousness of a sub-area.

^a To be used in computing runoff prior to development regardless of zoning classification.

^b Residential Planned Development – Investigate development (in field or from plans) before allocating value of I_d

Source: Bureau of Engineering Manual Part G, Storm Drain Design.

G.2. SURFACE WATER QUALITY

1. INITIAL STUDY SCREENING PROCESS

A. Initial Study Checklist Question

- VIII.a): Violate any water quality standards or waste discharge requirements?
- VIII.b): Substantially deplete groundwater supplies or interfere substantially with ground water recharge such that there would be a net deficit in aquifer volume of a lowering of the local groundwater table level (e.g., the production rate of pre-existing nearby wells would drop to a level which would not support existing land uses or planned uses for which permits have been granted)?
- VIII.C): substantially alter the existing drainage pattern of the site or area, including through the alteration of the course of a stream or river, in a manner which would result in substantial erosion or siltation on- or off-site?
- VIII.g): Place housing within a 100-year flood hazard area as mapped on a federal flood hazard Boundary or flood Insurance Rate Map or other flood hazard delineation map?

B. Introduction

Water quality may be impacted by pollutants discharged directly into receiving waters. Industrial flows discharged from manufacturing, cleaning, or cooling operations, and activities such as dewatering of groundwater encountered during construction can usually be directed to an outfall or pipe and are therefore categorized as “point sources.”

Water quality may also be affected by pollutants found in surface water runoff originating from a wide range of dispersed sources, or “nonpoint sources.” In rural settings, such as agricultural or forestland, this runoff is treated as non-point sources. In urban settings, this runoff is typically guided into a “storm drain system” and ultimately discharged to the receiving waters at a specific location(s). Hence, these storm drain system discharges are treated as point sources. Stormwater runoff is part of the natural hydrologic cycle. Drainage patterns and pollutant concentrations are frequently altered through processes such as urbanization and agriculture. Recent studies have indicated that stormwater runoff is a significant source of water pollution, which may result in declines in fisheries and other aquatic life, restrictions on recreational activities, and general

impairment of the existing and potential beneficial uses of receiving waters. "Stormwater runoff" encompasses "urban runoff," which includes the discharge of pollutants to water bodies from such non-storm (or "dry weather") related activities as irrigation, hosing sidewalks, draining swimming pools, and washing cars. Dry weather flows also include illegal discharges to the storm drain system, such as unauthorized connections, leaks, or spills.

Regulatory Framework

In 1948, Congress enacted the Water Pollution Control Act, which has since been amended significantly on several occasions, and is now commonly referred to as the Clean Water Act (CWA). The CWA delineates a national permitting system for point discharges known as the National Pollutant Discharge Elimination System (NPDES). NPDES is the basic regulatory and enforcement tool available under the CWA. NPDES permits typically incorporate specific discharge limitations for point source discharges to ensure that dischargers meet permit conditions and protect state-defined water quality standards. California is authorized to administer key components of the federal water quality management program in the state.

The existing NPDES framework was expanded in 1987 to regulate stormwater runoff (discharges) originating from municipal and industrial sources. The Los Angeles Regional Water Quality Control Board (LARWQCB) is authorized to implement a municipal stormwater-permitting program as part of its general NPDES authority, as an agent of the State Water Resources Control Board (State Board). Municipal permits typically require permittees to develop an areawide stormwater management plan, implement best management practices (BMPs) and perform stormwater monitoring. The City of Los Angeles is a co-permittee under the County of Los Angeles municipal permit.

In general, environmental impacts to surface water quality are assessed in relation to the existing characteristics of the body of water that would receive the discharge (receiving water body), including its size, flows, designated beneficial uses, and present concentrations of pollutants. Increased concentrations of toxic metals, organic compounds, suspended solids, nutrients, pathogenic microorganisms and other pollutants, or changes in temperature may result in sedimentation, eutrophication, habitat degradation, and/or threats to public health.

For point source discharges from proposed projects, the nature of the discharge is directly related to the process that produces the discharge. Nonpoint source impacts to receiving waters during project operation are related to such factors as land use type, size, design, and intensity. Construction activities may also result in the discharge of stormwater runoff pollutants, including dissolved solids, to receiving waters. If a project includes point source discharges, the

pollutants associated with the discharges may need to be identified and quantified for an NPDES permit from the LARWQCB.

Major surface water bodies in the City of Los Angeles include: the Los Angeles River, Tujunga Wash, Ballona Channel, Santa Monica Bay, and San Pedro Bay. In addition, the City is served by an extensive network of storm drains which either drain directly to the Santa Monica Bay, San Pedro Bay, or to waterways that ultimately drain to Santa Monica or San Pedro Bays.

C. Screening Criteria

Would the proposed project:

- Involve or allow an activity or process that would result in a point source discharge to a receiving water body?
- Create conditions, which may result in soil erosion, sediment runoff or nonpoint sources of contamination?

A "yes" response to any of the preceding questions indicates further study in an expanded Initial Study, Negative Declaration, Mitigated Negative Declaration or EIR may be required. Refer to the Significance Threshold for Surface Water Quality, and review the associated Methodology to Determine Significance, as appropriate.

A "no" response to all of the preceding questions indicates that there would normally be no significant impact on Surface Water Quality from the proposed project.

D. Evaluation of Screening Criteria

Review the description of the proposed project, project site, and surrounding area. Consider the location, size and slope of the site and the type, size, and intensity of land use(s) proposed. A receiving water body may include rivers, lakes, reservoirs, the ocean and others, as appropriate. Evaluate activities such as manufacturing, processing, cleaning, grading, cooling, dredging, dewatering of groundwater (during construction or operation), auto-related uses (e.g., parking¹, auto

¹ *The City of Los Angeles CEQA Guidelines include a categorical exemption for surface parking lots of up to 110 spaces (equivalent to 35,310 square feet).*

repair), storage of raw materials and/or finished products, use or storage of solid waste or hazardous/toxic materials, agriculture, waste water treatment operations, and landfills. Compare this information to the Screening Criteria.

2. DETERMINATION OF SIGNIFICANCE

A. Significance Threshold

A project would normally have a significant impact on surface water quality if discharges associated with the project would create pollution, contamination or nuisance as defined in Section 13050 of the California Water Code (CWC) (see definitions below) or that cause regulatory standards to be violated, as defined in the applicable NPDES stormwater permit or Water Quality Control Plan for the receiving water body.

B. Methodology to Determine Significance

Environmental Setting

In a description of the environmental setting, include a general description of the project site and adjacent areas to which runoff currently drains directly or eventually. Describe the locations of on- or off-site water bodies and existing drainage outlets (i.e., storm drains). Address the existing water quality of water bodies to which the site drains and applicable adopted water quality objectives or standards. Water quality is increasingly being addressed through watershed programs. Within the next few years TMDLs (Total Maximum Daily Loads) will be developed for local watersheds, and the impact of projects on the TMDL allocations will need to be evaluated.

Project Impacts

The CWC includes the following definitions:

“Pollution” means an alteration of the quality of the waters of the state to a degree which unreasonably affects either of the following: 1) the waters for beneficial uses or 2) facilities which serve these beneficial uses. “Pollution” may include “Contamination.”

“Contamination” means an impairment of the quality of the waters of the state by waste to a degree, which creates a hazard to the public health through poisoning or through the spread of

disease. “Contamination” includes any equivalent effect resulting from the disposal of waste, whether or not waters of the state are affected.

“**Nuisance**” means anything which meets all of the following requirements: 1) is injurious to health, or is indecent or offensive to the senses, or an obstruction to the free use of property, so as to interfere with the comfortable enjoyment of life or property; 2) affects at the same time an entire community or neighborhood, or any considerable number of persons, although the extent of the annoyance or damage inflicted upon individuals may be unequal; and 3) occurs during, or as a result of, the treatment or disposal of wastes.

Review the description of the proposed project, project site and surrounding area. Determine the nature, quantity, duration, and affect of project discharges. Describe any proposed treatment of the discharge. Assess the impact on the receiving water body relative to existing conditions and any applicable water quality objectives or standards. Consider factors such as the size of the site as a percentage of the entire watershed and the predominant land uses in the watershed. The percentage of imperviousness factors reproduced in Exhibit G.1-1² may be used to evaluate the relative amount of runoff from various land use types. Consult with the Bureau of Engineering, the Los Angeles County Flood Control District, the LARWQCB, the Environmental Protection Agency (EPA), or the Army Corps of Engineers (ACOE), as appropriate. A professional consultant may be required.

Cumulative Impacts

Review the description of the related projects. Identify those that are in the same watershed or that drain to the same water body as the proposed project. Evaluate the combined impact on the receiving water body of related project discharges in combination with the proposed project discharge as described for project impacts.

Sample Mitigation Measures

Potential mitigation measures include the following:

- Establish an erosion control plan prior to construction. Include such measures as:

² *Exhibit G.1-1, Development Classifications, is found in G.1. SURFACE WATER HYDROLOGY.*

- Use of natural drainage, detention ponds, sediment ponds, or infiltration pits to allow runoff to collect and seep into the ground at a rate which would reduce or prevent downhill erosion,
- Use of barriers to direct and slow the rate of runoff and to filter out large-sized sediments,
-
- Use of downdrains or chutes to carry runoff from the top of a slope to the bottom, and
- Control the use of water for irrigation so as to avoid off-site runoff;
- Employ permeable paving materials that permit water penetration to a soil depth of 18 inches or more, or provide a coefficient of runoff of 0.6 or less;
- Include properly designed and maintained biological oil and grease removal systems in new storm drain systems to treat water before it leaves the project site;
- Properly store hazardous materials to prevent contact with precipitation or runoff;
- Develop and maintain effective monitoring and cleanup program for spills and leaks of hazardous materials;
- Place equipment to be repaired or maintained in uncovered areas on a pad of absorbent material to contain leaks, spills, or small discharges;
- Provide periodic and consistent removal of landscape and construction debris;
- Sweep parking lots at regular, frequent intervals to remove debris. Remove any significant chemical residue left by vehicles by appropriate methods;
- Use non-toxic alternatives for such applications as insecticides, herbicides, rodenticides, and fertilizers. Apply chemical controls only when precipitation is not forecast for the area;
- Use permeable surfaces (such as grassy swales, green strips near parking areas, or porous pavement) to allow infiltration to reduce the peak flow of runoff and minimize the transport of pollutants to receiving waters;

- Install detention basins to remove suspended solids by settlement. Fit basins with trash racks at the inlets to catch floating solids; and
- Periodically monitor the water quality of runoff before discharge.

3. DATA, RESOURCES, AND REFERENCES

For updated information about City ordinances and permit requirements for surface water runoff, contact the Bureau of Engineering, Stormwater Management Division, at 650 South Spring Street, Suite 700, Los Angeles, California 90014; Telephone: 213-847-6350.

LARWQCB Waste Discharge Requirements, Stormwater/Urban Runoff Discharge for Los Angeles County and Co-Permittees, Water Quality Order No. 96-054, NPDES Permit No. CAS614001.

LARWQCB Water Quality Control Plan, June 13, 1994.

National Research Council, Monitoring Southern California's Coastal Waters 1990.

Santa Monica Bay Restoration Project, State of the Bay 1993, January 1994.

State Board, General Permit for Stormwater Discharges Associated With Construction Activities, Water Quality Order No. 92-06-DWQ; General Permit No. CAS000002.

State Board, General Permit for Stormwater Discharges Associated With Industrial Activities Excluding Construction Activities, Water Quality Order No. 91-13-DWQ (as amended by Water Quality Order No. 92-12-DWQ); General Permit No. CAS000001.

State Board, Ocean Plan, August 1995.

State Board, Stormwater Bulletin Board Service. Monitoring data for various watersheds in California.

State Board, Stormwater Quality Task Force, California Stormwater Best Management Practice Handbooks, March 1993. Provides general guidance in developing and implementing BMPs for stormwater quality for municipal, industrial and construction activities. Primarily

addresses the requirements of the stormwater program as developed from section 402 (p) of the CWA.

EPA, Office of Wastewater Enforcement and Compliance, Draft Stormwater Pollution Prevention for Industrial Activities, 1992.

EPA, Water Planning Division, Final Report of the Nationwide Runoff Program, December 30, 1983.

Regulatory Framework

The State Board has the overall responsibility to develop and implement state water quality control policy and is the EPA-designated agency for administering applicable federal CWA programs, including adopting water quality standards for waters of the state. The California Water Code (CWC) establishes nine administrative areas in the State, which are administered by Regional Water Quality Control Boards (RWQCB), which adopt Water Quality Control Plans for their respective regions. The Water Quality Control Plans designate beneficial uses for each receiving water body and establish water quality objectives to ensure reasonable protection of the beneficial uses. The primary method of plan implementation for point discharges is through the issuance of permits.

The owner or operator of any facility discharging or proposing to discharge waste to surface waters (typically from a point source) is required to apply for an NPDES permit with the appropriate RWQCB. Effluent limits are set by the RWQCB for each potential pollutant in accordance with applicable state and federal water quality criteria for the receiving water body. Within the City, the criteria are contained in the Los Angeles Region Basin Plan. The owner or operator of any facility discharging or proposing to discharge waste that may affect groundwater quality or from which waste may be discharged in a diffused manner (e.g. erosion from soil disturbance) must first obtain Waste Discharge Requirements (WDR) from the appropriate RWQCB.

The State Board has issued two general stormwater discharge permits to cover industrial and construction activities, which are required for specific industry types based on standard industrial classification and construction activities on one acre or more or less than one acre but are part of a larger common plan of development that in total disturbs one or more acres. The RWQCB oversees implementation and enforcement of the general permits. The Bureau of Sanitation and Watershed Protection, Stormwater Management Division, are the agencies responsible for overseeing implementation of permit responsibilities for the City. Presently, under

the General Construction Stormwater Permit, projects of one acre or greater are required to incorporate, to the maximum extent possible, permanent or post-construction BMPs in project planning and design as discussed in the current permit, which was approved in December 2001.

Selected Legislation

Federal

NPDES (40 CFR Sec. 122.1)

The NPDES program requires permits for the discharge of pollutants from any point source into waters of the United States. These point sources include: concentrated animal feeding operations, concentrated aquatic animal production facilities, discharges into aquaculture projects, and discharges of stormwater.

Federal Water Pollution Control Act (Clean Water Act - CWA) (33 U.S.C. 1251)

Clean Water Act Amendments of 1972, PL 92-500

Clean Water Act Amendments of 1977, PL 95-217

Clean Water Act Amendments of 1987, PL 100-4

The objective of the CWA is to restore and maintain the chemical, physical, and biological integrity of the Nation's waters.

State

CWC, Division 7 Water Quality

This division of the Code addresses: the conservation, control and utilization of water resources; water quality; and charges the state and regional water boards with coordination and control of water quality. Section 13050 defines pollution, contamination and nuisance, as well as other terms used in the water code.

G.3. GROUNDWATER LEVEL

1. INITIAL STUDY SCREENING PROCESS

A. Initial Study Checklist Questions

- VIII.b): Would the project substantially deplete groundwater supplies or interfere substantially with groundwater recharge such that there would be a net deficit in aquifer volume or a lowering of the local groundwater table level (e.g., the production rate of pre-existing nearby wells would drop to a level which would not support existing land uses or planned uses for which permits have been granted)?
- VIII.f): Would the project otherwise substantially degrade water quality?
- VIII.g): Would the project place housing within a 100-year flood hazard area as mapped on a federal flood hazard Boundary or flood Insurance Rate Map or other flood hazard delineation map?
- VIII.i): Would the project expose people or structures to a significant risk of loss, injury or death involving flooding, including flooding as a result of the failure of a levee or dam?
- VIII.j): Would the project inundation by seiche, tsunami, or mudflow?

B. Introduction

The City of Los Angeles overlies eight groundwater basins as identified in the Los Angeles Region Water Quality Control Plan, adopted by the Los Angeles Regional Water Quality Control Board (LARWQCB), and designated by the California Department of Water Resources (DWR). The Los Angeles Coastal Plain includes the West Coast Basin, the Central Basin, the Santa Monica Basin, and the Hollywood Basin. The San Fernando Valley overlies the San Fernando Basin and portions of the Eagle Rock, Verdugo, and Sylmar Basins. These groundwater basins are depicted in Exhibits G.3-1 and G.3-2. The Los Angeles Region Water Quality Control Plan identifies several beneficial uses common to all of these basins including municipal and domestic supply, industrial process and industrial service supply, and agricultural supply.

Groundwater is a major component of the water supply for many public water suppliers in the Los Angeles metropolitan area, and is also used by private industries, as well as a limited number of

private agricultural and domestic users. Local groundwater provides approximately 15 percent of the total water supply of the City of Los Angeles. The Los Angeles Department of Water and Power (DWP) owns and operates these wells and can act as lead agency under CEQA for projects involving wells and water production facilities. Production rights are adjudicated in three of the four major groundwater basins (West Coast, Central, and San Fernando Basins), and are monitored and controlled by a Watermaster. The DWP serves as the Watermaster for the San Fernando Basin. Production rights are not adjudicated in the Santa Monica and Hollywood basins.

Each groundwater basin is replenished by deep percolation of precipitation and return water from irrigation. Individual basins may also be replenished by surface spreading of local runoff, imported water and reclaimed water; injection of imported water (for protection against saline intrusion); and subsurface inflow from other basins. The major spreading areas are generally on the higher portions of the valley floor near the mountain front, or along major streams or channels.

Water table changes and/or changing the direction of flow may result from extracting groundwater for water supply needs or site dewatering, increasing or decreasing groundwater recharge, intercepting and removing groundwater from cuts or excavations, or remediation of contaminated groundwater. Earthwork cuts or excavations in areas of shallow groundwater may necessitate the use of temporary or permanent removal of groundwater by dewatering systems.¹ Groundwater recharge may be reduced if an area currently available for spreading of stream runoff is reduced, if permeable streambeds are lined, or if permeable areas located above groundwater basins are replaced by hard surfaces (paving, buildings, etc.). Groundwater recharge may be increased if larger permeable areas are created.

Possible impacts resulting from lowering the water table include changes in the production of nearby existing wells, reduced basin yield, salt water intrusion (see G.4, GROUNDWATER QUALITY), subsidence (see E.1., GEOLOGIC HAZARDS), stream flow reduction (see G.1., SURFACE WATER HYDROLOGY), impacts to vegetation, and changes in the direction and rate of travel of existing contaminants in the groundwater. Possible impacts of raising the water table include seepage or other impacts on below ground structures, structural damage from settling or expansion of clay soils (see E.1., GEOLOGIC HAZARDS), and changes in the direction and rate of flow of contaminants including saltwater intrusion (see G.4. GROUNDWATER QUALITY).

¹ *Permanent removal of groundwater allocated to DWP requires an agreement with DWP.*

C. Screening Criteria

- Does the project include the installation of production water wells or a permanent groundwater extraction or dewatering system in a groundwater basin used for potable water supply purposes?
- Does the project include planned groundwater recharge through surface spreading or injection?
- Would the project involve cuts or excavation that would intercept an aquifer?
- Would the project reduce permeable areas overlying a spreading ground used for groundwater recharge?
- Would the run-off factor for the developed project site exceed the percentage of imperviousness for the existing land use category, as contained in Part G of the Bureau of Engineering Manual, Storm Drain Design²?

A "yes" response to any of the preceding questions indicates further study in an expanded Initial Study, Negative Declaration, Mitigated Negative Declaration, or EIR may be required. Refer to the Significance Threshold for Groundwater Level, and review the associated Methodology to Determine Significance, as appropriate.

A "no" response to each of the preceding questions indicates that there would normally be no significant impact from the proposed project on Groundwater Level.

D. Evaluation of Screening Criteria

Review the description of the proposed project, project site and surrounding area. Locate any underlying groundwater basins, aquifers, and spreading grounds. Review Exhibits G.3-1 and G.3-2, and the Environmental and Public Facilities Map, Groundwater Basins and Groundwater Contamination Areas, as necessary. Identify any proposed water wells, recharge activities, permanent groundwater extraction or dewatering systems, or any proposed cuts or excavations that may intercept an aquifer. Evaluate whether there would be a reduction in permeable areas overlying a spreading ground used for groundwater recharge. Determine the percentage of imperviousness and review Exhibit G.1-1.² Compare this information with the Screening Criteria.

²

Percentage of imperviousness factors from the Bureau of Engineering Manual are reprinted in G.1. SURFACE WATER HYDROLOGY in Exhibit G.1-1.

2. DETERMINATION OF SIGNIFICANCE

A. Significance Threshold

A project would normally have a significant impact on groundwater level if it would:

- Change potable water levels sufficiently to:
 - Reduce the ability of a water utility to use the groundwater basin for public water supplies, conjunctive use purposes, storage of imported water, summer/winter peaking, or to respond to emergencies and drought;
 - Reduce yields of adjacent wells or well fields (public or private); or
 - Adversely change the rate or direction of flow of groundwater; or
- Result in demonstrable and sustained reduction of groundwater recharge capacity.

B. Methodology to Determine Significance

Environmental Setting

In a description of the environmental setting, include the following information:

- Identification and description of the underlying groundwater basin(s), including the level, quality, direction of flow, and existing uses of the water;
- Location, existing uses, production capacity, quality, and other pertinent data for spreading grounds and potable water wells in the vicinity (usually within a one mile radius);
- Area and degree of permeability of soils on site; and
- Ongoing or planned groundwater remediation activities.

Project Impacts

Review the description of the proposed project and the information from the Evaluation of Screening Criteria.

Determine which activities could impact the groundwater resources by considering the following factors:

- The rate, duration, location and quantity of extraction, dewatering, spreading, injection, or other activities;
- The projected reduction in groundwater resources and any existing wells in the vicinity (usually within a one mile radius); and
- The projected change in local or regional groundwater flow patterns.

For subsurface cuts and excavation that intercept an aquifer, determine the projected change in localized flow and the quantities of potable groundwater that would require removal, if any. Note impacts to structures from seepage or other potential conditions and determine whether groundwater removals would be temporary or permanent.

If there is a projected loss of a large permeable area, including permeable streambeds, which historically allowed water to percolate, address the following:

- The total amount of permeable area that would be covered or lost;
- The average reduction in volume of recharge water due to project implementation (short-term and long-term, if applicable); and
- The lost recharge potential as compared to the adjudicated or estimated safe yield of the underlying groundwater basin.

Consult with local and regional water agencies and utilities, as needed.

Cumulative Impacts

Review the list of related projects and identify those located over the same groundwater basin or near the same recharge area or well(s) as the proposed project that could change potable water levels or reduce groundwater recharge capacity. Analyze the potential combined effects of the related projects with the proposed project, using the method described in Project Impacts.

Sample Mitigation Measures

Potential mitigation measures include the following:

- Relocate proposed wells;
- Compensate existing, adjacent well owners who would be affected by the proposed project;
- Reduce proposed impermeable areas that would result in loss of recharge capacity;
- Construct replacement recharge capacity at an alternative location in the same basin;
- Avoid areas of shallow groundwater when locating roadways, underground trenches, and buildings requiring subsurface foundations; and
- If use of areas with shallow groundwater is deemed unavoidable, develop a dewatering plan, subject to review and approval of the City. The plan may include such measures as:
 - Modify the structural design of the project so that a permanent dewatering system is not needed, where feasible;
 - Removal of all standing water from excavations during construction;
 - Installation of subsurface drains;
 - Construction of retaining walls to carry water collecting behind the wall to a controlled drainage system;

- Sealing bedrock fractures; or
- Returning the water to the groundwater basin by injection well, where feasible.

3. DATA, RESOURCES, AND REFERENCES

LADWP/Upper Los Angeles River Area (ULARA) Watermaster, 111 North Hope Street, Los Angeles, California 90012-2694; Telephone: (213) 367-0896.

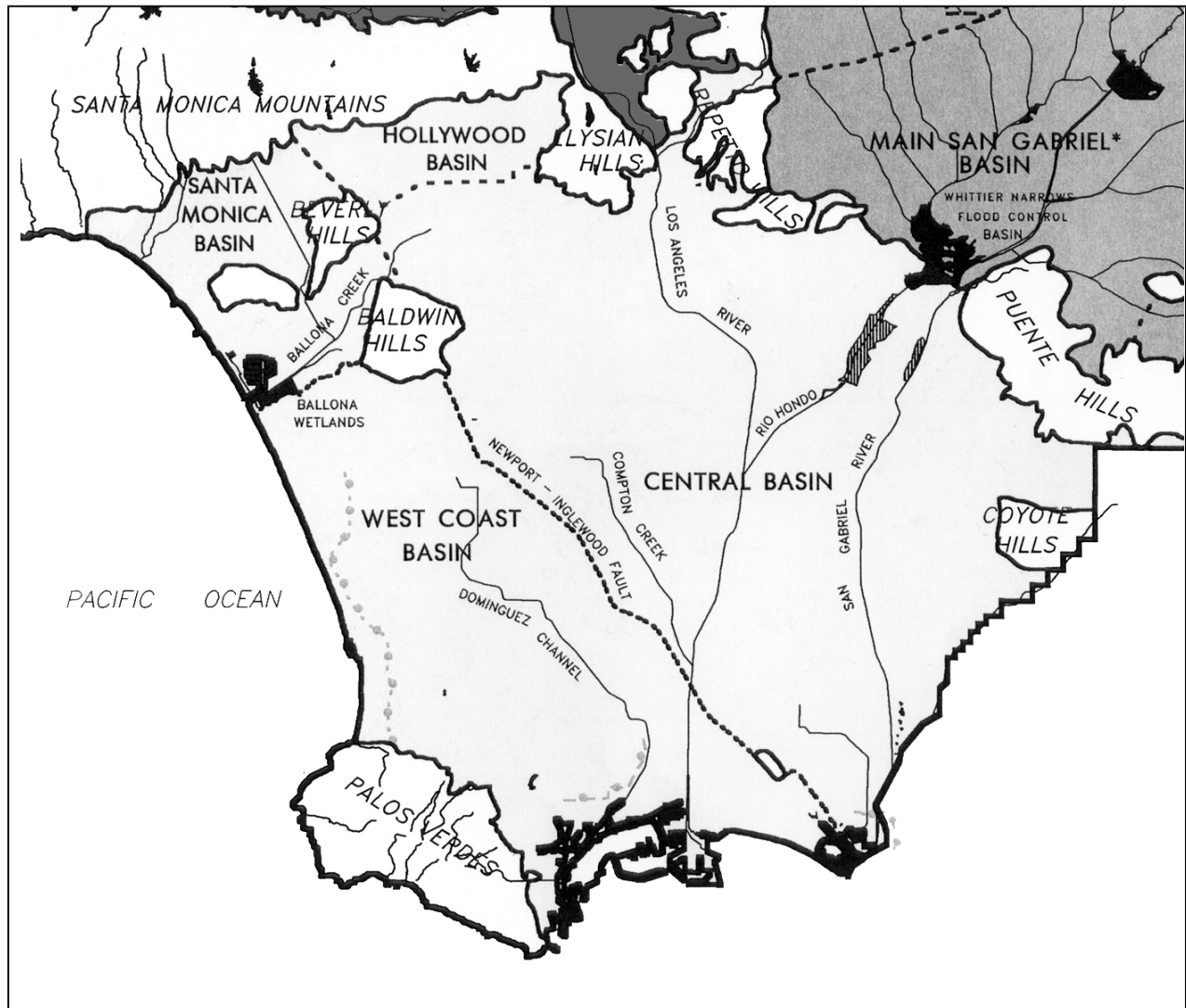
Adjudication Documentation, Report of Referee, Superior Court, Los Angeles County No. 650079, July 1992. A thorough description of the groundwater resources of the San Fernando Valley area.

DWR, Annual Watermaster Reports, published for the Central Basin, West Coast Basin, and Upper Los Angeles River Basin (covering the San Fernando Basin).

DWR Bulletin 104: Planned Utilization of the Ground Water Basins of the Coastal Plain of Los Angeles County, June 1991. The most comprehensive study of the area resources for the Coastal Plain Basins.

City Planning Department, Environmental and Public Facilities Maps (1996): Groundwater Basins and Groundwater Contamination Areas.

LARWQCB, Water Quality Control Plan, June 13, 1994.



^
N

Exhibit G. 3-1
Los Angeles Basin

—— Regional Boundary
—— Streams

* The main San Gabriel is a part of the San Gabriel groundwater basins

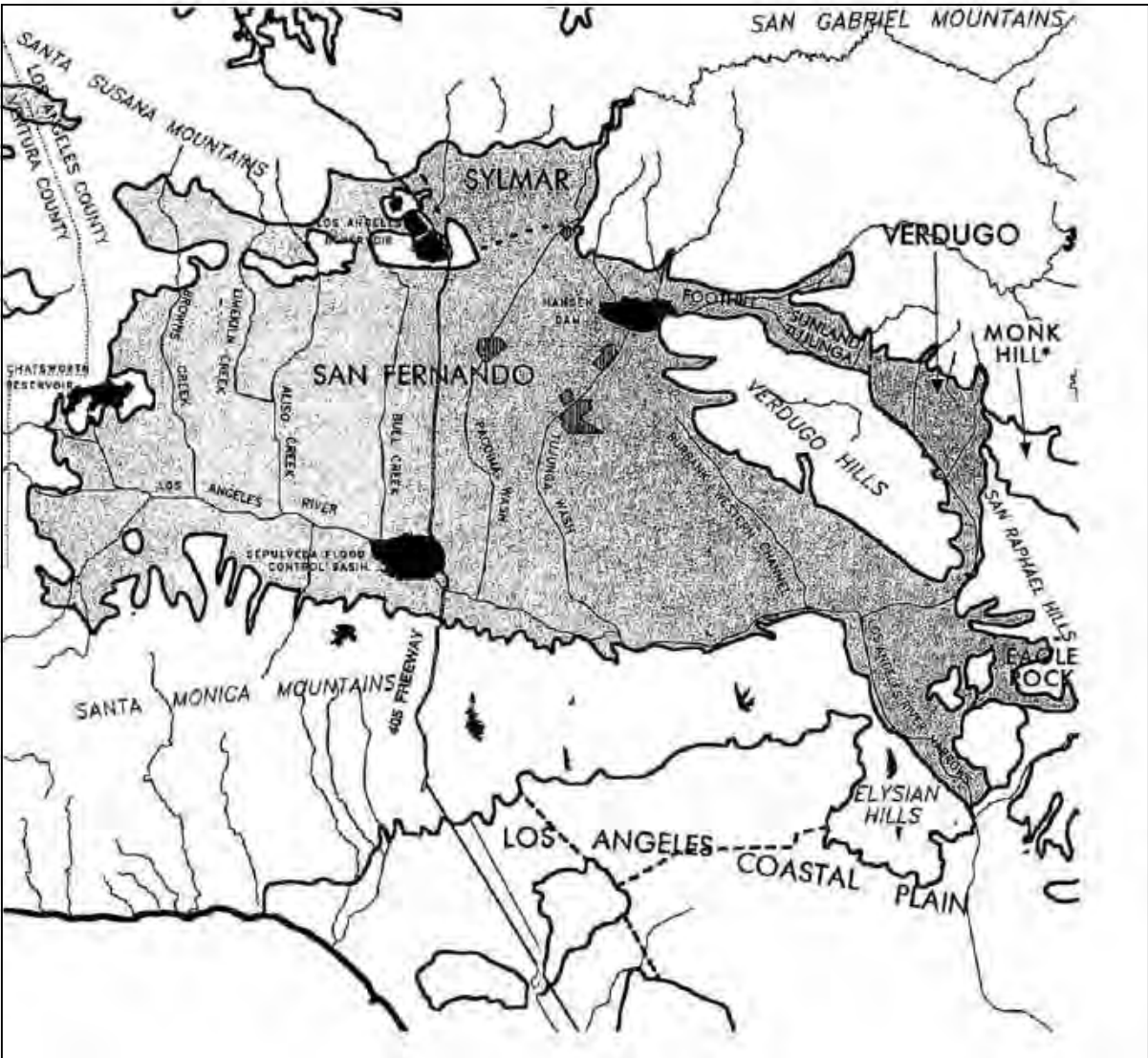


Exhibit G. 3-2
San Fernando Basin

- Regional Boundary
- Streams
- County Line

G.4. GROUNDWATER QUALITY

1. INITIAL STUDY SCREENING PROCESS

A. Initial Study Checklist Questions

- VIII.ga): Would the project place housing within a 100-year flood hazard area as mapped on a federal flood hazard Boundary or flood Insurance Rate Map or other flood hazard delineation map?
- VIII.h): Would the project place within a 100-year flood hazard area structures, which would impede or redirect flood flows?

B. Introduction

The City of Los Angeles overlies eight groundwater basins, as identified in the Los Angeles Region Water Quality Control Plan, adopted by the Los Angeles Region Water Quality Control Board (LARWQCB) and designated by the California Department of Water Resources (DWR). The Los Angeles Coastal Plain includes the West Coast Basin, the Central Basin, the Santa Monica Basin and the Hollywood Basin. The San Fernando Valley overlies the San Fernando Basin, and portions of the Eagle Rock, Verdugo and Sylmar Basins. These groundwater basins are depicted in Exhibits G.3-1 and G.3-2¹.

The Los Angeles Region Water Quality Control Plan identifies a number of beneficial uses common to all of these basins, including municipal and domestic supply, industrial process and industrial service supply, and agricultural supply. It also establishes water quality objectives for a number of constituents of each groundwater basin to protect these uses, identifies existing water quality problems in general terms, and sets forth an implementation plan to maintain or improve groundwater quality to allow the objectives to be met.

Historically, the groundwater basins have become contaminated as a result of human activities and natural phenomena. Contamination can result from spills, leaks, leachate, or discharges of contaminants; returns from agricultural or urban irrigation; salt water intrusion; septic system and wastewater discharges; and other sources. Areas of contaminated groundwater are relatively well-

documented in the Los Angeles area by several agencies that regulate, use or manage groundwater supplies, including the LARWQCB. The Environmental and Public Facilities Map, Groundwater Basins and Groundwater Contamination Areas, indicates major known areas of contamination underlying the City.

Degradation of groundwater quality may result from a variety of activities, including: the discharge or application of wastewater, groundwater, or solid waste to the land surface or subsurface areas; groundwater injections or withdrawals, or other activities that could result in a change in the flow direction of existing plumes of groundwater contamination or saltwater intrusion; drilling that intercepts areas of groundwater contamination; leaking underground or above-ground storage tanks; or accidental spills or releases or other hazardous materials on permeable soils. (See also G.3. GROUNDWATER LEVEL.)

Responsibility for implementation of the Water Quality Control Plan to protect groundwater quality rests with the LARWQCB. A primary mechanism of implementation used by the LARWQCB is the issuance and enforcement of permits (Waste Discharge Requirements, or WDRs) for discharge of any wastewater, groundwater, or contaminants to the ground surface or subsurface. Discharges that require WDRs include, but are not limited to: septic systems, dewatering systems, holding/equalization tanks, evaporation ponds, percolation ponds and leachfields, landfills, land treatment units (bioremediation), oil field brine disposal and land disposal of wastes. Additionally, the LARWQCB, California Department of Toxic Substances Control (DTSC), and the Environmental Protection Agency (EPA) can investigate, regulate, and remediate groundwater contamination (e.g. Superfund projects).

C. Screening Criteria

- Would the project include the installation or operation of water wells,² or any groundwater extraction or recharge system, that is in the vicinity (usually within one mile) of the coast, an area of known groundwater contamination or seawater intrusion, a municipal supply well or spreading ground facility?
- Would the project include surface or subsurface application or introduction of potential contaminants or waste materials during construction or operation? Examples of such projects include: on-site disposal systems (septic systems), holding/equalization tanks, evaporation ponds, underground or above-ground storage tanks, percolation ponds and

² *Other than monitoring wells and wells intended to remediate existing, or prevent future, groundwater contamination or saltwater intrusion.*

leachfields, landfills and other land surface waste disposal facilities, land treatment units (bioremediation), oil field brine disposal, and agricultural activities.

- Could the project result in releases or spills of contaminants that could reach a groundwater recharge area or spreading ground or otherwise reach groundwater through percolation?
- Would the project involve drilling to or through a clean or contaminated aquifer?

A "yes" response to any of the preceding questions indicates further study in an expanded Initial Study, Negative Declaration, Mitigated Negative Declaration or EIR may be required. Refer to the Significance Threshold for Groundwater Quality, and review the associated Methodology to Determine Significance, as appropriate.

A "no" response to all of the preceding questions indicates that there would normally be no significant impact on Groundwater Quality from the proposed project.

D. Evaluation of Screening Criteria

Review the description of the proposed project site, construction and operational activities and the relationship of the site to underlying groundwater basins. Review Exhibits G.3-1 and G.3-2,³ and the Environmental and Public Facilities Map, Groundwater Basins and Groundwater Contamination Areas, or other relevant maps, reports, and studies to identify groundwater recharge areas, spreading grounds, aquifers, or known areas of contamination. Identify any proposed installation or operation of water wells; groundwater extraction or recharge systems; direct or indirect introduction of contaminants; or drilling to or through an aquifer. Compare this information to the Screening Criteria.

The LARWQCB is a primary source of information regarding existing water quality problems. In addition, water utilities and the Watermaster of each adjudicated groundwater basin may be contacted for information regarding water rights, hydrologic features and groundwater contamination.

³ See G.3. GROUNDWATER LEVEL.

2. DETERMINATION OF SIGNIFICANCE

A. Significance Threshold

A project would normally result in a significant impact on groundwater quality if it would:

- Affect the rate or change the direction of movement of existing contaminants;
- Expand the area affected by contaminants;
- Result in an increased level of groundwater contamination (including that from direct percolation, injection or salt water intrusion); or
- Cause regulatory water quality standards at an existing production well to be violated, as defined in the California Code of Regulations (CCR), Title 22, Division 4, and Chapter 15 and in the Safe Drinking Water Act.

B. Methodology to Determine Significance

Environmental Setting

In a description of the environmental setting, include the following information:

- Identification and description of the underlying groundwater basin(s), recharge areas, spreading grounds, aquifers and wells. Include the quality, quantity and use of the water;
- Area and degree of permeability of soils on the project site and in areas where operations could involve surface discharges;
- The location and nature of any existing groundwater contamination in the vicinity of the project site (usually within a one-mile radius), including saltwater intrusion and leaking underground storage tanks (available from the local fire department, the County Health Department, or the State Leaking Underground Storage Tanks (LUST) database);
- Description of any ongoing or planned remediation activities; and
- Existing groundwater levels and direction of flow in the vicinity of the project.

Project Impacts

Using the information from the Evaluation of Screening Criteria, describe proposed construction and operational features of the project that involve any intrusion into groundwater, including extraction, dewatering, planned surface application, subsurface disposal, percolation, or injection of potential contaminants or waste materials. Consider the characteristics of the material proposed for application or injection; any pre-treatment; methods of application, injection; etc. Analyze any potential changes in the amount of groundwater contamination (e.g., concentration, levels or area involved) or the rate and direction of flow of existing groundwater contamination due to project-related activities. Also, determine the impact on the water quality of existing production wells and the size of the contaminated area.

Cumulative Impacts

Review the list of related projects and identify those located over the same groundwater basin or in the vicinity of the same area of known groundwater contamination, or seawater intrusion, municipal supply well, spreading ground facility or the coast that could increase groundwater contamination. Analyze the potential combined effect of the related projects with the project using the methods described in Project Impacts.

Sample Mitigation Measures

Potential mitigation measures include the following:

- Modification to reduce or eliminate the discharge or contamination;
- Reduction or modification of planned groundwater extraction; and
- Treatment of extracted contaminated water.

3. DATA, RESOURCES, AND REFERENCES

Los Angeles Department of Water and Power (DWP)/Upper Los Angeles River Area (ULARA), 111 North Hope Street, Los Angeles, California 90012; Telephone: (213) 367-0906. Annual ULARA Watermaster Report describes water rights, and general hydrologic features for the San Fernando, Sylmar, Eagle Rock and Verdugo Basins, and groundwater contamination.

Los Angeles Fire Department (LAFD) - Records of known leaking underground storage tanks and other information on the location and use of hazardous materials.

LARWQCB, 320 West 4th Street, Suite 200, Los Angeles, California 90013; Telephone: (213) 576-6600.

City Planning Department, Environmental and Public Facilities Maps (1996): Groundwater Basins and Groundwater Contamination Areas.

LARWQCB Remedial Investigation of Groundwater Contamination in the San Fernando Valley, December 1991, which describes the nature and extent of groundwater contamination in the San Fernando, Sylmar, Verdugo and Eagle Rock basins. Also provides geologic and hydrogeologic characterizations for each basin.

LARWQCB, Los Angeles Region Water Quality Control Plan, 1994, which describes groundwater basins, beneficial uses, water quality objectives, and the implementation plan to protect water quality objectives and beneficial uses.

Safe Drinking Water Act of 1974, PL 93-523; Safe Drinking Water Act of 1986, PL 99-339, which establishes a federal program to monitor and increase the safety of all commercially and publicly supplied drinking water.

This page intentionally left blank.

H. LAND USE

H.1. LAND USE CONSISTENCY

1. INITIAL STUDY SCREENING PROCESS

A. Initial Study Checklist Questions

- IX.b): Would the project conflict with any applicable land use plan, policy, or regulation of an agency with jurisdiction over the project (including, but not limited to the general plan, specific plan, local coastal program or zoning ordinance) adopted for the purpose of avoiding or mitigating an environmental effect?
- IX.c): Would the project conflict with any applicable habitat conservation plan or natural community conservation plan?

B. Introduction

This section addresses the consistency or compliance of proposed projects with the goals and policies of the General Plan and its elements, including the Framework Element, 35 adopted Community Plans, as well as the Planning and Zoning Code,¹ and any applicable specific plans, interim control ordinances (ICOs), community design overlay districts (CDOs), local coastal plans and redevelopment plans. City and regional utility plans and other adopted plans that contain environmental policies related to the physical environment that are applicable to the project activities and/or site may also be relevant.

C. Screening Criteria

- Is the project inconsistent with the General Plan or its elements, or an applicable specific plan, local coastal plan, redevelopment plan, interim control ordinance or adopted environmental goals or policies?
- Would the project require a General Plan amendment or zone change?

A "yes" response to any of the preceding questions indicates further study in an expanded Initial Study, Negative Declaration, Mitigated Negative Declaration, or EIR may be required. Refer to the

¹ Chapter 1 of the Los Angeles Municipal Code (LAMC).

Significance Threshold for Land Use Consistency, and review the associated Methodology to Determine Significance, as appropriate.

A "no" response to all of the preceding questions indicates that there would normally be no significant impact on Land Use Consistency from the proposed project.

D. Evaluation of Screening Criteria

Review the proposed project for consistency with the General Plan and other adopted environmental goals and policies. Potential areas of inconsistency include, but are not limited to: land use type; height, bulk, design or density; waste or wastewater generation; resource consumption or degradation; and other plan policies that relate to the physical environment. Use the most recent Community Plan maps and Zone Information & Map Access System (ZIMAS) <http://zimas.lacity.org/> to assist in identifying ordinances and plan areas that may pertain to the project site, or consult the Community Planning Bureau of the City Planning Department. As appropriate, evaluate the General Plan and its elements (including the Framework Element), Community Plans, specific plans, ICOs, CDO's, local coastal plans, redevelopment plans, Planning & Zoning Code, utility plans, and resource management plans. Identify and assess the project's consistency with applicable habitat conservation plans or natural community conservation plans. Consider whether policies are mandatory or guidance, and which is the agency with primary jurisdiction. Compare this information to the Screening Criteria.

2. DETERMINATION OF SIGNIFICANCE

A. Significance Threshold

The determination of significance shall be made on a case-by-case basis, considering the following factors:

- Whether the proposal is inconsistent with the adopted land use/density designation in the Community Plan, redevelopment plan or specific plan for the site; and
- Whether the proposal is inconsistent with the General Plan or adopted environmental goals or policies contained in other applicable plans.

B. Methodology to Determine Significance

Environmental Setting

In a description of the environmental setting, include the following information:

- Community Plan land use and density designation;

- Zoning designation and other Planning and Zoning Code land use regulations relevant to the project site;
-
- Adopted ICOs, specific plan, redevelopment plan, CDO's local coastal plan or provisions of the Coastal Act, if any, applicable to the project site;
- Other City land use policies, such as the General Plan and Elements, including the Framework Element, Airport Hazard Zone Regulations, etc., if applicable to the project site; and
- Adopted City environmental policies, ordinances and plans, such as the City Solid Waste Management Policy Plan (CiSWMPP), Source Reduction and Recycling Element (SRRE), utility and resource conservation plans or programs, wastewater policies, Clean Air Program (CAP), etc., if any, applicable to the project site.

Project Impacts

Using the information from the Evaluation of Screening Criteria, evaluate the project for consistency with detailed local standards and requirements as well as with the broader context of the General Plan and its elements, environmental plans and policies, and regional utility/environmental plans. Identify project elements that conflict with the plans or policies and whether the conflict(s) would result in the project being inconsistent with the land use designation and/or environmental goals and policies of the City. Consider whether the project includes a proposed General Plan (land use) amendment and/or zone change, and whether all elements of the inconsistency have been addressed (i.e., density, design, etc.). For conflicts with environmental goals and policies, consider whether the project would interfere with the City's efforts to meet such goals, or be inconsistent with adopted policies.

Cumulative Impacts

Identify related projects in the vicinity of the proposed project and evaluate them in the same manner as the proposed project to determine if, when viewed together with the proposed project, conformance with the General Plan or other adopted plans or environmental policies would be significantly affected. Consider whether the combination of projects would conflict with the planned land uses and densities in the General Plan, or would interfere with adopted environmental goals and plans. Plans with a broad, regional perspective may be more applicable or useful in evaluating cumulative impacts because the goals and objectives of these plans may be implemented by comprehensive measures taken by government agencies.

Sample Mitigation Measures

Generally, a project determined to be inconsistent with the General Plan will require, as a condition of approval, a General Plan amendment or zone change to eliminate the inconsistency. This requires a finding that the requested change would not substantially alter the City's goals for the affected community. To mitigate an inconsistency prior to this determination, consider the following:

- Modify the project's proposed land uses to be consistent with designated land uses, zoning and/or General Plan and its element(s); or
- Relocate proposed structures or reduce the project's density/intensity to reduce conflicts or inconsistencies with the Land Use Element and plans.

3. DATA, RESOURCES, AND REFERENCES

The following references are available from the City Planning Department, Community Planning Bureau, 200 N. Spring St., 6th Floor, Los Angeles, California 90012. The Bureau may be reached at (213) 978-3893:

- General Plan and its elements, including the Framework Element and the 35 adopted Community Plans;
- District Zoning maps;
- ICOs;
- CDOs;
- Specific plans;
- Local coastal plans; and
- Airport Hazard Zone maps.

Planning and Zoning Code, (Chapter 1 of the LAMC) is available from the City Planning Department's Central Publications Unit at 200 N. Spring St., 5th Floor, Los Angeles, California 90012; Telephone: (213) 978-1255. For further information, call (213) 978-1310

Zone Information & Map Access System (ZIMAS) available online at: <http://zimas.lacity.org>.

Redevelopment plans are available from the Community Redevelopment Agency (CRA) of the City of Los Angeles, 354 South Spring Street, Suite 800, Los Angeles, California 90013; Telephone: (213) 977-1600.

City utility plans are available from the following City departments:

Department of Water and Power

- Utility Plans/Power Division
111 North Hope Street, Room 1121
Los Angeles, California 90012
Telephone: (213) 367-0285

- Urban Water Management Plan
Division of Public Affairs
Telephone: (213) 367-1361

Department of Public Works
Bureau of Sanitation

- Wastewater plans
Wastewater Engineering Service Division
Telephone: (323) 342-6235

- Hyperion System
Hyperion Treatment Plant
Telephone: (310) 648-5000

CiSWMPP and SRRE are available from the Solid Resources Citywide Recycling Division of the Bureau of Sanitation, 433 South Spring Street, 5th Floor, Los Angeles, California 90013; Telephone: (213) 473-8228.

Southern California Association of Governments (SCAG) is the Metropolitan Planning Organization (MPO) for the region and offers resources and assistance. SCAG is located at 818 West Seventh Street, 12th Floor, Los Angeles, California 90017; Telephone: (213) 236-1800.

California Department of Fish and Game, South Coast Region, 4949 Viewridge Avenue, San Diego, CA 92123-1662; Telephone: (858) 467-4201.

H.2. LAND USE COMPATIBILITY

1. INITIAL STUDY SCREENING PROCESS

A. Initial Study Checklist Question

IX.a): Would the project physically divide an established community?

IX.b): Would the project conflict with any applicable land use plan, policy, or regulation of an agency with jurisdiction over the project including, but not limited to the general plan, specific plan, local coastal program or zoning ordinance) adopted for the purpose of avoiding or mitigating an environmental effect?

IX.c): Would the project conflict with any applicable habitat conservation plan or natural community conservation plan?

B. Introduction

This section addresses the potential for projects or programs to create situations of incompatibility between land uses or activities. Such incompatibility may result from environmental impacts associated with the proposed land use. Examples of incompatibility include land uses, which create noise, odor, safety hazards, visual, or other environmental impacts which conflict with surrounding land uses and the activities and conditions typically associated with those land uses. In addition, a project may disrupt the physical arrangement of an established community by introducing new infrastructure or isolating land uses that could interrupt the typical activities or change the land use conditions in a community.

C. Screening Criteria

- Would the project include a land use type that is incompatible with existing or proposed adjacent land uses (due to size, intensity, density or type of use)?
- Would the project include features such as a highway, aboveground infrastructure, or an easement through an established neighborhood community that could cause a permanent disruption in the physical arrangement of that established community or otherwise isolate an existing land use?

- Would the project result in a “spot” zone?

A "yes" response to any of the preceding questions indicates further study in an expanded Initial Study, Negative Declaration, Mitigated Negative Declaration, or EIR may be required. Refer to the Significance Threshold for Land Use Compatibility and review the associated Methodology to Determine Significance, as appropriate.

A "no" response to all of the preceding questions indicates that there would normally be no significant Land Use Compatibility impact from the proposed project.

D. Evaluation of Screening Criteria

Review the description of the proposed project, including the proposed land use or activity, and the size, density and intensity of the operation. Noise, odor, signage, safety hazards, traffic or other impacts may indicate an incompatibility with existing adjacent or surrounding land uses or current zoning for those sites, if vacant. Also, consider the types of land uses surrounding the project and the typical activities that occur at these sites, compared to those that would occur at the proposed project. Indicate the presence or lack of buffers between the project and adjacent land uses of other types. Note that a zone change required to implement the project may indicate a potential incompatibility with adjacent existing land uses. Review specific plans for urban design compatibility programs or regulations and their relevance to project design.

If the project includes elements such as a highway, aboveground infrastructure or an easement, identify the existing land uses that would be removed or would be adjacent to the new infrastructure. Determine the duration of any disruption of the physical arrangement of an established neighborhood or community. Such impacts may result from a physical separation or the creation of barriers that would disrupt the social or physical interaction between established land uses that comprise a neighborhood or community.

A “spot” zone occurs when the zoning or land use designation for only a portion of a block changes, or a single zone or land use designation becomes surrounded by more or less intensive land uses.

Compare this information to the Screening Criteria.

2. DETERMINATION OF SIGNIFICANCE

A. Significance Threshold

The determination of significance shall be made on a case-by-case basis, considering the following factors:

- The extent of the area that would be impacted, the nature and degree of impacts, and the type of land uses within that area;
- The extent to which existing neighborhoods, communities, or land uses would be disrupted, divided or isolated, and the duration of the disruptions; and
- The number, degree, and type of secondary impacts to surrounding land uses that could result from implementation of the proposed project.

B. Methodology to Determine Significance

Environmental Setting

In a description of the environmental setting, describe and map, as appropriate, the existing land uses and current zoning of the project site and the properties in the immediate vicinity of the proposed project. Also, identify uses near the site such as schools, libraries and residences which may be particularly sensitive to potential nuisance impacts (e.g., noise, odor, safety hazards) associated with the proposed project.

If the proposed project may disrupt or divide an established community, evaluate the existing neighborhoods or communities immediately surrounding the project. Address the type of land uses in the area, and the location of residences, businesses, schools, and other community facilities in relation to the proposed project and supporting residences.

Project Impacts

A significant land use compatibility impact may be indicated by the presence of one or more significant project impacts, which suggest that the location or intensity of the proposed project could conflict with existing uses. However, the presence of project impacts does not automatically indicate a land use compatibility impact and the effect of these impacts should be evaluated within the primary impact category (e.g., noise, traffic).

Evaluate the nature, extent and number of secondary impacts to determine the extent of any conflict between the project and existing uses in the area. Consider the type of activities typically expected to occur at land uses adjacent to the project and whether nuisance impacts from the proposed project would conflict with these activities.

If the proposed project would add such features as a highway, aboveground infrastructure or easement, determine the extent to which existing neighborhoods or communities would be impacted by its implementation. Evaluate the extent of the physical separation, barrier or other disruption of existing land uses or activities that could result from the proposed project. Indicate the duration of the disruption (e.g., long-term, permanent) of the physical or social interaction between land uses that comprise an established neighborhood or community.

Cumulative Impacts

The cumulative impact assessment should identify other known projects or land use changes proposed in the vicinity of the project that may either combine with the proposed project to create a land use incompatibility with the existing land uses, or be subject to nuisance impacts resulting from a proposed project that creates a land use incompatibility with the related projects. Evaluate the potential impacts using the methodology described above.

Sample Mitigation Measures

Mitigation measures to reduce secondary impacts are found in the individual sections (noise, traffic, etc.). Potential mitigation measures that may reduce land use compatibility impacts include:

- Change the project design, configuration, visual screening, setbacks, building heights, etc., to be compatible with surrounding uses;
- Restrict certain operational characteristics of the proposed use to reduce or eliminate impacts, such as limiting hours of operation or placing restrictions on specific types of uses or activities proposed for the project, etc.;
- Provide enclosed structures around certain activities that normally occur outdoors;
- Place aboveground infrastructure under ground, or grade separate key portions of the proposed highway, rail line, or other infrastructure to minimize physical separations;

- Provide pedestrian and bicycle routes or crossings to increase mobility; and
- Provide a buffer (such as a decorative wall or landscaping) where residential uses are adjacent to non-residential uses.

3. DATA, RESOURCES, AND REFERENCES

City Planning Department, 201 North Figueroa Street, 3rd Floor, Los Angeles, California 90012; Telephone: (213) 977-6083. For plan check, first go to Counter A, 4th floor (Building and Safety). They will refer visitors to the Planning Department as appropriate.

See also H.1. LAND USE CONSISTENCY.

I. NOISE

I.1. CONSTRUCTION NOISE

1. INITIAL STUDY SCREENING PROCESS

A. Initial Study Checklist Questions

- XI.a): Would the project result in exposure of persons to or generation of noise levels in excess of standards established in the local general plan or noise ordinance, or applicable standards of other agencies?
- XI.b): Would the project result in exposure of persons to or generation of excessive groundborne vibration or groundborne noise levels?
- XI.d): Would the project result in a substantial temporary or periodic increase in ambient noise levels in the project vicinity above levels existing without the project?
- XI.e): For a project located within an airport land use plan or, where such a plan has not been adopted, within two miles of a public airport or public use airport, would the project expose people residing or working in the project area to excessive noise levels?
- XI.f): For a project within the vicinity of a private airstrip, would the project expose people residing or working in the project area to excessive noise levels?

B. Introduction

Construction of facilities and structures requires the use of equipment, which may generate high noise levels and adversely affect noise sensitive uses.¹ In assessing the impact of construction noise upon the environment, the nature and level of activities that generate the noise, the pathway through which the noise travels, the sensitivity of the receptor, and the period of exposure are all considered.

Environmental noise is measured in decibels (dB). To better approximate the range of sensitivity of the human ear to sounds of different frequencies, the A-weighted decibel scale (dBA) was devised. Because the human ear is less sensitive to low frequency sounds, the A-scale de-emphasizes these frequencies by incorporating frequency weighting of the sound signal. When the A-scale is used, the decibel levels are represented by dBA. On this scale, the range of human hearing extends from about 3 dBA to about 140 dBA. A 10-dBA increase is judged by most people as a doubling of the sound level.

¹ For impacts during operation, see I.2 OPERATIONAL NOISE, I.3. RAILROAD NOISE, and I.4. AIRPORT NOISE, as appropriate.

To account for the fluctuation in noise levels over time, noise impacts are commonly evaluated using time-averaged noise levels. The Community Noise Equivalent Level (CNEL) represents an energy average of the A-weighted noise levels over a 24-hour period with 5 dBA and 10 dBA increases added for nighttime noise between the hours of 7:00 p.m. and 10:00 p.m. and 10:00 p.m. to 7:00 a.m., respectively. The increases were selected to account for reduced ambient noise levels during these time periods and increased human sensitivity to noise during the quieter periods of the day.

Typical construction equipment types are presented in Exhibit I.1-1. Noise levels from these equipment types ranges from 76 to 91 dBA for equipment powered by internal combustion engines, saws, and vibrators and from the mid-80s to more than 100 dBA for impact equipment. Exhibit I.1-2 provides typical noise levels for each construction phase. The excavation and finishing phases include the noisiest construction activities.

The Environmental Protection Agency (EPA), establishes emission standards for construction equipment according to the provisions of the Noise Control Act of 1972, set forth in 40 CFR, Part 204. In addition, the City of Los Angeles Noise Ordinance addresses noise generated at construction sites, including permissible hours of construction, increases in ambient noise levels, and the technical feasibility of reducing noise from certain construction equipment. The Los Angeles Police Department (LAPD) enforces the provisions of the Noise Ordinance.²

C. Screening Criteria

- Would construction activities occur within 500 feet of a noise sensitive use?
- For projects located within the City of Los Angeles, would construction occur between the hours of 9:00 p.m. and 7:00 a.m. Monday through Friday, before 8:00 a.m. or after 6:00 p.m. on Saturday, or at anytime on Sunday?

A “yes” response to any of the preceding questions indicates further study in an expanded Initial Study, Negative Declaration, Mitigated Negative Declaration, or EIR may be required. Refer to the Significance Threshold for Construction Noise and review the associated Methodology to Determine Significance, as appropriate.

² Refer to Sections 41.40, 112.02, and 112.05 of the Los Angeles Municipal Code (LAMC). Technical infeasibility means that specified noise limitations cannot be achieved despite the use of mufflers, shields, sound barriers and/or any other noise reduction devices or techniques during operation of the equipment.

A “no” response to all of the preceding questions indicates that there would normally be no significant impact from the proposed project.

D. Evaluation of Screening Criteria

Review the description of the proposed project, including information on construction activities. Consult a map showing the location of noise sensitive uses within 500 feet of the project site. Noise sensitive uses include residences, transient lodgings, schools, libraries, churches, hospitals, nursing homes, auditoriums, concert halls, amphitheaters, playgrounds, and parks. Determine whether construction activities would occur within 500 feet of a noise sensitive use or during the hours specified in the Screening Criteria.

2. DETERMINATION OF SIGNIFICANCE

A. Significance Threshold

A project would normally have a significant impact on noise levels from construction if:

- Construction activities lasting more than one day would exceed existing ambient exterior noise levels by 10 dBA or more at a noise sensitive use;
- Construction activities lasting more than 10 days in a three month period would exceed existing ambient exterior noise levels by 5 dBA or more at a noise sensitive use; or
- Construction activities would exceed the ambient noise level by 5 dBA at a noise sensitive use between the hours of 9:00 p.m. and 7:00 a.m. Monday through Friday, before 8:00 a.m. or after 6:00 p.m. on Saturday, or at anytime on Sunday.

B. Methodology to Determine Significance

Environmental Setting

In a description of the environmental setting, include the following information:

- Identification of noise sensitive land uses within 500 feet of the project site, including description, location, and distance from the project; and

- Quantification of ambient noise levels (existing and projected at the time of construction) measured in CNEL.

One of the following methodologies can be used to determine ambient noise levels:

- Field measurements involving the use of a noise meter at and surrounding the project site;
- “Presumed Ambient Noise Levels,” as set forth in the LAMC, Section 111.03 (see Exhibit I.1-3); or
- A noise monitoring program performed according to the procedures set forth in the LAMC, Sections 111.02 and 112.05. This involves taking measurements at selected locations to establish ambient background noise levels.

Project Impacts

Review the description of the proposed project, including the duration of construction activities. Identify the type, amount, and scheduling of construction equipment to be used during each construction phase, and the distance from construction activities to noise sensitive uses.

Calculate the noise emissions from individual equipment by using the noise levels shown in Exhibits I.1-1 and I.1-2, or other applicable references, the distance to the noise sensitive uses, and noise attenuation standards. Noise models may be used, as appropriate. Noise levels 50 feet from a source decrease by approximately 3 dBA over a hard, unobstructed surface, such as asphalt, and by approximately 4.5 dBA over a soft surface, such as vegetation. For every doubling of distance thereafter, noise levels drop another 3 dBA over a hard surface and 4.5 dBA over a soft surface. Machinery equipped with noise control devices or other noise-reducing design features does not generate the same level of emissions as that shown in Exhibit I.1-1.

Determine the combined noise levels from equipment that will be operated simultaneously. Noise levels measured in decibels increase logarithmically and cannot be added arithmetically. When transmission path topography between the construction noise source and the receptor location is complex, consult an experienced noise specialist, as necessary.

Establish the change in noise level from construction activities at the location of sensitive receptors. Subtract the projected noise level without construction equipment from the projected noise level during construction activities. Considering the number of days various noise levels are

projected, determine whether construction activities would exceed both the number of days, times of day, and dBA increases in the Significance Threshold.

Cumulative Impacts

As feasible, identify construction activities for related projects that would coincide with the project's construction operations. Calculate noise levels using the methodology in Project Impacts and logarithmically add the noise from these construction activities to the project-related construction noise to determine the cumulative effect of the construction activities. Consult a noise specialist, or use a noise model, as needed.

Sample Mitigation Measures

Potential mitigation measures include the following:

- Use noise control devices, such as equipment mufflers, enclosures, and barriers. Natural and artificial barriers such as ground elevation changes and existing buildings can shield construction noise. Stage construction operations as far from noise sensitive uses as possible;
- Avoid residential areas when planning haul truck routes;
- Maintain all sound-reducing devices and restrictions throughout the construction period;
- Replace noisy equipment with quieter equipment (for example, a vibratory pile driver instead of a conventional pile driver and rubber-tired equipment rather than track equipment); and
- Change the timing and/or sequence of the noisiest construction operations to avoid sensitive times of the day.

3. DATA, RESOURCES, AND REFERENCES

Noise Ordinance No. 161,574, LAMC Section 112.05 and No. 166,170, LAMC Section 41.40 provide construction hours and construction equipment noise thresholds.

Noise Ordinance No. 156,363, LAMC Section 111.02 provides sound level measurement procedures.

Noise Ordinance No. 156,363, LAMC Section 111.03 provides ambient noise levels.

Los Angeles Association of Environmental Professionals (AEP), Thresholds of Significance, Construction noise threshold used by Port of Long Beach, 1992.

EPA, Noise from Construction Equipment and Operations, Building Equipment and Home Appliances, Prepared by Bolt, Beranek and Newman, 1971.

Categories of Construction Equipment

1. Impact equipment and tools: This group includes pile drivers, pavement breakers, tampers, rock drills, and small; hand-held pneumatically, hydraulically, or electrically powered tools. In the case of conventional pile drivers, whether steam-powered or diesel-powered, the impact of the hammer dropping onto the pile is the dominant noise-generating component. However, sonic or vibratory pile drivers do not produce impact noise as it vibrates the pile at resonance, rather than using a drop hammer.
2. Equipment powered by internal combustion engines: The internal combustion engine, usually of the diesel type, is used to provide motive and/or operating power. Engine powered equipment can be divided into categories according to its mobility and operating characteristics as earthmoving equipment (highly mobile), materials handling equipment (semi-mobile), and stationary equipment.
3. Other equipment: Certain types of construction equipment, such as power saws or concrete vibrators do not fall under either of the two categories above.

Selected Legislation

Federal

Federal Noise Control Act of 1972 (40 CFR Sec. 204)

Public Law 92-574. Regulates noise emissions from operation of all construction equipment and facilities; establishes noise emission standards for construction equipment and other categories of equipment; and provides standards for the testing, inspection, and monitoring of such equipment. Gives states and municipalities primary responsibility for noise control.

State

California Noise Control Act of 1973 (Health and Safety Code, Division 28)

Declares that excessive noise is a serious hazard to the public health and welfare; establishes the Office of Noise Control with the responsibility to set standards for noise exposure in cooperation with local governments or the state legislature.

Exhibit I.1-1
NOISE LEVEL RANGES OF TYPICAL CONSTRUCTION EQUIPMENT

| <u>Equipment</u> | <u>Levels in dBA at 50 feet^a</u> |
|----------------------------|--|
| Front Loader | 73-86 |
| Trucks | 82-95 |
| Cranes (moveable) | 75-88 |
| Cranes (derrick) | 86-89 |
| Vibrator | 68-82 |
| Saws | 72-82 |
| Pneumatic Impact Equipment | 83-88 |
| Jackhammers | 81-98 |
| Pumps | 68-72 |
| Generators | 71-83 |
| Compressors | 75-87 |
| Concrete Mixers | 75-88 |
| Concrete Pumps | 81-85 |
| Back Hoe | 73-95 |
| Pile Driving (peaks) | 95-107 |
| Tractor | 77-98 |
| Scraper/Grader | 80-93 |
| Paver | 85-88 |

^a Machinery equipped with noise control devices or other noise-reducing design features does not generate the same level of emissions as that shown in this table.

Source: EPA, Noise from Construction Equipment and Operations, Building Equipment and Home Appliances, PB 206717, 1971.

Exhibit I.1-2
OUTDOOR CONSTRUCTION NOISE LEVELS

| Construction Phase | Noise Level (dBA Leq) | |
|---------------------------|--------------------------------|----------------------------|
| | Noise Levels at 50 feet | |
| | 50 feet | with Mufflers (dBA) |
| Ground Clearing | 84 | 82 |
| Excavation, Grading | 89 | 86 |
| Foundations | 78 | 77 |
| Structural | 85 | 83 |
| Finishing | 89 | 86 |

Source: EPA, Noise from Construction Equipment and Operations, Building Equipment and Home Appliances, PB 206717, 1971.

Exhibit I.1-3
PRESUMED AMBIENT NOISE LEVELS (dBA)

| | Zone | Day | Night |
|----------------------|--|------------|--------------|
| Residential: | A1, A2, RA, RE, RS,
RD, RW1, RW2, R1, R2,
R3, R4, R5 | 50 | 40 |
| Commercial: | P, PB, CR, C1, C1.5, C2,
C4, C5, CM | 60 | 55 |
| Manufacturing: | M1, MR1, MR2 | 60 | 55 |
| Heavy Manufacturing: | M2, M3 | 65 | 65 |

Source: LAMC, Section 111.03.

I.2. OPERATIONAL NOISE

1. INITIAL STUDY SCREENING PROCESS

A. Initial Study Checklist Questions

- XI.a): Would the project result in exposure of persons to or generation of noise levels in excess of standards established in the local general plan or noise ordinance, or applicable standards of other agencies?
- XI.b): Would the project result in exposure of persons to or generation of excessive groundborne vibration or groundborne noise levels?
- XI.c): Would the project result in a substantial permanent increase in ambient noise levels in the project vicinity above levels existing without the project?
- XI.d): A substantial temporary or periodic increase in ambient noise levels in the project vicinity above the existing without the project?
- XI.e): For a project located within an airport land use plan or, where such a plan has not been adopted, within two miles of a public airport or public use airport, would the project expose people residing or working in the project area to excessive noise levels?
- XI.f): For a project within the vicinity of a private airstrip, would the project expose people residing or working in the project area to excessive noise levels?

B. Introduction

Stationary and mobile vehicular noise sources associated with the operation of a project may increase existing noise levels and/or adversely expose people to severe noise levels.¹

Environmental noise is measured in decibels (dB). To better approximate the range of sensitivity of the human ear to sounds of different frequencies, the A-weighted decibel scale (dBA) was devised. Because the human ear is less sensitive to low frequency sounds, the A-scale de-emphasizes these frequencies by incorporating frequency weighting of the sound signal. When the A-scale is used, the decibel levels are represented by dBA. On this scale, the range of human hearing extends from about 3 dBA to about 140 dBA. A 10-dBA increase is judged by most people as a doubling of the sound level.

¹ For other noise impacts, see I.1. CONSTRUCTION NOISE, I.3. RAILROAD NOISE, and I.4. AIRPORT NOISE, as appropriate.

To account for the fluctuation in noise levels over time, noise impacts are commonly evaluated using time-averaged noise levels. The Community Noise Equivalent Level (CNEL) represents an energy average of the A-weighted noise levels over a 24-hour period with 5 dBA and 10 dBA increases added for nighttime noise between the hours of 7:00 p.m. and 10:00 p.m. and 10:00 p.m. to 7:00 a.m., respectively. The increases were selected to account for reduced ambient noise levels during these time periods and increased human sensitivity to noise during the quieter periods of the day.

Because stationary noise sources include a wide range of noise-generating equipment and processes, which come from an equally wide range of uses, noise levels generated by stationary sources can vary substantially (for examples and descriptions, see 3. Data, Resources, and References). The effects of stationary noise depend on factors such as characteristics of the equipment and operations, distance and pathway between the generator and receptor, and weather. Stationary noise sources may be regulated at the point of manufacture (e.g., equipment or engines) or as a part of local codes and requirements (e.g., noise ordinance or zoning).

The predominant noise source within the City of Los Angeles is transportation, including railroad, airport and motor vehicle sources. Traffic volume, average speed, vehicular fleet mix (i.e., combination of automobiles, motorcycles, buses, and trucks), roadway steepness, distance and characteristics of the pathway between generator and receptor, and weather all influence the level of noise near roadways. For example, as the roadway traffic volume, speed, proportion of fleet mix represented by trucks, and roadway grade increase, so do the composite noise levels at the locations affected by the traffic noise. However, as the roadway volume increases beyond a certain point, congestion increases, in turn causing reduced traffic speeds, which would to some extent offset noise from the traffic volume increase. Dense urban areas within the City of Los Angeles may experience noise levels ranging from the low- to high-70 decibel range. The California Department of Motor Vehicles (DMV) has jurisdiction over noise emissions from individual vehicles (Motor Vehicle Code Section 23130).

C. Screening Criteria

- Would the proposed project introduce a stationary noise source² likely to be audible beyond the property line of the project site?
- Would the project include 75 or more dwelling units, 100,000 square feet (sf) or greater of

² *Stationary noise sources may include, but are not limited to, machinery, engines, energy production, and other mechanical or powered equipment and activities such as loading and unloading or public assembly that may occur at commercial, industrial, manufacturing, or institutional facilities. Stationary noise sources do not include vehicles entering or exiting the property.*

nonresidential development or have the potential to generate 1,000 or more average daily vehicle trips?

A "yes" response to any of the preceding questions indicates further study in an expanded Initial Study, Negative Declaration, Mitigated Negative Declaration, or EIR may be required. Refer to the Significance Threshold for Operational Noise, and review the associated Methodology to Determine Significance, as appropriate.

A "no" response to all of the preceding questions indicates that there would normally be no significant impact from Operational Noise from the proposed project.

D. Evaluation of Screening Criteria

Review the description of the proposed project and the project traffic study to determine the size of each land use involved, information on stationary noise sources such as machinery or motorized equipment, and the vehicle trips that would be generated by the project. L.1. INTERSECTION CAPACITY explains how to calculate the number of average daily vehicle trips.

Determine the noise level from stationary sources at the property line by evaluating the decibel output of each source, the distance to the property line and the path over which the sound travels. Use an applicable noise model, as needed. In general, at a distance of 50 feet from the source over a hard surface, the decibel level decreases by 3 dBA, and over a soft surface (such as grass) the decibel level decreases by 4.5 dBA. For every doubling of distance thereafter, noise levels drop another 3 dBA over a hard surface and 4.5 dBA over a soft surface.³

Compare this information to the Screening Criteria.

2. DETERMINATION OF SIGNIFICANCE

A. Significance Threshold

A project would normally have a significant impact on noise levels from project operations if the project causes the ambient noise level measured at the property line of affected uses to increase by 3 dBA in CNEL to or within the "normally unacceptable" or "clearly unacceptable" category, or any 5 dBA or greater noise increase (see the chart below).

³ *Federal Highway Administration (FHWA), Highway Traffic Noise Prediction Model (FHWA R77-108), 1978.*

| <u>Land Use</u> | <u>Community Noise Exposure</u>
<u>CNEL_d db</u> | | | |
|---|---|---------------------------------|------------------------------|-----------------------------|
| | <u>Normally Acceptable</u> | <u>Conditionally Acceptable</u> | <u>Normally Unacceptable</u> | <u>Clearly Unacceptable</u> |
| Single Family, Duplex, Mobile Homes | 50 - 60 | 55 - 70 | 70 - 75 | above 70 |
| Multi-Family Homes | 50 - 65 | 60 - 70 | 70 - 75 | above 70 |
| Schools, Libraries, Churches, Hospitals,
Nursing Homes | 50 - 70 | 60 - 70 | 70 - 80 | above 80 |
| Transient Lodging - Motels, Hotels | 50 - 65 | 60 - 70 | 70 - 80 | above 80 |
| Auditoriums, Concert Halls, Amphitheaters | - | 50 - 70 | - | above 65 |
| Sports Arena, Outdoor Spectator Sports | - | 50 - 75 | - | above 70 |
| Playgrounds, Neighborhood Parks | 50 - 70 | - | 67 - 75 | above 72 |
| Golf Courses, Riding Stables, Water
Recreation, Cemeteries | 50 - 75 | - | 70 - 80 | above 80 |
| Office Buildings, Business and
Professional Commercial | 50 - 70 | 67 - 77 | above 75 | - |
| Industrial, Manufacturing, Utilities,
Agriculture | 50 - 75 | 70 - 80 | above 75 | - |

Normally Acceptable: Specified land use is satisfactory, based upon the assumption that any buildings involved are of normal conventional construction without any special noise insulation requirements.

Conditionally Acceptable: New construction or development should be undertaken only after a detailed analysis of the noise reduction requirements is made and needed noise insulation features included in the design. Conventional construction, but with closed windows and fresh air supply systems or air conditioning will normally suffice.

Normally Unacceptable: New construction or development should generally be discouraged. If new construction or development does proceed, a detailed analysis of the noise reduction requirements must be made and needed noise insulation features included in the design.

Clearly Unacceptable: New construction or development should generally not be undertaken.

Source: California Department of Health Services (DHS).

B. Methodology to Determine Significance

Environmental Setting

In a description of the environmental setting, include the following information:

- Identification of surrounding land uses, including description, location and distance from the project; and

- Quantification of ambient noise levels (existing and projected at the time of project occupancy) measured in CNEL.

One of the following methodologies can be used to determine ambient noise levels:

- Field measurements involving the use of a noise meter at and surrounding the project site;
- "Presumed Ambient Noise Levels," as set forth in the Los Angeles Municipal Code (LAMC), Section 111.03 (see Exhibit I.1-1⁴); or
- A noise-monitoring program performed according to the procedures set forth in LAMC, Section 111.02 and 112.05. This involves taking measurements at selected locations to establish ambient background noise levels.

Project Impacts

The change in ambient noise levels is measured by adding project-generated operational noise to the projected future ambient noise level at the time of project occupancy. The incremental increase in noise generated by the project is the project impact. Calculate the future exterior ambient noise level according to the procedure outlined above, under Environmental Setting.

Stationary Sources

Review the project description and identify the type, amount, noise impact, and operating characteristics of proposed equipment on the project site (e.g., 24-hour function, sporadic use expected). Identify the distance and the characteristics of the pathway between the noise source and the nearby land uses that would receive the noise. Noise models may be used, as appropriate.

Noise levels 50 feet from a source decrease by approximately 3 dBA over a hard, unobstructed surface, such as asphalt, and by approximately 4.5 dBA over a soft surface, such as a vegetated area. For every doubling of distance thereafter, noise levels drop another 3 dBA over a hard surface and 4.5 dBA over a soft surface. These reduction rates can be used to adjust noise levels at the noise receptor locations, based on their relative distances from the project equipment.

⁴ See I.1. CONSTRUCTION NOISE.

Once noise levels from individual pieces of equipment on the project site have been calculated, logarithmically add together the noise levels from all equipment operating simultaneously. (Noise levels measured in decibels increase logarithmically and cannot be added arithmetically.) Where the noise transmission path between the source and the receptor is complex, consult a noise specialist as necessary.

To determine the change in noise level, subtract the projected ambient noise level without the project's stationary noise from the projected noise level during project operation. Use the chart in the Significance Threshold to determine the significance of the difference.

Mobile Vehicular Sources

Review the project description, determine the number of vehicle trips to be generated by the project, and distribute the trips on the street system (use the traffic study or methodology described in L.1. INTERSECTION CAPACITY). Determine the characteristics of the noise transmission pathway. Using a mobile noise prediction model, project the future exterior ambient noise levels for these streets with and without the proposed project. Base the selected noise model on the Federal Highway Administration (FHWA) highway noise prediction procedures described in FHWA-77-108 or the most recent revision. The City of Los Angeles recommends the use of either LEQV2 or SOUND32 prediction models as developed by California Department of Transportation (Caltrans). LEQV2 requires the following information: (a) traffic volumes, (b) roadway, barrier and receiver geometry, (c) vehicle speed, (d) number of lanes, (e) fleet mix, and (f) drop-off rates. It uses angles, distances and elevations to define source-receptor spatial relationships. SOUND32 requires the following information: (a) traffic volumes, (b) roadway, barrier and receiver geometry, and (c) drop-off rates. This model uses a three dimensional coordinate system to define source-receptor spatial relationships.

If monitoring was used to quantify existing noise levels, use existing traffic conditions (volumes, roadway geometry, etc.) to model the existing noise levels. A comparison of monitored existing noise levels and modeled existing noise levels can be used to calibrate the modeling resulting.

To determine the change in noise level, subtract the projected noise level on the selected roadways without the project's traffic-generated noise from the projected noise level, including the project's traffic-generated noise. Use the chart in the Significance Threshold to determine the significance of the difference.

Noise levels increase approximately 3 dBA for each doubling of roadway traffic volume, assuming that the speed and fleet mix remain constant. A change in vehicle speed can also change noise levels. If vehicle speed and fleet mix can be assumed to remain constant after project implementation, and the project would result in traffic that is less than double the existing traffic, then the project's mobile noise impacts can be assumed to be less than significant.

For a program-level analysis where project details are unknown, assume the full build out of allowable land use and density. Use the methodology above to determine program-generated noise increases.

Cumulative Impacts

For impacts from stationary sources, as feasible, identify the type and amount of equipment to be used by the related projects. Determine whether noise from these sources would impact the same land uses impacted by the proposed project. For those, calculate and logarithmically add the related project noise to project-generated noise to determine the cumulative effect of the activities.

The analysis for project impacts from mobile vehicular sources uses future traffic levels to establish future ambient noise levels. As these traffic levels include trips from the related projects, additional evaluation is not required.

Sample Mitigation Measures

Potential mitigation measures include the following:

Stationary Sources

- Redesign the source to radiate less noise (e.g., substitute a quieter equipment type process or enclose the source with sound absorbent material);
- Use insulation or construct solid barriers between noise sources and noise receivers;
- Separate noise sources from noise receivers by distances sufficient to attenuate the noise to acceptable levels;
- Insulate structures;

- Limit the hours of use for the equipment;
- Prepare an acoustical analysis and adopt the resulting insulation and attenuation measures; and
- Conduct inspections of the equipment prior to issuance of the occupancy permit to verify on-site containment of noise emissions.

Mobile Vehicular Sources

- Attenuate the sound by using barriers, or redirect sound transmission paths;
- Reduce vehicle trip generation, or reduce speed limits on roadways; and
- Locate any delivery, truck loading, or trash pickup areas as far from noise sensitive land uses as possible. Limit designated hours for deliveries.

3. DATA, RESOURCES, AND REFERENCES

Noise Element, 1999. Available from the City Planning Department's Central Publications Unit at 200 N. Spring St., 5th Floor, Los Angeles, California 90012; Telephone: (213) 978-1255.

Noise Ordinance No. 156,363, LAMC Section 111.02 provides sound level measurement procedures.

Noise Ordinance No. 156,363, LAMC Section 111.03 provides ambient noise levels.

Noise Control Act of 1972.

Association of Environmental Professionals (AEP), Thresholds of Significance, Noise Thresholds, 1992.

FHWA Highway Traffic Noise Prediction Model (FHWA-RD-77-108), 1978.

LEQV2 and SOUND32 sound prediction models, developed by Caltrans.

California Noise Insulation Standards, CAC, Title 25, Housing and Community Development.

California Motor Vehicle Code, Section 23130.

Stationary Source Categories

Agricultural operations: Agricultural noise is generated by a host of soil preparation and crop harvesting equipment, pesticide applicators, and conveying and elevating equipment.

Commercial/Institutional: Building service equipment is generally considered a stationary noise source. Building service equipment includes heating, ventilating, and air conditioning facilities, water and waste water systems elevators, and escalators. The most common urban noise source in the air conditioning category is the modern high efficiency-cooling tower, which contains two noise sources - fans and water spray. The increasing use of window or through the wall packaged air conditioning units leads to the generation of noise outside. In addition to their inherent noise characteristics, as these units age, loose metal parts and window frames may rattle.

Home workshops and gardening tools: Noise from these sources includes various motors that operate power mowers, power trimmers, edgers and leaf blowers, and power operated saws and drills.

Industrial: Much of the equipment used in industry and many industrial processes and operations generate noise. The intakes and discharges from fans, compressors, and engines often penetrate the walls of industrial buildings. Even a wholly enclosed industrial plant can generate noise because ducts and piping outside buildings radiate the noises generated from the inside. Inadequately insulated walls and roofs transmit noise. Sheet metal walls, for example, vibrate in response to inside noise and become effective noise radiators. Outdoor industrial operations also constitute sources of noise, including storage operations, steel and scrap yards, and truck and rail freight handling yards.

Lumbering operations: These operations involve the use of diesel powered equipment, chain saws, and hoisting and conveying equipment. Sawmill noise is produced by saws and planers and other lumber shaping equipment, the operation of hoisting and conveying equipment, and the operation of yard and loading equipment.

Mineral production: Mineral production includes both surface and underground mining; sand and gravel pit operations, and crushed rock operations. Noises generated from these sources include sounds emanating from rock crushers, screens, conveyor belts, diesel engines, electric motors, dump trucks, power shovels, rock drills, and blasting.

Petroleum production and refining: Principal sources of noise from petroleum production operations include pressure-reducing valves in pipes, steam turbines, derricks, gear boxes, compressors, electric

motors, diesel engines, and maintenance equipment.

Port Operations: Primary noise sources from port activities include bulk-loading facilities, shipping container-handling equipment, truck traffic, and train movements. The sound of ship engines and trains running contribute to the low steady-state noise emanating from a port, which is punctuated by ship whistles and train horns.

Public and private utilities: Public and private utilities engage in construction activities producing the same kind of noises discussed in I.1 CONSTRUCTION NOISE. They also operate hydroelectric, steam and diesel electric generation plants, compressors, pumps and pipelines, all of which generate noises similar to those discussed above as industrial noise sources.

Public services: Sources of noise from public services include sirens on emergency vehicles, truck and loading noise from rubbish collection and disposal, and equipment noise generated through the maintenance of streets, sewers and water systems.

Mobile Source Categories

Automobiles: The passenger automobile usually makes much less noise than other types of motor vehicles. They produce little exhaust noise except at low frequencies. The combination of wind, gearing, and tire noises produces an identifiable spectrum of noise at speeds over 40 mph and at distances over 100 feet. At higher speeds, this combination of sounds is identifiable at distances up to one mile under quiet ambient conditions. The loudest element of automobile noise at a long distance is the sound of tires.

Buses: Buses tend to radiate less noise than other heavy vehicles because their engine compartments are sealed. Bus noise, however, usually increases with use because of damage to these seals.

Motorcycles: Motorcycle noise is distinctive because, in addition to noise from intake, exhaust, and gearing systems, motorcycles radiate considerable noise directly through the engine walls.

Trucks: Trucks make more noise than other motor vehicles. Diesel trucks are generally the most significant motor vehicle noise source. A single, large diesel truck may produce noise levels equal to noise generated by 30 passenger cars. Under most conditions of operation, exhaust noise predominates. At low speeds, under heavy acceleration, engine and transmission noise may be louder. At high speeds on level roadways, tire noise predominates. Other sources of noise from trucks include the chassis, brakes, sheet metal parts, loose pins, and cargo.

I.3. RAILROAD NOISE

1. INITIAL STUDY SCREENING PROCESS

A. Initial Study Checklist Questions

- XI.a): Would the project result in exposure of persons to or generation of noise levels in excess of standards established in the local general plan or noise ordinance, or applicable standards of other agencies?
- XI.b): Would the project result in exposure of persons to or generation of excessive groundborne vibration or groundborne noise levels?
- XI.c): A substantial permanent increase in ambient noise levels in the project vicinity above levels existing without the project?
- XI.d): A substantial temporary or periodic increase in ambient noise levels in the project vicinity above the existing without the project?

B. Introduction

Railroad operations may increase existing noise levels and/or adversely affect noise-sensitive land uses. The effects of railroad noise depend on factors such as characteristics of the equipment and operations; distance and characteristics of the pathway between the generator and receptor; and weather. Section 17 of the Federal Noise Control Act, rather than state or local regulations, establishes controls and limits on railroad operations, through the United States Environmental Protection Agency (EPA) and United States Department of Transportation (U.S. DOT).

Environmental noise is measured in decibels (dB). To better approximate the range of sensitivity of the human ear to sounds of different frequencies, the A-weighted decibel scale (dBA) was devised. Because the human ear is less sensitive to low frequency sounds, the A-scale de-emphasizes these frequencies by incorporating frequency weighting of the sound signal. When the A-scale is used, the decibel levels are represented by dBA. On this scale, the range of human hearing extends from about 3 dBA to about 140 dBA. A 10 dBA increase is judged by most people as a doubling of the sound level.

To account for the fluctuation in noise levels over time, noise impacts are commonly evaluated using time-averaged noise levels. The Community Noise Equivalent Level (CNEL) represents an energy average of the A-weighted noise levels over a 24-hour period with 5 dBA and 10 dBA

during these time periods and increased human sensitivity to noise during the quieter periods of the day. The Day-Night Sound Level (Ldn), like CNEL, measures noise exposure over a 24-hour period and adds a penalty based on the time of day, although only for late night/early morning hours (10 dBA penalty from 10:00 p.m. to 7:00 a.m.). Thus, the Ldn measurement is slightly less sensitive than CNEL, but it results in very similar noise ratings for most community settings, usually differing by less than 1 dBA.

Railroad operations are generally classified into either line operations or yard operations. Line operations consist of the movements of trains of various types over the main line and local tracks; yard operations are the various activities concentrated in a railway terminal. Yard operations generate noise through the disassembling and recoupling of cars to form new trains, and the maintenance and repair of cars and locomotives. For analytical purposes these may be considered as complex sources of stationary noise. Railroad operations are a much more common source of railroad noise than yard operations. The noise generated by train pass-bys is based on the type of vehicle in use, how it is operated, and the configuration of the track-bed relative to the surrounding terrain. The Federal Transit Authority (FTA) regulates noise generated by moving trains (e.g. whistles, warning signals, wheels on rails), rail maintenance yards, and activity associated with rail facilities.

The Department of Housing and Urban Development (HUD) prepared a Noise Guidebook, which addresses railroad noise, provides guidance on calculating noise levels from railroad operations, and includes a threshold of 3,000 feet between a railroad line and a noise-sensitive land use.

C. Screening Criteria

- Would project development result in a noise-sensitive land use being located within 3,000 feet of a railroad line?
- Would the project result in an increase in the number or length of non-commuter trains operating on existing tracks within 3,000 feet of a noise-sensitive land use?

A "yes" response to any of the preceding questions indicates further study in an expanded Initial Study, Negative Declaration, Mitigated Negative Declaration, or EIR may be required. Refer to the Significance Threshold for Railroad Noise and review the associated Methodology to Determine Significance, as appropriate.

A "no" response to all of the preceding questions indicates that there would normally be no significant impact from Railroad Noise from the proposed project.

D. Evaluation of Screening Criteria

Review the description of the proposed project, including information on railroad activities. Consult a map showing the location of noise-sensitive land uses within 3,000 feet of the project site. Noise-sensitive land uses include residences, schools, libraries, hospitals, day-care facilities, convalescent/retirement homes, and parks. Determine whether the project would result in railroad noise being generated within 3,000 feet of a noise-sensitive land use.

2. DETERMINATION OF SIGNIFICANCE

A. Significance Threshold

A project would normally have a significant impact with regard to exterior noise levels resulting from railroad operations if the project causes noise measured at the property line of a noise sensitive receptor to increase by 3 dBA in CNEL, to or within the "normally unacceptable" or "clearly unacceptable" category, or any 5 dBA or greater noise increase (see the chart below).

| <u>Land Use</u> | <u>Community Noise Exposure</u> | | | |
|---|--|--|-------------------------------------|------------------------------------|
| | <u>CNEL, dB</u> | | | |
| | <u>Normally Acceptable</u> | <u>Conditionally Acceptable</u> | <u>Normally Unacceptable</u> | <u>Clearly Unacceptable</u> |
| Single Family, Duplex, Mobile Homes | 50 - 60 | 55 - 70 | 70 - 75 | above 70 |
| Multi-Family Homes | 50 - 65 | 60 - 70 | 70 - 75 | above 70 |
| Schools, Libraries, Churches, Hospitals,
Nursing Homes | 50 - 70 | 60 - 70 | 70 - 80 | above 80 |
| Playgrounds, Neighborhood Parks | 50 - 70 | --- | 67 - 75 | above 72 |

Normally Acceptable: Specified land use is satisfactory, based upon the assumption that any buildings involved are of normal conventional construction without any special noise insulation requirements.

Conditionally Acceptable: New construction or development should be undertaken only after a detailed analysis of the noise reduction requirements is made and needed noise insulation features included in the design. Conventional construction, but with closed windows and fresh air supply systems or air conditioning will normally suffice.

Normally Unacceptable: New construction or development should generally be discouraged. If new construction or development does proceed, a detailed analysis of the noise reduction requirements must be made and needed noise insulation features included in the design.

Clearly Unacceptable: New construction or development should generally not be undertaken.

Source: California Department of Health Services (DHS).

B. Methodology to Determine Significance

Environmental Setting

In a description of the environmental setting, include the following information:

- Identification of noise-sensitive land uses within 3,000 feet of the project site, including description, location and distance from the site; and
- Ambient noise levels (existing and future) measured in CNEL.

One of the following methodologies can be used to determine ambient noise levels:

- Field measurements involving the use of a noise meter at and surrounding the project site;
- "Presumed Ambient Noise Levels", as set forth in the Los Angeles Municipal Code (LAMC), Section 111.03 (see Exhibit I.1-1¹); and
- A noise measurement program performed according to the procedures in the LAMC, Section 111.02 and 112.05. This involves taking measurements at selected locations to establish ambient background noise levels.

Project Impacts

Review the project description and identify the proposed number and type of rail operations per day. Use a map showing existing land uses to determine the location of, and distance between, sensitive receptors and railroad noise sources.

Guidance in the HUD Noise Guidebook can be used to calculate the resulting Ldn and, thus, CNEL levels. Using Exhibits I.3-1 and I.3-2, and based on the receptor distance from the railroad track, locate the appropriate distance on the horizontal axis (Effective Distance) and vertical axis (Average Daily Number of Operations). At the point of intersection of these two measurements, the diagonal axis will show the Ldn level.

HUD Methodology Assumptions:

- A clear line of sight exists between the railway track and the sensitive receptor;
- There are 50 cars per train;

¹ See I.1. CONSTRUCTION NOISE.

- The average train speed is 30 miles per hour; and
- Nighttime operations represent 15 percent of the 24-hour total.

With diesel locomotives:

- There are two locomotives per train; and
- The site is not near a grade crossing requiring prolonged use of the train's horn or whistle.

With rapid transit and passenger trains:

- Rails are welded together.

If the project characteristics vary substantially from the HUD methodology assumptions, consult a qualified noise specialist for a more detailed analysis, as necessary. For diesel locomotives, the model described in *Assessment of Noise Environment Around Railroad Operations* may be utilized.² It includes variables not included in the HUD model, such as attenuation due to barrier shielding, duration in time of a train pass-by, correction for the presence of additional helper locomotives on an upgrade, and accounting for welded rails, bridges, and grade crossings. In addition, this model has several graphs for use in conjunction with the formula. These graphs include the decibel volume for the duration of a train pass-by depending on distance from the source, the noise level of rail cars based on the speed they are traveling, and the attenuation of sound levels due to a shielding barrier.

Establish the change in noise level from the project. Subtract the projected noise level without the project's railroad operations from the projected noise level with the project's railroad operations. Compare this information to the Significance Threshold.

Cumulative Impacts

As feasible, identify the type and amount of railroad activity expected as a result of related projects. Consider noise-sensitive land uses within 3,000 feet of the proposed and related projects(s). Add the increase in noise at the sensitive receptors from the related projects to that from the proposed project to determine the cumulative impact.

² Wyle Laboratories, *Assessment of Noise Environments Around Railroad Operations*, pages 3-24 - 3-37, 1973.

Sample Mitigation Measures

Potential mitigation measures include the following:

Railroad Lines and Vehicles

- Use continuous welded rail instead of jointed rail on the steel wheel/rail interface;
- Utilize lightweight trucks to minimize unsprung weight;
- Use special grinding (truing) equipment to ensure smooth wheel/rail interaction;
- Use resilient rail fasteners instead of fixed rail fasteners for track fixation;
- Utilize resiliently supported ties where resilient rail fasteners are inadequate; and
- Provide sound barrier walls or insulation.

Rail Yards

- Enclose rail yards with solid fencing or walls;
- Insulate buildings; and
- Include sound attenuators on fans and ducts.

3. DATA, RESOURCES, AND REFERENCES

American Public Transit Association, Guidelines and Principles for Design of Rapid Transit Facilities, 1983.

T.J. Schultz, W.J. Galloway, Office of Policy Development and Research, HUD, Noise Assessment Guidelines - Technical Background, 1980.

U.S. DOT, Los Angeles Rail Rapid Transit Project Final Environmental Impact Statement (EIS), 1983.

EPA, Background Document for Railroad Noise Emission Standards, 1975.

HUD, Noise Guidebook.

Wilson, Ihrig and Associates, Inc., Noise and Vibration Study for the Metro Rail Project, Final Report, 1982.

Wyle Laboratories, Assessment of Noise Environments Around Railroad Operations, 1973 (prepared for Southern Pacific Transportation Co., Union Pacific Railroad, the Atchison, Topeka and Santa Fe Railway Company, the Association of American Railroads.)

See also I.2. OPERATIONAL NOISE.

Railroad Operations and Characteristics

There are three major railroad companies with regular freight traffic operating in the City of Los Angeles: Southern Pacific, Santa Fe, and Union Pacific. The Southern Pacific has an active rail yard in the Boyle Heights area within the City of Los Angeles. The Santa Fe and Union Pacific rail yards are located outside the City of Los Angeles, in the cities of Vernon and Commerce, respectively. In addition, such rapid transit systems as Amtrak, light rail trains (Blue Line), and commuter trains (MetroLink) serve the City of Los Angeles.

There are three general types of railroad vehicles: locomotives, rail cars, and rapid transit vehicles. These vehicles, either in combination with one of the other types or by themselves, form three general train categories. These are freight trains, conventional passenger trains, and rapid transit trains. A freight train consists of one or more locomotives, usually diesel, pulling a combination of various types of freight cars. A conventional passenger train is similar to a freight train in that it consists of one or more locomotives pulling several coaches, but one important difference is that the locomotive may either be diesel-electric or all electric (there are also gas turbine locomotives, but these are few in numbers). The third type, rapid transit trains, differs from the others in that there is not a centralized source of propulsion pulling a series of cars, but rather electric motors on the axles of each car.

A diesel locomotive utilizes a diesel engine driving an electrical alternator or generator, which in turn drives electric traction motors on the wheels. An all-electric locomotive, on the other hand, obtains its electrical power from an external source; normally an overhead line or third rail, to drive its traction motors. Having no propulsion system, freight cars and passenger coaches generate noise mainly by the rolling of the wheels on the rails. The magnitude of the noise depends heavily on the condition of the wheels and track, and on the type of vehicle suspension. In regards to rail cars, modern passenger coaches with auxiliary hydraulic suspension systems in addition to normal springs can be about 10 dBA quieter than older passenger coaches or freight cars which have only springs. The noise of rapid transit trains, even though there are electric motors on each axle that are sources of noise, is also predominantly generated by the interaction of the wheels upon the rails. In fact,

because rapid transit vehicles are usually newer and have better suspension systems, they are generally quieter than freight cars or passenger coaches. Exhibit I.3-4 shows average noise levels for locomotives, locomotives with mufflers and railcars.

Evidence indicates that jointed tracks exceed noise levels produced by welded tracks by up to 8 dBA. Railway traffic noise can be affected by several other sources, including jointed tracks, as indicated in Exhibit I.3-5. Rail yard noise is usually not an issue due to the size of rail yards and their location in less noise sensitive industrial areas. However, Exhibit I.3-6 includes some average noise levels for different sources of rail yard noise.

Selected Legislation

Federal

Section 17 of the Federal Noise Control Act requires that the EPA set noise emission standards for the equipment and facilities of interstate railroad carriers and establishes that the Secretary of Transportation will enforce them. In order to ensure safety considerations and technological availability, any standard or revision to a standard may be issued only after consulting with the Secretary of Transportation. These standards apply to the equipment's use and maintenance. On December 31, 1975, the EPA issued its first railroad noise regulation. This regulation set noise emission standards for locomotives and rail cars operated by interstate rail carriers. The regulation, which became effective December 31, 1976, set the following noise emission standards for locomotives measured from a distance of 100 feet:

- 73 dBA at idle;
- 93 dBA stationary at all other throttle settings; and
- 96 dBA moving at any speed.

The standards established for rail cars were:

- 88 dBA up to 46 miles per hour; and
- 93 dBA greater than 45 miles per hour.

For new locomotives in service after December 31, 1979, the standards set were:

- 70 dBA at idle;
- 87 dBA stationary at all other throttle settings; and
- 90 dBA moving.

In January 1980, the EPA published final noise emission regulations for four railroad noise sources. The regulations, which took effect in January 1984, set additional noise emission standards for rail yard operations and equipment, such as switcher locomotives, retarders, and car coupling.

Local

The Noise Element includes the following guidelines:

- Ensure that any steel track rapid transit system serving the City considers the use of welded rails in preference to jointed rails in order to reduce track vibration noise; and
- Develop a program to encourage railroads to provide noise-attenuating buffers along railroad rights-of-way (ROW) in residential areas.

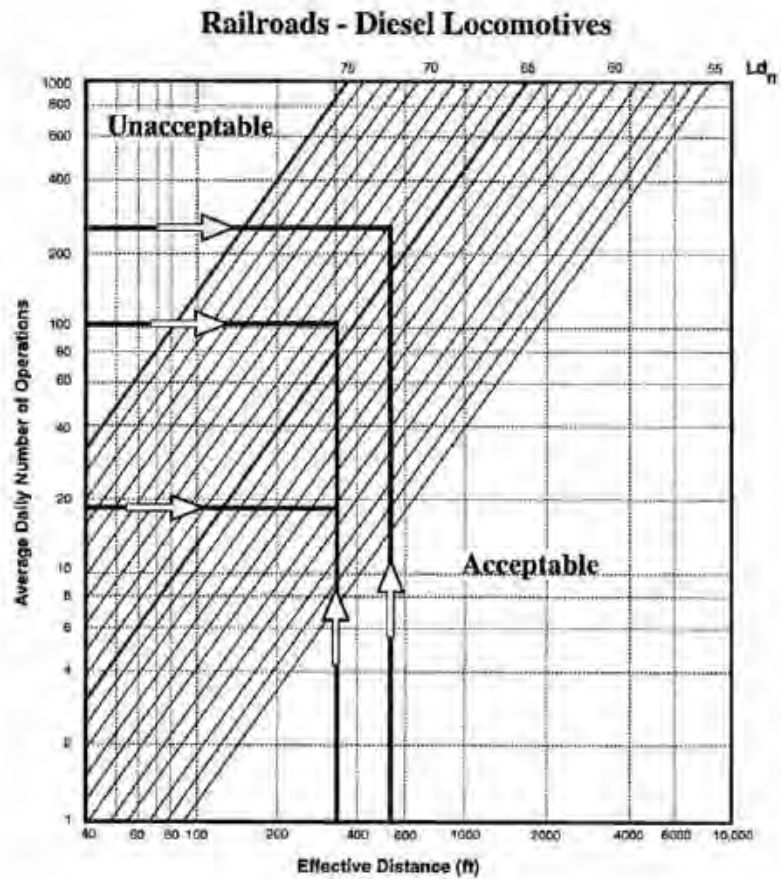


Exhibit I 3-1

Planning
Consultants
Research

FIGURE 1
DIESEL LOCOMOTIVES NOISE

Source: U.S. Department of Housing
and Urban Development

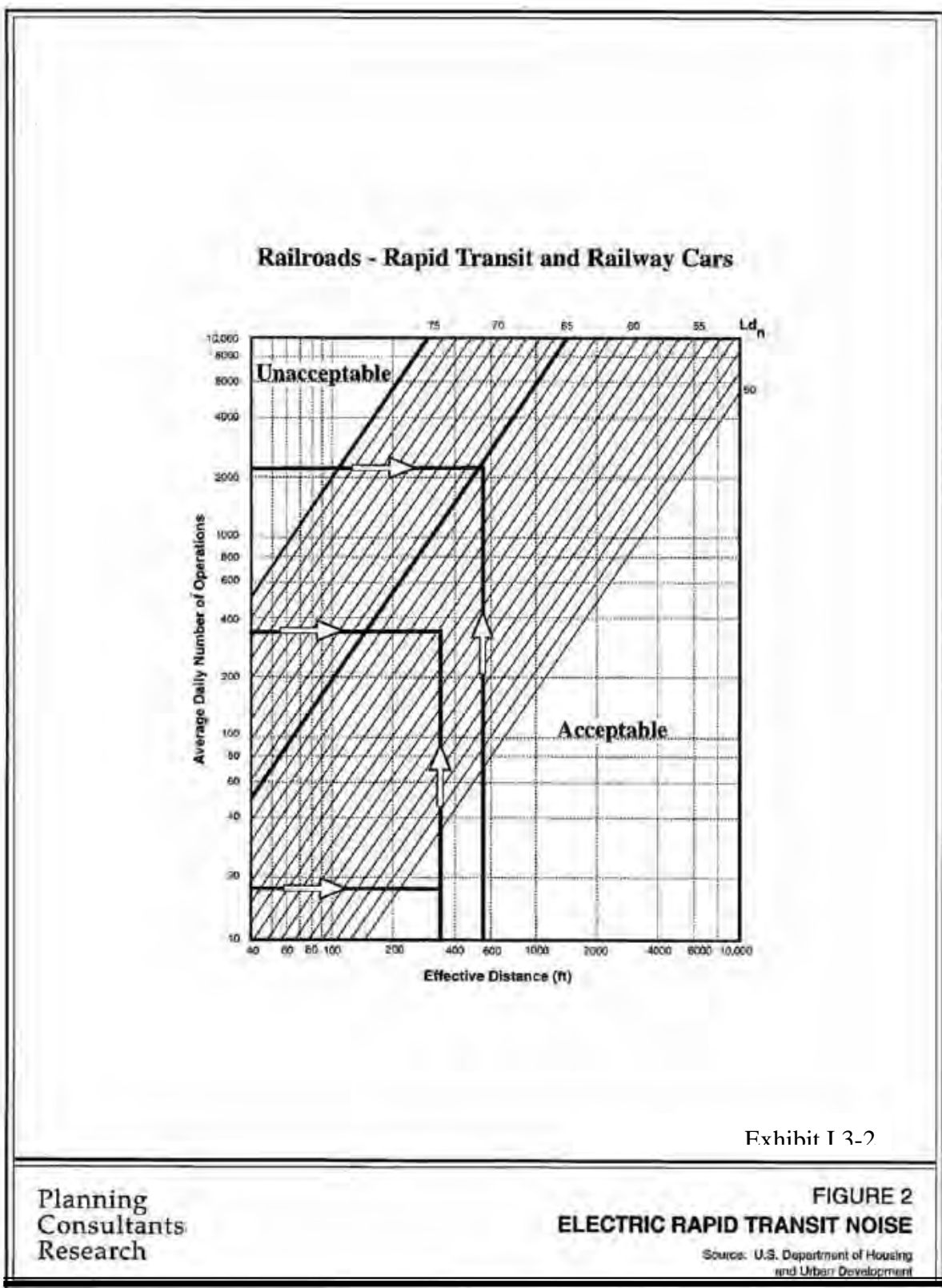


Exhibit I.3-3
AVERAGE LOCOMOTIVE, RAILCAR, AND RAPID TRANSIT NOISE LEVELS

| Type | Overall Maximum ^a
(dBA) |
|--|---------------------------------------|
| Locomotive | 93 |
| Locomotive with Exhaust Muffler | 87 |
| Railcar -less than 45 miles per hour (mph) | 88 |
| Railcar - over 45 mph | 93 |
| Rapid Transit | 85 |

^a At a distance of 100 feet

Source: EPA, Background Document for Railroad Noise Emission Standards, pages 2-2 to 2-4.

Exhibit I.3-4
VARIABLES AFFECTING RAILCAR WHEEL/RAIL NOISE EMISSION

| Variable | Noise Emission ^a |
|---|-----------------------------|
| Jointed Rails (vs. Welded) | 4 to 8 dBA |
| Grade Crossings | 6 to 8 dBA |
| Wheel Irregularities – Flat Spots or Built-up Tread | Up to 15 dBA |
| Bridges | |
| a. Light Steel Structure | Up to 30 dBA |
| b. Heavy Steel Structure | Up to 15 dBA |
| c. Concrete Structure | 0 to 12 dBA |
| Short Radius Curves | |
| a. Less than 600 foot radius | 15 to 25 dBA |
| b. 600 to 900 foot radius | 5 to 15 dBA |

^a These factors are assumed to act individually. When in combinations of two or more, the net increase will not be equal to the sum of each component, but most likely the largest individual factor.

Source: Wyle Laboratories, Assessment of Noise Environments Around Railroad Operations, page 2-3.

Exhibit I.3-5
AVERAGE RAIL YARD NOISE LEVELS

| Noise Source | Level (dBA)^a |
|--|--------------------------------|
| Switcher Movement | 76 - 80 |
| Car Impact | 91 |
| Retarder | 94 - 109 |
| Public Address Systems | 90 - 95 |
| Engine Load Tests | 92 |
| Locomotive Service Racks | 79.5 |
| Mechanical Refrigerator Car - Engine Side | 71 |
| Mechanical Refrigerator Car - Condenser Side | 64 |
| Idling Locomotive | 73 |
| Idling Locomotive with Exhaust Muffler | 70 |

^a At a distance of 100 feet

Source: Wyle Laboratories, Assessment of Noise Environments Around Railroad Operations, pages 4-1 to 4-29.

I.4. AIRPORT NOISE

1. INITIAL STUDY SCREENING PROCESS

A. Initial Study Checklist Questions

- XI.a): Exposure of persons to or generation of noise levels in excess of standards established in the local general plan or noise ordinance, or applicable standards of other agencies?
- XI.b): Exposure of persons to or generation of excessive groundborne vibration or groundborne noise levels?
- XI.c): A substantial permanent increase in ambient noise levels in the project vicinity above levels existing without the project?
- XI.d): A substantial temporary or periodic increase in ambient noise levels in the project vicinity above the existing without the project?
- XI.e): For a project located within an airport land use plan or, where such a plan has not been adopted, within two miles of a public airport or public use airport, would the project expose people residing or working in the project area to excessive noise levels?
- XI.f): For a project within the vicinity of a private airstrip, would the project expose people residing or working in the project area to excessive noise levels?

B. Introduction

New or modified airport and heliport operations and associated aircraft activities may increase existing noise levels and may adversely affect noise-sensitive land uses. The California Department of Transportation's (Caltrans) Division of Aeronautics has developed a set of noise regulations, based on the Federal Aviation Administration's (FAA) Federal Aviation Regulations (FAR), which set noise limits for specific aircraft and provide guidance for land-use compatibility around airports. The effects of airport noise depends on factors such as characteristics of the equipment and operations; distance and pathway between the generator and receptor; and weather. Noise generated due to aircraft flyovers depends upon such variables as type and size of the aircraft (e.g. 2- or 3-engine turbofan versus 4-engine widebody turbofan) and its operating characteristics (primarily its thrust level).

The four airports operated by the City of Los Angeles include Los Angeles International (LAX), Van Nuys, Palmdale, and Ontario. The Burbank-Pasadena-Glendale Airport, due to its proximity to the City, influences the noise environment in some areas of Los Angeles. Noise levels generated by the operation of two other airports within or near the City of Los Angeles, Santa

Monica Municipal Airport and Whiteman Airport, generally do not exceed 65 decibels within the Community Noise Equivalency Level (CNEL) contours, and as such do not strongly influence the City's noise environment.

Environmental noise is measured in decibels (dB). To better approximate the range of sensitivity of the human ear to sounds of different frequencies, the A-weighted decibel scale (dBA) was devised. Because the human ear is less sensitive to low frequency sounds, the A-scale de-emphasizes these frequencies by incorporating frequency weighting of the sound signal. When the A-scale is used, the decibel levels are represented by dBA. On this scale, the range of human hearing extends from about 3 dBA to about 140 dBA. A 10-dBA increase is judged by most people as a doubling of the sound level.

To account for the fluctuation in noise levels over time, noise impacts are commonly evaluated using time-averaged noise levels. CNEL represents an energy average of the A-weighted noise levels over a 24-hour period with 5dBA and 10 dBA penalties added for nighttime noise between the hours of 7:00 p.m. and 10:00 p.m. and 10:00 p.m. to 7:00 a.m., respectively. The penalties were selected to account for reduced ambient noise levels during these time periods and increased human sensitivity to noise during the quieter periods of the day. The Day-Night Sound Level (Ldn), like CNEL, measures noise exposure over a 24-hour period and adds a penalty based on the time of day, although only for late night/early morning hours (10 dBA penalty). Thus, the Ldn measurement is slightly less sensitive than CNEL, but it results in very similar noise ratings for most community settings, usually differing by less than 1 dBA.

For the purpose of airport noise impact analyses, CNEL levels are described as contours. A contour is an interpolation of noise levels drawn to connect all points of a similar level. These contours are displayed on maps and appear similar to topographical contours, forming "footprints" surrounding a noise source.

The FAA regulates noise levels for aircraft at all United States airports. In 1969, FAR Part 36 certified noise levels for specific aircraft. FAR Part 150, Airport Noise Compatibility Planning, which became effective in 1981, provides guidance for land-use compatibility around airports. This FAR established a voluntary program, which provides that airport noise impacts are quantified and made public and that noise compatibility plans and mitigation measures are subject to public review and FAA approval. Part 150 states that in general, residential uses are not compatible within the 65 or above dBA Ldn contour and that all types of land uses are compatible in areas below 65 dBA Ldn. In addition, the FAA's Airport Environmental Handbook indicates that its threshold of significance is a 1.5 dBA Ldn increase in noise in any sensitive area located within the 65 dBA Ldn contour.

The Division of Aeronautics is responsible for granting variances from compliance with state noise laws for airports in California. The Division of Aeronautics has also developed noise regulations, adopted in 1970, which are based in part on the FAR Part 150 guidelines. These regulations state that the aircraft noise level in a residential setting should be no greater than 65 dB CNEL. One of the objectives of the Division of Aeronautics is to create an urban development pattern in which all land included within the 65 dB CNEL contour is devoted to either airport or non-sensitive land uses.

C. Screening Criteria

- If the proposed project includes the construction or expansion of an airport or heliport and has the potential to expose noise-sensitive land uses to high noise levels (through proximity of such land uses to the flight path, etc.), would the project result in an incompatible land use existing within the 65 dB CNEL contour of an airport or heliport?

A "yes" response to the preceding question indicates further study in an expanded Initial Study, Negative Declaration, Mitigated Negative Declaration, or EIR may be required. Refer to the Significance Threshold for Airport Noise and review the associated Methodology to Determine Significance, as appropriate.

A "no" response to the preceding question indicates that there would normally be no significant impact from Airport Noise from the proposed project.

D. Evaluation of Screening Criteria

Review the description of the proposed project, including information on airport activities. Consult a map showing the 65 dB CNEL contour and surrounding land uses. Consider whether potential incompatible land uses have acoustical insulation, an aviation agreement with the airport operator, etc. Operations at commercial airports involving turboprop or piston engine aircraft under 70,000 lbs. have reduced potential to expose sensitive land uses to high noise levels because of the quieter noise levels generated by these aircraft. Compare this information with the screening criteria to determine whether incompatible uses would be located within the 65 dB CNEL contour.

Incompatible land uses include the following¹:

- Residences, including but not limited to, detached single-family dwellings, multi-family dwellings, high-rise apartments, condominiums and mobile homes, unless:

¹ *Division of Aeronautics, Noise Standards (Title 21, Subchapter 6, Article 1) 1990, pages 225-226.*

- An avigation easement² for aircraft noise, has been acquired by the airport proprietor;
 - A dwelling unit which was in existence at the same location prior to January 1, 1989, and has adequate acoustic insulation to ensure an interior CNEL of 45 dB or less due to aircraft noise in all habitable rooms;
 - A residence is a high rise apartment or condominium having an interior CNEL of 45 dB or less in all habitable rooms due to aircraft noise, and an air circulation or air conditioning system, as appropriate;
 - A residence exposed to an exterior CNEL less than 80 dB (75 dB if the residence has an exterior normally occupiable private habitable area) where the airport proprietor has made a genuine effort to acoustically treat the residence or acquire avigation easements for the residence involved, or both, but the property owner has refused to take part in the program; or
 - A residence which is owned by the airport proprietor;
- Public and private schools of standard construction for which an avigation easement for noise has not been acquired by the airport proprietor, or that do not have adequate acoustic performance to ensure an interior CNEL of 45 dB or less in all classrooms due to aircraft noise;
 - Hospitals and convalescent homes for which an avigation easement for noise has not been acquired by the airport proprietor, or that do not have adequate acoustic performance to provide an interior CNEL of 45 dB or less due to aircraft noise in all rooms used for patient care; and
 - Churches and other places of worship for which an avigation easement for noise has not been acquired by the airport proprietor or that do not have adequate acoustic performance to ensure an interior CNEL of 45 dB or less due to aircraft noise.

² *An avigation easement is a legal agreement to purchase the right to fly over a property owner's land without penalty.*

2 DETERMINATION OF SIGNIFICANCE

A. Significance Threshold

A significant impact on ambient noise levels would normally occur if noise levels at a noise sensitive use attributable to airport operations exceed 65 dB CNEL and the project increases ambient noise levels by 1.5 dB CNEL or greater.

B. Methodology to Determine Significance

Environmental Setting

In a description of the environmental setting, include the following:

- Identification of ambient noise levels (existing and future) measured in CNEL. Use the 65 dB CNEL contour map or mathematical models to assess existing (at the expected time of project implementation) noise conditions. Model future noise levels by establishing parameters and assumptions, including aircraft fleet compositions at the airport for which a project is being analyzed, fleet forecasts, appropriate aircraft substitutions, departure profiles, tracks, thrusts settings, operational time of day (day, evening, or night), airport configurations (runway length and location, departure and landing thresholds, etc), and the algorithms used to calculate individual aircraft noise profiles. Use a recognized aircraft noise model, such as one of the following:
 - The Integrated Noise Model (INM), developed by the FAA and used extensively for commercial airports, produces noise contours to geographically demonstrate the location and level of average, weighted noise impacts;
 - The Area Equivalent Method (AEM), developed by the FAA, produces the aggregate area of noise impact without demonstrating the location of specific noise levels; it can be used as a screening tool to determine whether the more sophisticated and time consuming INM is warranted;
 - The Helicopter Noise Model (HNM), developed by the FAA, is used for projects which primarily involve helicopter operations; and
 - The Noise Map, developed by the United States Air Force (USAF), is primarily used to analyze military operations.

- Characterization of noise-sensitive land uses within the 65-dBA contour of airport operations, including the description and location within the contour. Identify noise attenuation devices, aviation easements, and other relevant features of the land uses; and

Project Impacts

Use the information from the Evaluation of Screening Criteria and Environmental Setting and one of the aircraft noise models described above to develop future noise contours. Results from the INM are preferred for commercial airports because of the level of sophistication and detail provided. Identify noise sensitive uses at which noise levels exceed 65 dB CNEL as a result of airport operations. Calculate the increase in ambient noise levels due to project operations at these locations. Compare this information to the Significance Threshold.

Cumulative Impacts

The projection of future baseline ambient noise levels incorporates background increases in noise and airport-related noise from the related projects. Therefore, no new analysis is required.

Sample Mitigation Measures

Possible mitigation measures include the following:

- Redirect air traffic over the ocean (for coastal airports) or over less populated areas;*
- Acquire noise-impacted land. The FAA's Uniform Relocation Assistance and Real Property Acquisition rules and provisions govern land acquisition and relocation assistance;
- Purchase aviation easements;
- Reduce the number of flights during evening and nighttime hours;*
- Increase takeoff angles within safety parameters or reducing thrust settings, depending on proximity and configuration of surrounding land uses;*
- Plan runway utilization schedules to take into account adjacent residential areas, noise characteristics of aircraft, and noise-sensitive time periods;*

- Employ shielding to obstruct the noise path to incompatible uses, using natural terrain, buildings, and other obstructions to noise; and
- Develop compatible land uses within the noise boundary through rezoning, or application of acoustical insulation.

** Strategies marked with * require FAA approval*

3. DATA, RESOURCES, AND REFERENCES

Los Angeles World Airports, Van Nuys Airport Noise Control Regulation EIR, 1992.

Los Angeles World Airports, Draft Van Nuys Airport Master Plan, 1995.

Division of Aeronautics, Noise Standards, 1990.

FAA, Airport Environmental Handbook, 1985.

See also I.2. OPERATIONAL NOISE.

Selected Legislation

Federal

FAR, Part 36

Establishes noise standards and provisions for issuing certificates for various types of aircraft. Also, the aircraft must meet the airworthiness regulations constituting the type certification basis of the aircraft under the conditions in which compliance with this part is shown.

FAR, Part 150

Describes the procedures, standards, and methodology governing the development, submission, and review of airport noise exposure maps and airport noise compatibility programs, including the process for evaluating and approving or disapproving those programs. Makes matching funds available for abatement programs.

State

California Airport Noise Standards Act, 1970 (CAC, Title 4)

Implements the FAA airport standards, administered by the State Division of Aeronautics. Requires civilian airports to meet FAA noise standard of 65 dB CNEL at airport boundaries.

CCR, Title 21 (Business Regulations)

Requires airports to monitor noise impacts and report to the County Airport Land Use Commission and State Division of Aeronautics on a quarterly basis.

This page intentionally left blank.

J. POPULATION AND HOUSING

J.1. POPULATION AND HOUSING GROWTH

1. INITIAL STUDY SCREENING PROCESS

A. Initial Study Checklist Question

- XII.a): Would the project induce substantial population growth in an area either directly (for example, by proposing new homes and businesses) or indirectly (for example, through extension of roads or other infrastructure)?
- XII.b): Would the project displace substantial numbers of existing housing, necessitating the construction of replacement housing elsewhere?

B. Introduction

The quantity and distribution of population and households in the City affects the environment, use of infrastructure, and the demand for public services. Thus, in order to respond to and plan for future population and households, the General Plan, including the Framework and Housing Elements, and the Southern California Association of Government (SCAG) Regional Comprehensive Plan and Guide (RCP&G) include forecasts of population and housing trends.¹ Because the projections are used to plan the infrastructure and level of service required to support the future population, actual growth in excess of the projections can lead to deficiencies. According to the CEQA Guidelines Section 15064(e): “Economic and social changes resulting from a project shall not be treated as significant effects on the environment. Economic or social changes may be used, however, to determine that a physical change shall be regarded as a significant effect on the environment.” Population and housing growth are examples of economic and social changes.

Population refers to the occupants of housing projects, population indirectly associated with workers of proposed non-residential projects, or changes in the amount and distribution of

¹ *The City of Los Angeles uses two different estimates of its population. The first is prepared by the California Department of Finance (DOF) and provided to SCAG. For purposes of conformity with the requirements of these other agencies, the City uses this estimate when and where appropriate. The City Planning Department prepares an estimate of its population based on a number of locally derived factors including: building and demolition permits issued, school enrollments, and the percentage of active electric meters. The City Planning Department estimates are used for planning purposes in the City of Los Angeles. It should be noted that both sets of numbers are estimates and, therefore, only close approximations of the actual population. Every 10 years these estimates are reconciled by the U.S. Census.*

population and employment permitted by adoption or revision to a land use plan. Important areas include changes in the number, characteristics, geographic distribution, and timing of new residents directly or indirectly resulting from a proposed project, and the degree to which project-related changes are consistent with City, regional or other adopted population growth policies. Other issues are the degree to which project-related population is already present in the area under analysis (i.e., already residing or working in the area), or whether they represent in-migrants (i.e., likely to relocate into the area from some other more distant location as a result of the project).

Housing impacts may result directly from projects, which include housing units, or indirectly from, for example, revisions to the Housing Element or changes in housing demand associated with new non-residential development projects. Important issues include changes in the number, characteristics (including rent level or purchase price), geographic distribution, and timing of new housing units associated with a proposed project, supply-demand relationships, and the degree to which project-related changes are consistent with City, regional or other adopted housing growth policies.

C. Screening Criteria

- Would the project include a General Plan amendment, which could result in an increase in population over that projected in the adopted Community Plan or General Plan?
- Would the project induce substantial growth on the project site or surrounding area?

A "yes" response to any of the preceding questions indicates further study in an expanded Initial Study, Negative Declaration, Mitigated Negative Declaration or EIR may be required. Refer to the Significance Threshold for Population and Housing Growth, and review the associated Methodology to Determine Significance, as appropriate.

A "no" response to all of the preceding questions indicates that there would normally be no significant impact on Population and Housing Growth from the proposed project.

D. Evaluation of Screening Criteria

Review the description of the proposed project and the surrounding area. Determine whether the project includes a General Plan amendment, and identify the potential to induce substantial growth. General Plan amendments which could result in an increase in population are those for which the population in the planning subregion containing the project site would exceed the population forecast in the Framework Element after buildout to the maximum amount permitted under the General Plan amendment. The potential to induce substantial growth may be indicated by the introduction of a project in an undeveloped area or the extension of major infrastructure. As

necessary, contact the City Planning Department Demographics and Framework Monitoring Sections for current analysis, data, and department policy. Examples of major infrastructure systems include: major roads, highways, or bridges; major utility or service lines; major drainage improvements; or grading which would make accessible a previously inaccessible area. Compare this information to the Screening Criteria.

2. DETERMINATION OF SIGNIFICANCE

A. Significance Threshold

The determination of significance shall be made on a case-by-case basis, considering the following factors:

- The degree to which the project would cause growth (i.e., new housing or employment generators) or accelerate development in an undeveloped area that exceeds projected/planned levels for the year of project occupancy/buildout, and that would result in an adverse physical change in the environment;
- Whether the project would introduce unplanned infrastructure that was not previously evaluated in the adopted Community Plan or General Plan; and
- The extent to which growth would occur without implementation of the project.

B. Methodology to Determine Significance

Environmental Setting

In a description of the environmental setting, include the following information:

- Recent population and housing growth trends for the planning subregion containing the project site (e.g., past 10 years);
- Forecast or projection of population and housing growth for the planning subregion containing the project site; and
- Summary of population and/or housing growth policies that affect or regulate the project site. These may include, for example, the Community Plan, General Plan

(including the Framework and Housing Elements), redevelopment plan, the City's Housing and Urban Development (HUD) Consolidated Plan, or SCAG's RCP&G.

Project Impacts

Determine the amount of growth from the project by calculating the number of housing units included as part of the project and the occupancy of the units. Occupancy is related to design and the number of bedrooms per unit (i.e., for seniors, large families, etc.). For non-residential uses, estimate the population associated with employees based on the type of use and the corresponding type of employment (e.g., degree of skill required, wage levels, likelihood of causing in-migration). To evaluate the degree to which the project would exceed adopted population or housing projections for the planning subregion containing the project site, consider forecasts found in, for example, the applicable specific plan, General Plan, Framework Element, Community Plan, redevelopment plan, or RCP&G. A physical change in the environment would affect the land, air, water, flora, fauna, noise conditions, minerals, objects of historic or aesthetic significance, etc.

If the project is in an area that is currently undeveloped or unserved by major infrastructure, and the project would introduce infrastructure or accelerate development, then non-contiguous "leapfrog" or other undesirable or inefficient development patterns may result if project growth is not consistent with adopted projections and policies. Consider whether the proposed infrastructure has been analyzed or planned for in the Community Plan. Examples of major infrastructure systems include: major roads, highways, or bridges; major utility or service lines; major drainage improvements; or grading which would make accessible a previously inaccessible area.

Evaluate the extent to which growth would occur without implementation of the project by determining the amount, timing, and location of growth contemplated for the project site and surrounding area in the adopted population and housing projections. Compare this to the growth anticipated with the proposed project and determine whether potential impacts are significant.

Cumulative Impacts

Determine the increase in housing units, occupancy and population associated with the related projects in the same manner as described above under Project Impacts. Compare the combined effect of the growth from the project and the related projects to the amount, timing and location of growth forecast for the project site and surrounding area in the adopted population and housing projections. If the area is currently underdeveloped or the project

introduces new major infrastructure, also note whether the project or related projects would introduce infrastructure or accelerate development.

Sample Mitigation Measures

As noted in the Introduction, population and housing growth are not considered significant effects on the environment. Secondary or indirect impacts, such as increased traffic or noise, may be significant and may be physical changes caused by population and housing growth. Thus, mitigating these secondary impacts may mitigate the effects of population and housing growth.

3. DATA, RESOURCES, AND REFERENCES

City of Los Angeles: For adopted housing policies, see the Housing and Framework Elements and the City's HUD Consolidated Plan. The HUD Consolidated Plan is updated annually in July, and is available from the Community Development Department (CDD) at 215 West Sixth Street, Los Angeles, California 90014; Telephone: (213) 485-4682. For current population and housing estimates, see Population and Housing Estimates, 1999 (updated periodically), City Planning Department, Demographical Research Unit, 200 N. Spring St., 7th Floor, Los Angeles, California 90012; Telephone: (213) 978-1416; Internet: www.lacity.org/PLN (click on *Statistical Info*).

SCAG: RCP&G, Chapter 3: Growth Management. SCAG's regional growth forecast to the year 2025 is available in a Small Area Forecast edition, which includes employment, households and population (including limited characteristics) at the census tract level for the entire six-county SCAG region. Available at SCAG offices, 818 West Seventh Street, 12th Floor, Los Angeles, California 90017; Telephone: (213) 236-1800; Internet: www.scag.ca.gov.

Center for the Continuing Study of the California Economy (CCSCE): This research center based in Palo Alto, California, publishes an annual five-year forecast of economic and population growth at the county level. See for example, California County Projections, which includes data on population growth, household growth, and income growth, for each county in the state, including Los Angeles County. CCSCE is located at 610 University Avenue, Palo Alto, CA 94301; Telephone: (650) 321-8550.

U.S. Census of Population and Housing: The Bureau of the Census is generally regarded as the most authoritative source of population and housing data, although its estimates are only prepared every 10 years. Summary Tape Files 1 and 3 provide the most commonly used data, at a scale as small as a census block. Available at public libraries.

J.2. POPULATION AND HOUSING DISPLACEMENT

1. INITIAL STUDY SCREENING PROCESS

A. Initial Study Checklist Question

- XII.b): Would the project displace substantial numbers of existing housing, necessitating the construction of replacement housing elsewhere?
- XII.c): Would the project displace substantial numbers of people, necessitating the construction of replacement housing elsewhere?

B. Introduction

Within the City of Los Angeles, the supply of and demand for housing, especially affordable housing, indicates that the existing stock should be preserved, maintained, and expanded in order to provide for the population. The CEQA Guidelines Section 15064(e) states “economic and social changes resulting from a project shall not be treated as significant effects on the environment. Economic or social changes may be used, however, to determine that a physical change shall be regarded as a significant effect on the environment.”

A recent study prepared for the Housing Department¹ explored some of the current housing problems in the City of Los Angeles, including:

- Lack of growth in the supply of housing despite an increasing number of households;
- Household-housing type mismatch because average unit size is small and declining, while average household size is large and increasing;
- Overcrowding; and
- Increasing rent burden such that more than 30 percent of income goes for rent. This situation is related to household size, income, ethnicity, as well as the age of the head of the household.

¹ *Housing Department, 1994 Housing Study, prepared by Hamilton, Rabinovitz & Alschuler, Inc., December 1995.*

Adopted City programs and policies, designed to increase and conserve the supply of housing, particularly the supply of housing affordable to lower-income households, are contained in the Housing and Framework Elements, the Housing and Urban Development (HUD) Consolidated Plan, redevelopment plans, and the Rent Stabilization Ordinance. Examples of these policies and other regulations include:

- Housing Element, which discourages the demolition of affordable housing and encourages the replacement of affordable housing; obligates the City to provide relocation services to persons who are displaced as a result of City actions; and mandates mitigation of relocation and displacement hardships caused by housing demolitions, conversions or neighborhood gentrification;
- Comprehensive Housing Affordability Study (CHAS) -- a component of the HUD Consolidated Plan -- which contains a description of current housing policy, particularly with respect to low-income housing needs;
- The Rent Stabilization Ordinance, which includes requirements for relocation payments to tenants under “no-fault” evictions;
- State redevelopment law which specifies actual relocation assistance, in addition to payments, for displaced households and requires replacement of all lost units that occur within or as a result of redevelopment projects subject to a written agreement with the redevelopment agency or where financial assistance is provided by the redevelopment agency; and
- Federal law that mandates relocation payments and assistance when displacement results from a project supported with federal funds (e.g., HUD financing).

C. Screening Criteria

- Would the project result in a net loss of housing equal to or greater than a one-half block equivalent of habitable housing units through demolition, conversion, or other means? (One-half block is generally equivalent to 15 single-family or 25 multi-family dwelling units.)

- Would the project result in the net loss of any existing housing units affordable to very low- or low-income households (as defined by federal and/or City standards), through demolition, conversion, or other means?

A "yes" response to any of the preceding questions indicates further study in an expanded Initial Study, Negative Declaration, Mitigated Negative Declaration or EIR may be required. Refer to the Significance Threshold for Population and Housing Displacement, and review the associated Methodology to Determine Significance, as appropriate.

A "no" response to all of the preceding questions indicates that there would normally be no significant impact on Population and Housing Displacement from the proposed project.

D. Evaluation of Screening Criteria

Review the description of the proposed project and determine the number and type of housing units, which will be eliminated and added as a result of the proposed project. Calculate the net change in the number of habitable housing units, as well as units affordable to very low- or low-income households (See Exhibit J.2-1). Affordable units can be lost through conversion to market rate units. Compare this information to the Screening Criteria.

2. DETERMINATION OF SIGNIFICANCE

A. Significance Threshold

The determination of significance shall be made on a case-by-case basis, considering the following factors:

- The total number of residential units to be demolished, converted to market rate, or removed through other means as a result of the proposed project, in terms of net loss of market-rate and affordable units;
- The current and anticipated housing demand and supply of market rate and affordable housing units in the project area;
- The land use and demographic characteristics of the project area and the appropriateness of housing in the area; and

- Whether the project is consistent with adopted City and regional housing policies such as the Framework and Housing Elements, HUD Consolidated Plan and CHAS policies, redevelopment plan, Rent Stabilization Ordinance, and the Regional Comprehensive Plan and Guide (RCP&G).

B. Methodology to Determine Significance

Environmental Setting

In a description of the environmental setting, include the following information:

- Description of existing land uses on the project site and in the surrounding area;
- Recent (e.g., past 10 years) housing supply and demand trends, as well as housing supply characteristics (e.g., vacancy patterns, tenure, rent and sale price levels) for the project site and surrounding area;
- Housing supply and demand forecasts for the project site and surrounding area; and
- Summary of housing displacement policies applicable to the project. These may include policies in the Framework and Housing Elements, HUD Consolidated Plan, redevelopment plans, and the Rent Stabilization Ordinance.

Project Impacts

Review the description of the proposed project and identify the net change in the number of habitable housing units, as well as units affordable to low- and very-low income households, from the Evaluation of Screening Criteria.

To determine current and anticipated housing demand and supply in the project area, use the Population Estimate and Housing Inventory prepared by the City Planning Department, field research, published reports, or market research studies, as appropriate.

In evaluating the characteristics of the project area, survey the land uses and zoning designations for parcels in the surrounding area. Determine the character of the area and any recent housing trends, and consider the appropriateness of housing in that location in light of applicable housing policies and plans. Land use compatibility is addressed in H.2 LAND USE COMPATIBILITY.

Identify adopted housing projects in, for example, the applicable redevelopment plans, the Framework Element, HUD Consolidated Plan, Rent Stabilization Ordinance, or RCP&G. If necessary, consult with the City Planning Department, Housing Department, or Community Redevelopment Agency (CRA) of the City of Los Angeles.

Evaluate whether the project would be consistent with these policies.

Cumulative Impacts

Determine the number and type of housing units to be eliminated and added as a result of the related projects in the same manner as described above for Project Impacts. Compare the combined effect of the displacement from the project and the related projects to the current and anticipated housing demand and supply in the project area and adopted housing policies.

Sample Mitigation Measures

Potential mitigation measures include the following:

- Exceed the statutory requirements for relocation assistance; and
- Increase the number of housing units affordable to lower income households.

3. DATA, RESOURCES, AND REFERENCES

Population and Housing Estimates are available from the City Planning Department, Citywide Demographics Unit, 200 N. Spring Street, 7th Floor, Los Angeles, California 90012; Telephone: (213) 978-1416; Internet: www.lacity.org/PLN (click on *Statistical Info*).

Redevelopment plans are available from the CRA, 354 South Spring Street, Suite 800, Los Angeles, California 90013; Telephone: (213) 977-1600.

Rent Stabilization Ordinance, City of Los Angeles, adopted 1979 (periodically updated and revised). Available at the Housing Department's Public Counter, 3550 Wilshire Boulevard, 15th floor, Los Angeles, California 90010, open Monday through Friday from 8:00 a.m. to 4:30 p.m., or call toll free (866) 557-7368.

Housing Department, 1994 Rental Housing Study, prepared by Hamilton, Rabinovitz & Alschuler, Inc., December 1995.

See also J.1. POPULATION AND HOUSING GROWTH.

Selected Legislation

Federal

24 CFR Part 970.5

Tenants who are to be displaced as a result of demolition or disposition must be relocated to other decent, safe, sanitary, and affordable housing (at rents no higher than permitted under the Uniform Relocation Assistance and Real Property Acquisition Policies Act). The new housing, to the maximum extent practicable, should be housing of the tenants' choice, on a nondiscriminatory basis, without regard to race, color, religion (creed), national origin, handicap, age, or sex, in compliance with applicable Federal and State laws.

In addition to provision of relocation housing, assistance to all displaced tenants includes assistance in finding other suitable housing, including payment of actual, reasonable moving costs, and counseling and advisory services to assure that full choices and real opportunities exist for tenants displaced from public housing scheduled for demolition or other disposition to select relocation housing in a full range of neighborhoods in which suitable relocation housing may be found, in and outside areas of minority concentration.

Exhibit J.2-1

**MAXIMUM AFFORDABLE RENT
FOR VERY LOW- AND LOW-INCOME HOUSEHOLDS
IN THE CITY OF LOS ANGELES, FY 2003**

| Household Income Category
as Percent of Median
Family Income (MFI) | Household Size | | | | | |
|---|------------------------|-------------------------|-------------------------|-------------------------|-------------------------|-------------------------|
| | <u>1-Person</u> | <u>2-Persons</u> | <u>3-Persons</u> | <u>4-Persons</u> | <u>5-Persons</u> | <u>6-Persons</u> |
| Very Low-Income
(up to 50% of MFI) | | | | | | |
| Maximum Household Income ^a | \$19,740 | \$22,560 | \$25,380 | \$28,200 | \$30,456 | \$32,712 |
| Maximum Monthly Rent ^b | 494 | 564 | 635 | 705 | 761 | 818 |
| | | | | | | |
| Low-Income
(51-80% of MFI) | | | | | | |
| Maximum Household Income
(73% of MFI) ^a | \$28,820 | \$32,938 | \$37,055 | \$41,172 | \$44,466 | \$47,760 |
| Maximum Monthly Rent ^b | 720 | 823 | 926 | 1,029 | 1,112 | 1,194 |
| | | | | | | |

^a Per Department of HUD.

^b Assumes 30% of monthly income for rent, rounded to nearest dollar.

Source: Department of HUD; Hamilton, Rabinowitz & Alschuler, Inc., 1996 and the City of Los Angeles Housing Department, 2003.

This page intentionally left blank.

K. PUBLIC SERVICES

K.1. POLICE PROTECTION

1. INITIAL STUDY SCREENING PROCESS

A. Initial Study Checklist Question

XIII.a.ii): Would the project result in substantial adverse physical impacts associated with the provision of new or physically altered governmental facilities, need for new or physically altered governmental facilities, the construction of which could cause significant environmental impacts, in order to maintain acceptable service ratios, response times or other performance objectives for police protection?

B. Introduction

Public protection service and law enforcement are provided by the Los Angeles Police Department (LAPD) which operates 18 stations (also called areas) citywide within four Bureaus (Central, South, West, and Valley). Statistical data is compiled by Reporting Districts, smaller units within the stations.

Service needs are related to the size of the population and geographic area served, the number and type of calls for service, and other community characteristics. Projects that affect these factors may increase the demand for service from the LAPD.

The effect of increased traffic congestion on response times for police protection and other emergency services is discussed in K.2. FIRE PROTECTION AND EMERGENCY MEDICAL SERVICES.

C. Screening Criteria

- Would the proposed project result in a net increase of 75 residential units, 100,000 square feet (sf) of commercial floor area, or 200,000 sf of industrial floor area?

A "yes" response to the preceding question indicates further study in an expanded Initial Study, Negative Declaration, Mitigated Negative Declaration, or EIR may be required. Refer to the Significance Threshold for Police Protection, and review the associated Methodology to Determine Significance, as appropriate.

A "no" response to the preceding question indicates that there would normally be no significant impact on Police Protection from the proposed project.

D. Evaluation of Screening Criteria

Review the description of the proposed project and determine the type of land use(s) proposed (i.e., commercial, industrial, residential), and the size of the project (i.e., number of units, square footage). Compare this information to the Screening Criteria.

2. DETERMINATION OF SIGNIFICANCE

A. Significance Threshold

The determination of significance shall be made on a case-by-case basis, considering the following factors:

- The population increase resulting from the proposed project, based on the net increase of residential units or square footage of non-residential floor area;
- The demand for police services anticipated at the time of project buildout compared to the expected level of service available. Consider, as applicable, scheduled improvements to LAPD services (facilities, equipment, and officers) and the project's proportional contribution to the demand; and
- Whether the project includes security and/or design features that would reduce the demand for police services.

B. Methodology to Determine Significance

Environmental Setting

In a description of the environmental setting, include the following information:

- Name and characteristics of the station and Reporting District in which the project is located. If the Bureau, station, and Reporting District are unknown, refer to Exhibits K.1-1 through K.1-19; and

- Description of scheduled improvements to LAPD services (facilities, equipment, and officers) at the station serving the project site.

Project Impacts

Consider the description and location of the project. Determine the net population increase resulting from the project. The population conversion factors below may be used.

Based on consultation with LAPD, evaluate the demand for police services anticipated at the time of project buildout compared to the expected level of service available. Consider, as applicable, scheduled improvements (facilities, equipment, and officers) and the project's proportional contribution to the demand.

Evaluate project security features (e.g., security cameras, officers, lights, fencing, gates, etc.) if any, and any other project features, which would reduce the expected demand for police service.

POLICE SERVICE POPULATION CONVERSION FACTORS

| <u>Land Use</u> | <u>Conversion Factor</u> |
|---------------------------------|--------------------------|
| Residential | |
| Single, one-, two-bedroom units | 3 persons/unit |
| Three-, four-bedroom units | 4 persons/unit |
| Office | 4 persons/1,000 sf |
| Retail | 3 persons/1,000 sf |
| Hotel | 1.5 persons/room/day |

Cumulative Impacts

Identify the related projects, which would be served by the same LAPD facilities as the proposed project. Consider the characteristics of the related projects in terms of size, location, and types of land uses. Determine the net population increase resulting from the related projects. Based on consultation with LAPD, evaluate the cumulative demand for police services anticipated at the time of project buildout compared to the expected level of service available. Consider, as applicable, scheduled improvements (facilities, equipment, and officers) to the relevant LAPD facilities. As feasible, evaluate known security features (e.g., security cameras, officers, lights, fencing, gates, etc.) and any other features, which will reduce

the expected cumulative demand for police service. Consider the combined impact of the proposed and related projects and the project's proportional contribution to the cumulative demand.

Sample Mitigation Measures

Potential mitigation measures include the following:

- Require the project applicant to consult with the LAPD's Crime Prevention Section on the design and implementation of a security plan for the proposed project. Consider the following elements:
 - use of private security guards to monitor and patrol the project site during project construction and operation;
 - design entryways, elevators, lobbies and parking areas with lighting that eliminates areas of concealment;
 - eliminate areas of dead space;
 - provide solid core doors with deadbolt locks to all offices, shops, and hotel units; and
 - provide walls and fencing around parking areas.

3. DATA, RESOURCES, AND REFERENCES

LAPD, Crime Prevention Section, Telephone: (213) 485-3134.

Safety Element

Environmental and Public Facilities Maps (1996):

- Police Department Facilities; and
- Police Department Community Outreach Centers.

Exhibit K.1-1 **Location of Los Angeles Police Department Bureaus and Areas**

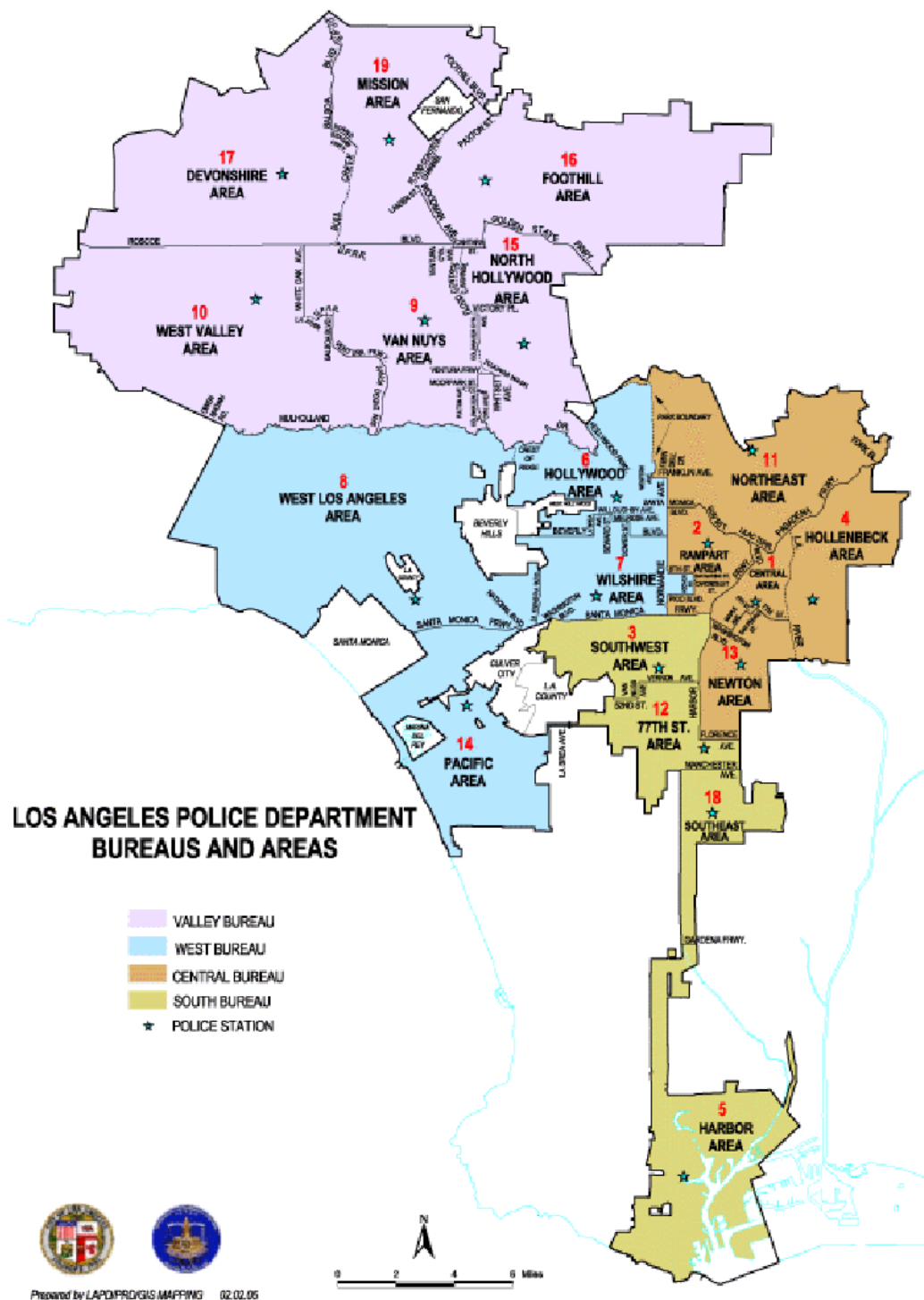


Exhibit K.1-1, continued
KEY TO LOCATION OF LOS ANGELES POLICE BUREAUS/AREAS

CENTRAL BUREAU

251 E. 6th Street, LA, CA 90014
(213) 485-3101

Central Area
251 E. 6th Street, LA, CA 90014
(213) 485-3294

Rampart Area
2710 W. Temple Street, LA, CA 90026
(213) 485-4061

Hollenbeck Area
2111 E. First Street, LA, CA 90033
(213) 485-2942

Northeast Area
3353 San Fernando Road, LA, CA 90065
(213) 485-2563

Newton Area
3400 South Central, LA, CA, 90011
(323) 846-6524

WEST BUREAU

4849 West Venice, Suite 213, LA, CA 90019
(213) 473-0277

Hollywood Area
1358 N. Wilcox Avenue,
Hollywood, CA. 90028
(213) 485-4302

Wilshire Area
4861 Venice Boulevard, LA, CA. 90019
(213) 485-4022

West Los Angeles Area
1663 Butler Avenue, LA, CA. 90025
(310) 575-8404

Pacific Area
12312 Culver Boulevard, LA, CA. 90066
(310) 202-4502

VALLEY BUREAU

6240 Sylmar Avenue, Van Nuys, CA 91401
(818) 756-8303

Van Nuys Area
6240 Sylmar Avenue, Van Nuys, CA 91401
(818) 756-8343

West Valley Area
19020 Vanowen Street, Reseda, CA 91335
(818) 756-8542

North Hollywood Area
11640 Burbank Blvd., North Hollywood, CA 91601
(818) 756-8861

Mission Area
11121 Sepulveda Blvd, Mission Hills, CA 91345
(818) 838-9800

Foothill Area
12760 Osborne Street, Pacoima, CA 91331
(818) 756-8861

Devonshire Area
10250 Etiwanda Avenue, Northridge, CA 91325
(818) 756-8285

SOUTH BUREAU

7600 S. Broadway, LA, CA 90003
(213) 485-4251

Southwest Area
1546 Martin Luther King Jr. Boulevard, LA,
CA 90062
(213) 485-2582

SOUTH BUREAU(cont.)

Exhibit K.1-1, continued
KEY TO LOCATION OF LOS ANGELES POLICE BUREAUS/AREAS

| | |
|--|---|
| Harbor Area
2175 John S. Gibson Boulevard
(310) 548-7605 | Central Facilities Building
251 E. 6 th Street, Room 221
Los Angeles, CA 90014
(213) 485-4091 |
|--|---|

| | |
|--|--|
| 77 th Street Area
7600 S. Broadway, LA, CA 90003
(213) 485-4164 | Motor Transport Division
151 N. San Pedro Street
Los Angeles, CA 90012
(213) 485-3495 |
|--|--|

| | |
|---|---|
| Southeast Area
145 W. 108 th Street
(213) 485-6914 | Police Training and Education
1880 N. Academy Drive
Los Angeles, CA 90012
(213) 847-3000 |
|---|---|

OTHER FACILITIES

| | |
|---|---|
| Parker Center
150 N. Los Angeles Street
Los Angeles, CA 90012
(213) 485-3266 | Ahmanson Recruit Training Center
5651 W. Manchester Boulevard
Los Angeles, CA 90045
(213) 342-3010 |
|---|---|

| | |
|--|---|
| Air Support Division
555 E. Ramirez Street
Los Angeles, CA 90012
(213) 485-2600 | The Edward M. Davis EVOC
Firearms/Tactics Training Facility
12001 Blucher Avenue
Granada Hills, CA 91344
818-832-3700 |
|--|---|

| | |
|--|---|
| LAX SubStation
802 World Way
Los Angeles, CA 90045
310-646-2255
Airport Substation
(213) 485-5299 | Supply Division
555 E. Ramirez Street
Los Angeles, CA 90012
(213) 485-2909 |
|--|---|

Jail Division
150 N. Los Angeles Street
Los Angeles, CA 90012
(213) 485-2547

Juvenile Division
150 N. Los Angeles Street
Los Angeles, CA 90012
(213) 485-2801

Metropolitan Division

Exhibit K.1-2

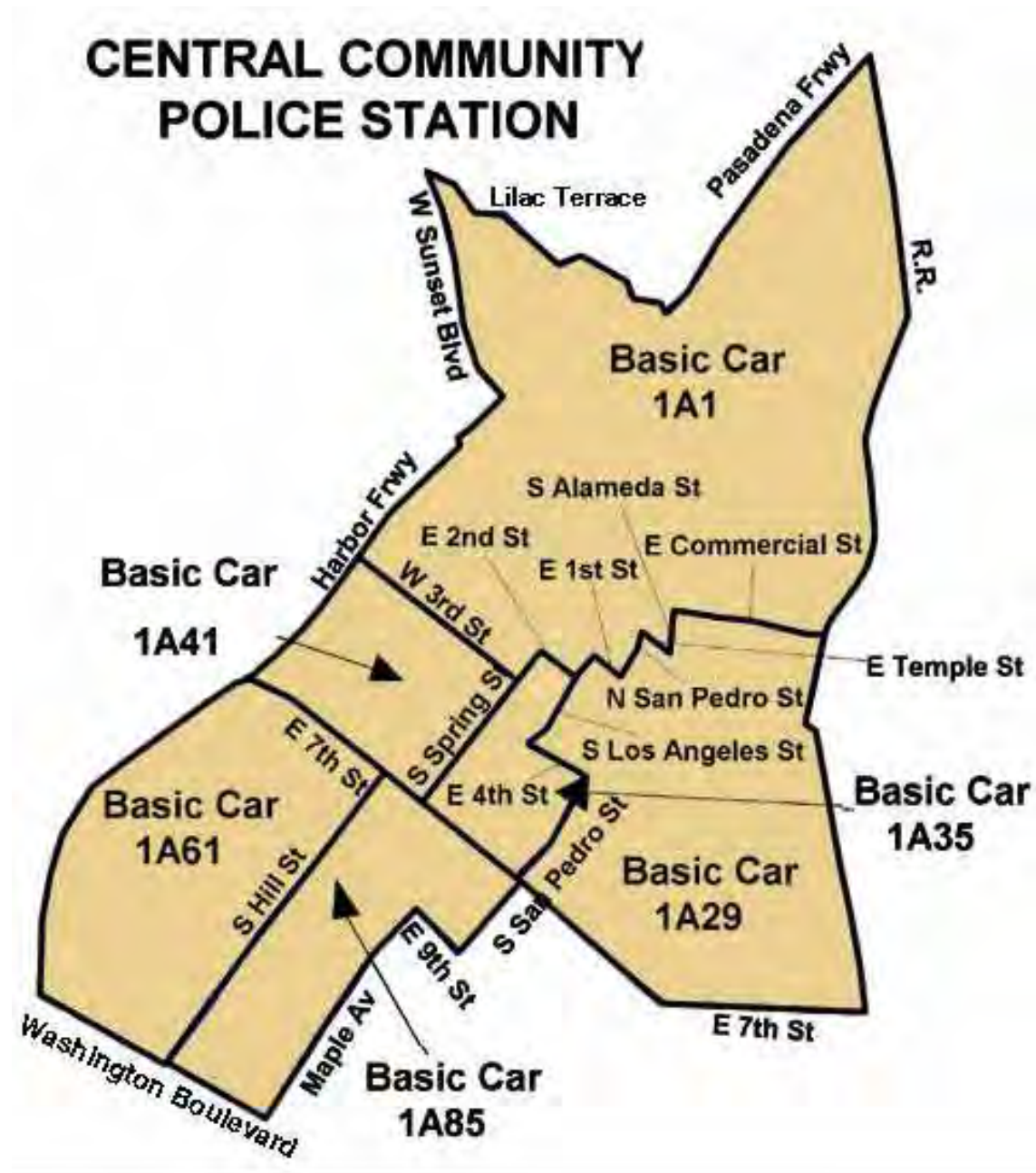


Exhibit K.1-3

RAMPART COMMUNITY POLICE STATION



Exhibit K.1-4

HOLLENBECK COMMUNITY POLICE STATION



Exhibit K.1-5

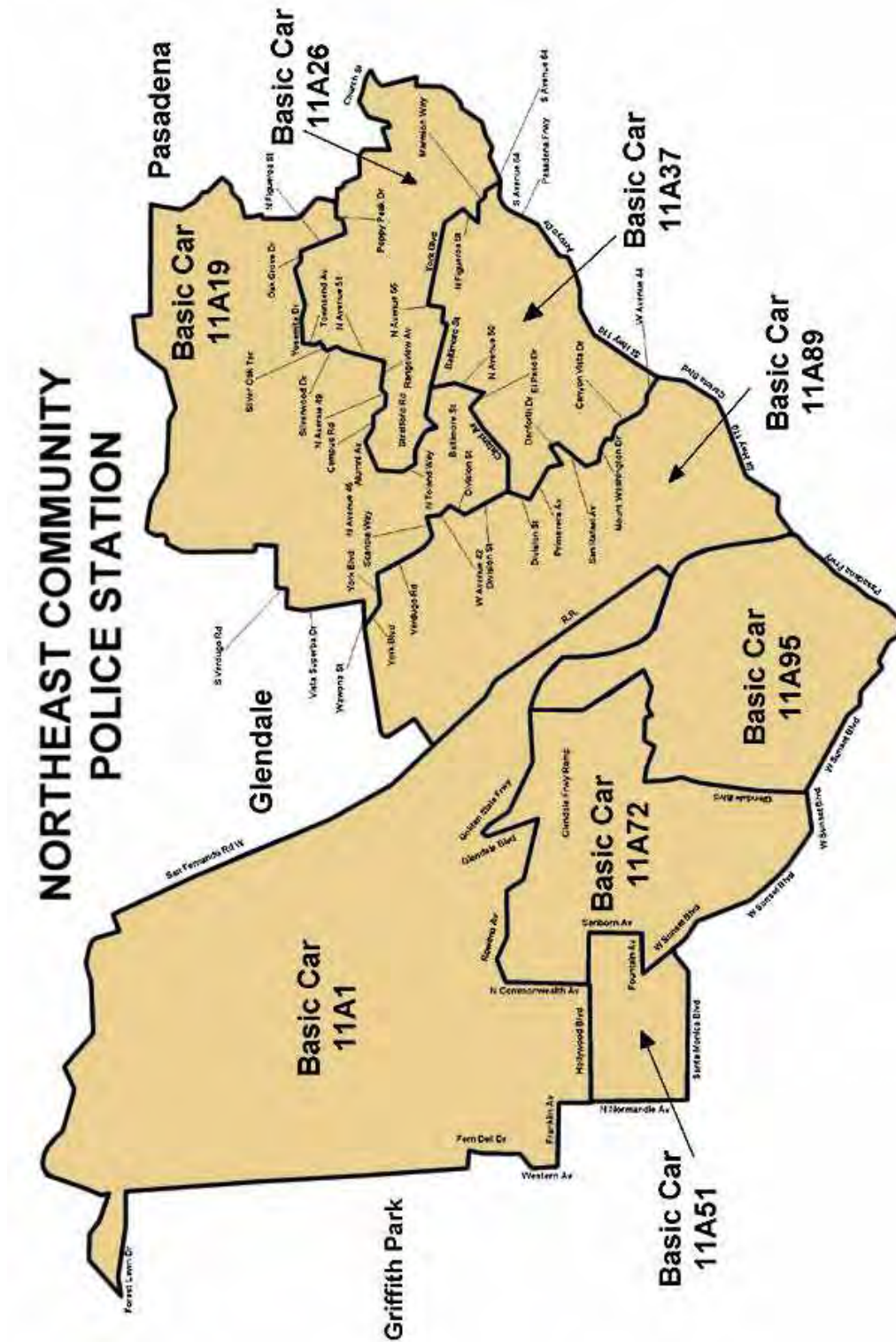
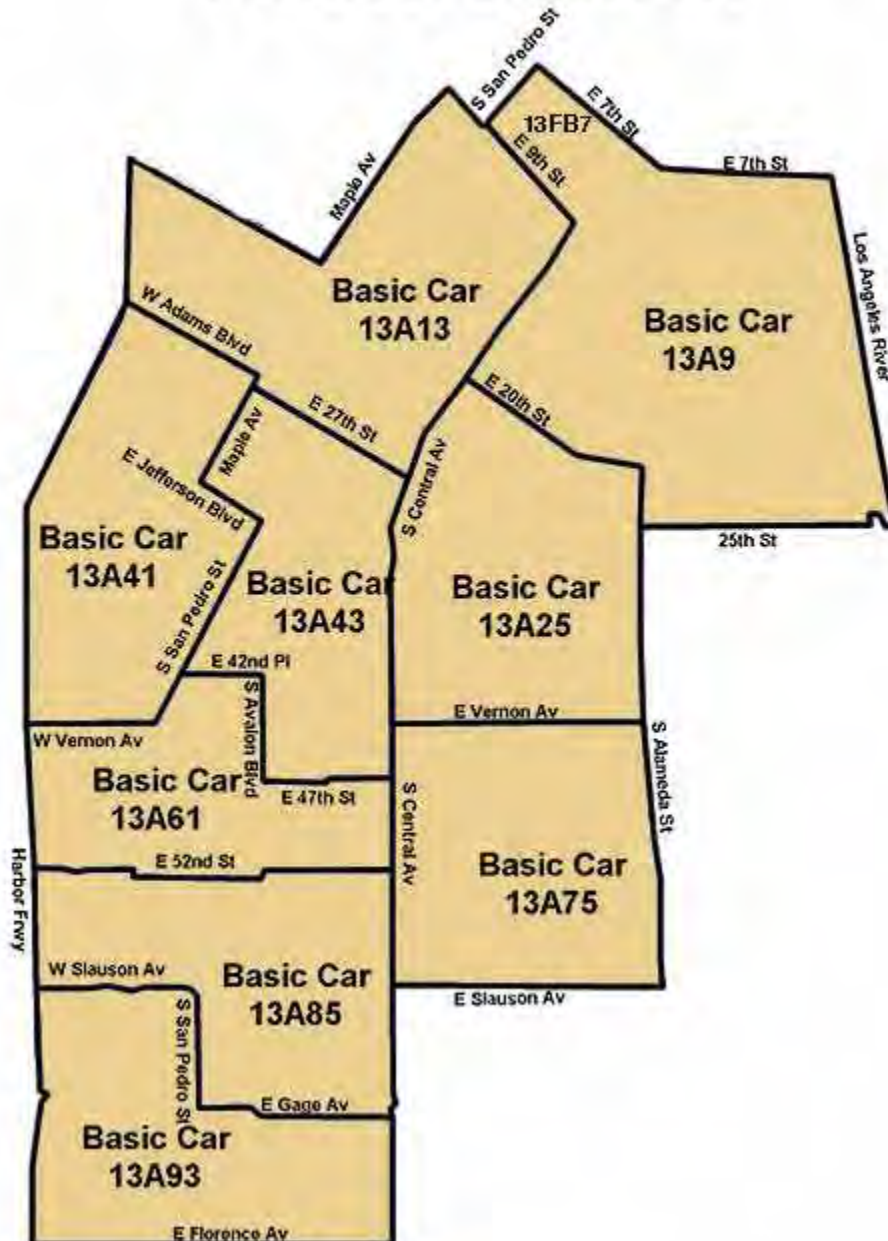


Exhibit K.1-6

NEWTON COMMUNITY POLICE STATION



L.A. CEQA Thresholds Guide
Page K.1-14



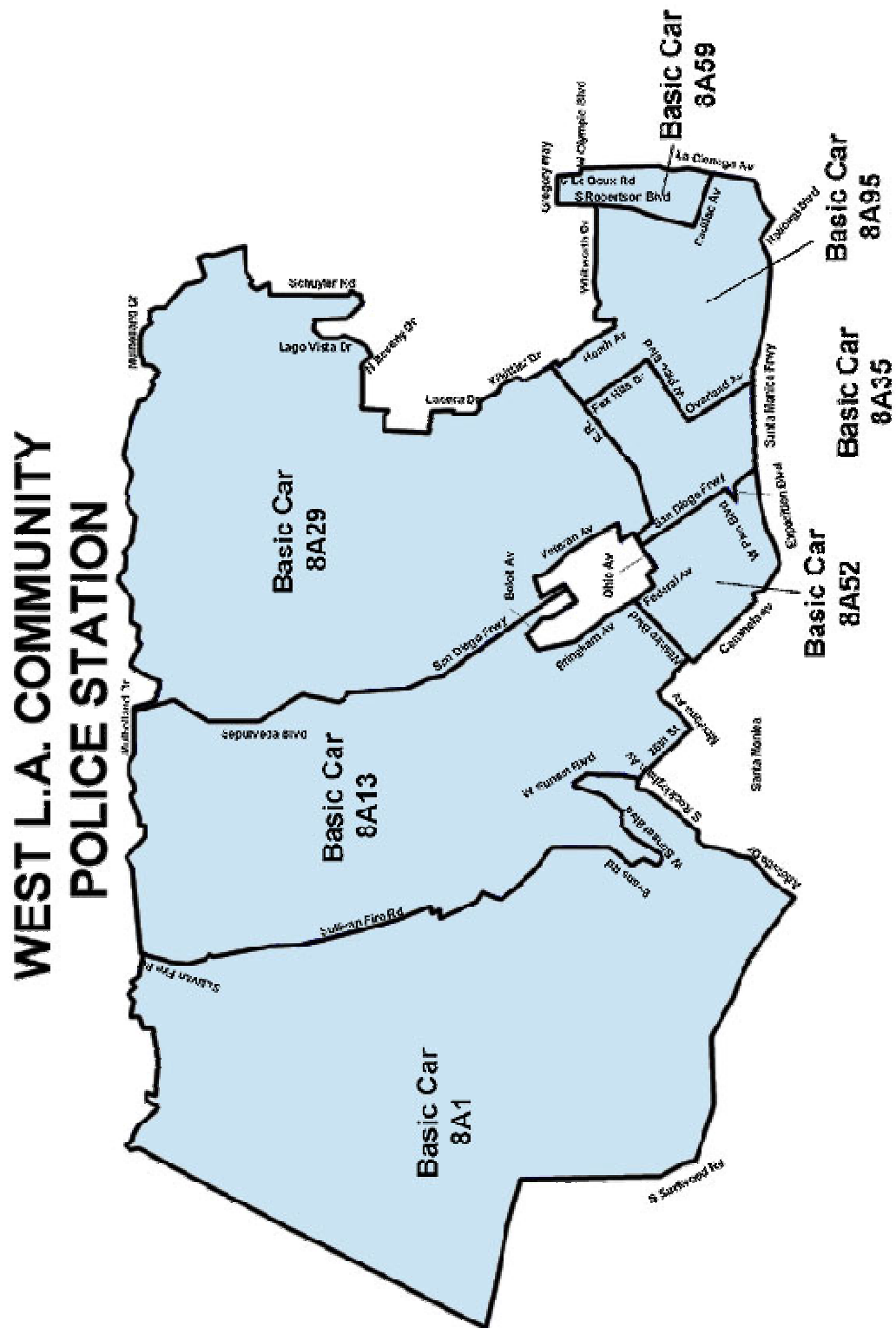
Exhibit K.1-9

Exhibit K.1-10



Exhibit K.1-11

VAN NUYS COMMUNITY POLICE STATION

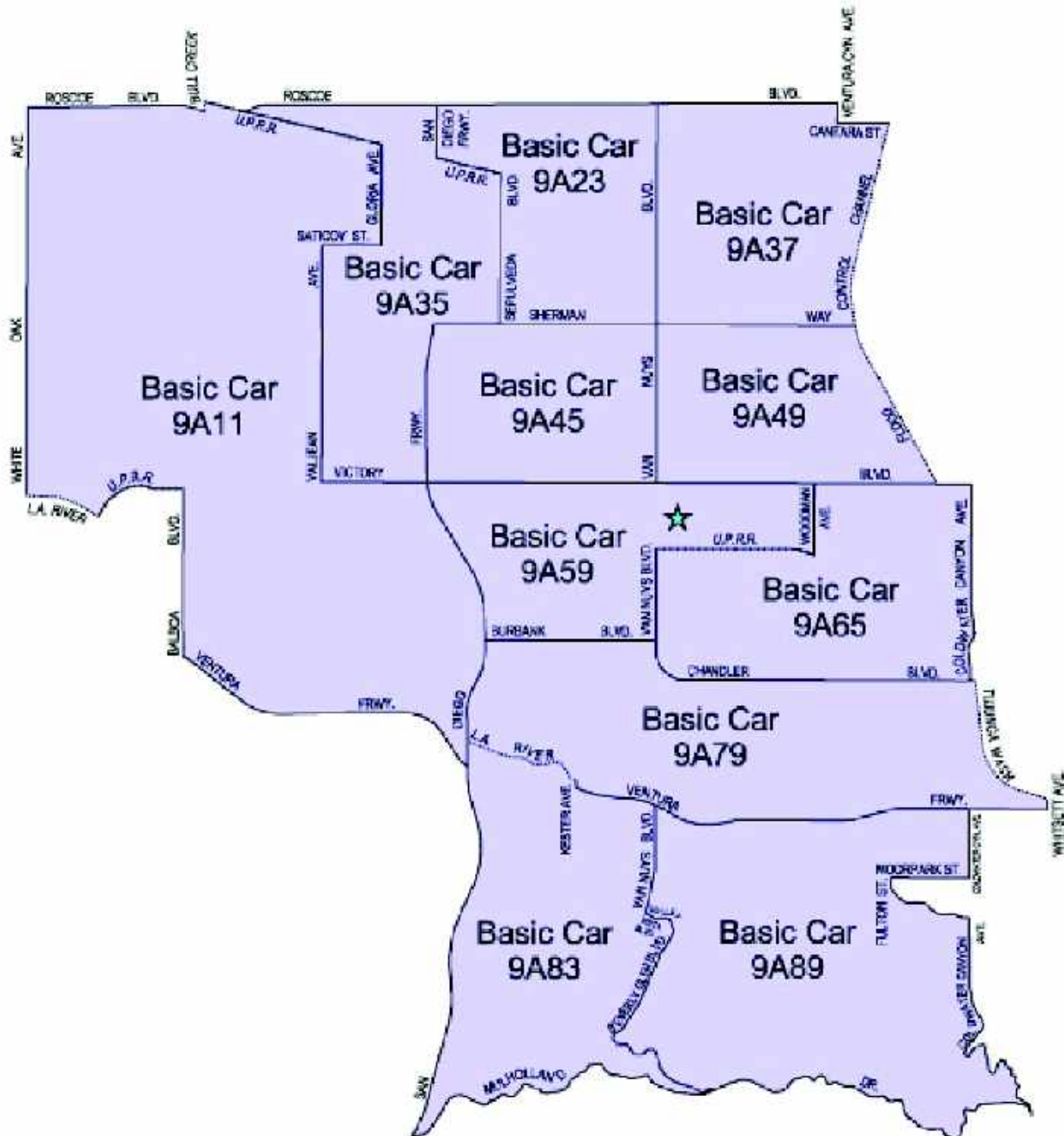


Exhibit K.1-12

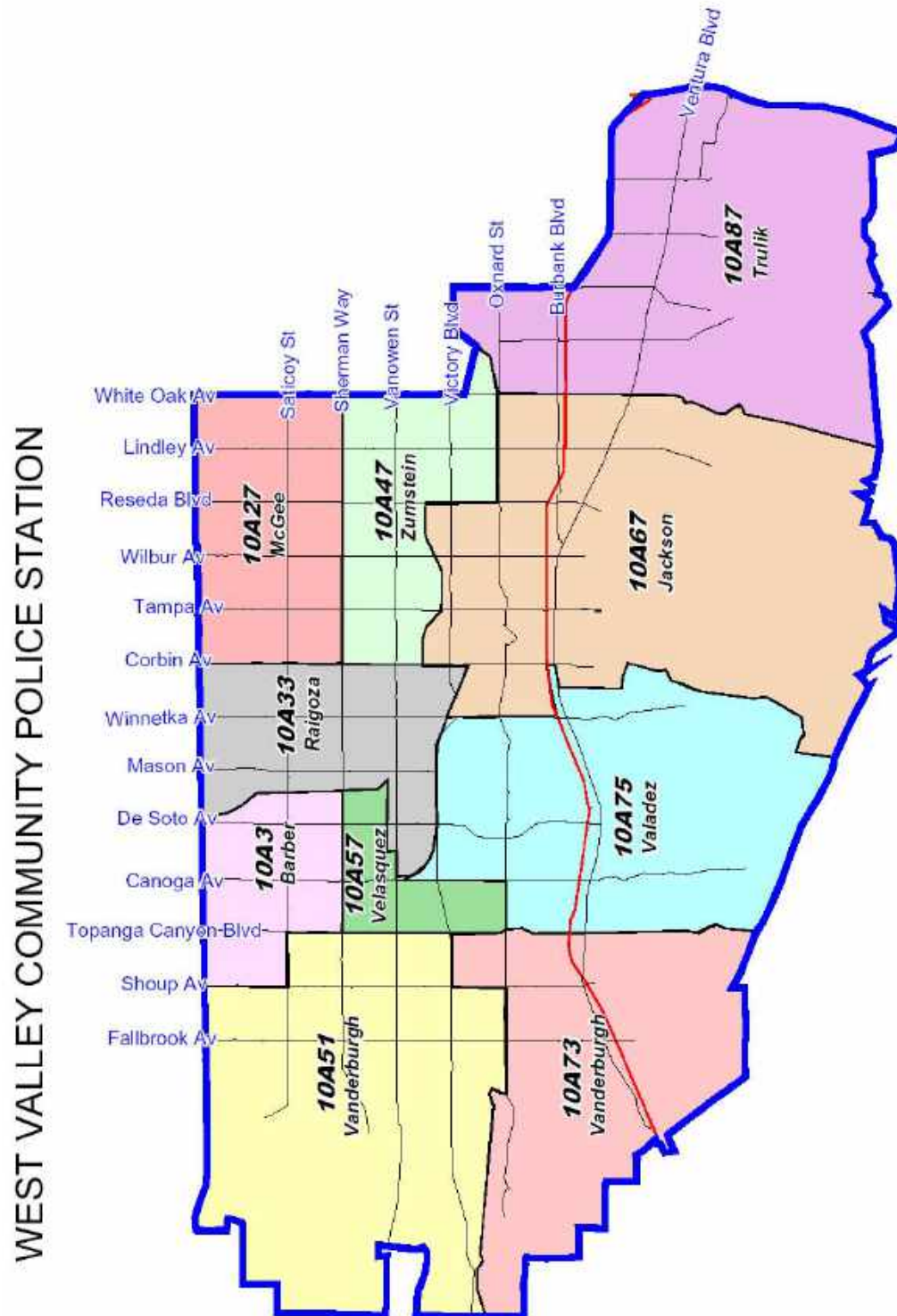
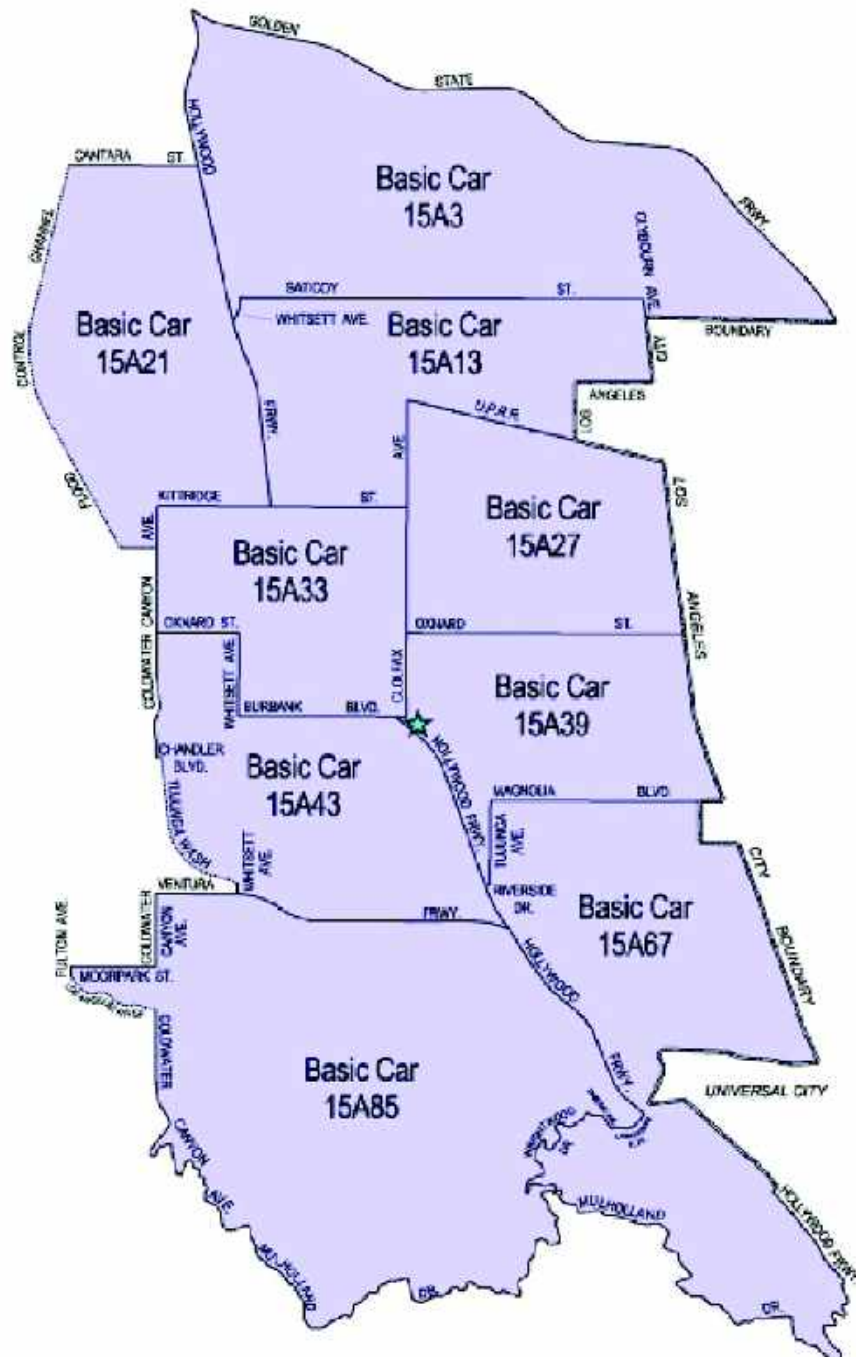


Exhibit K.1-13 NORTH HOLLYWOOD COMMUNITY POLICE STATION



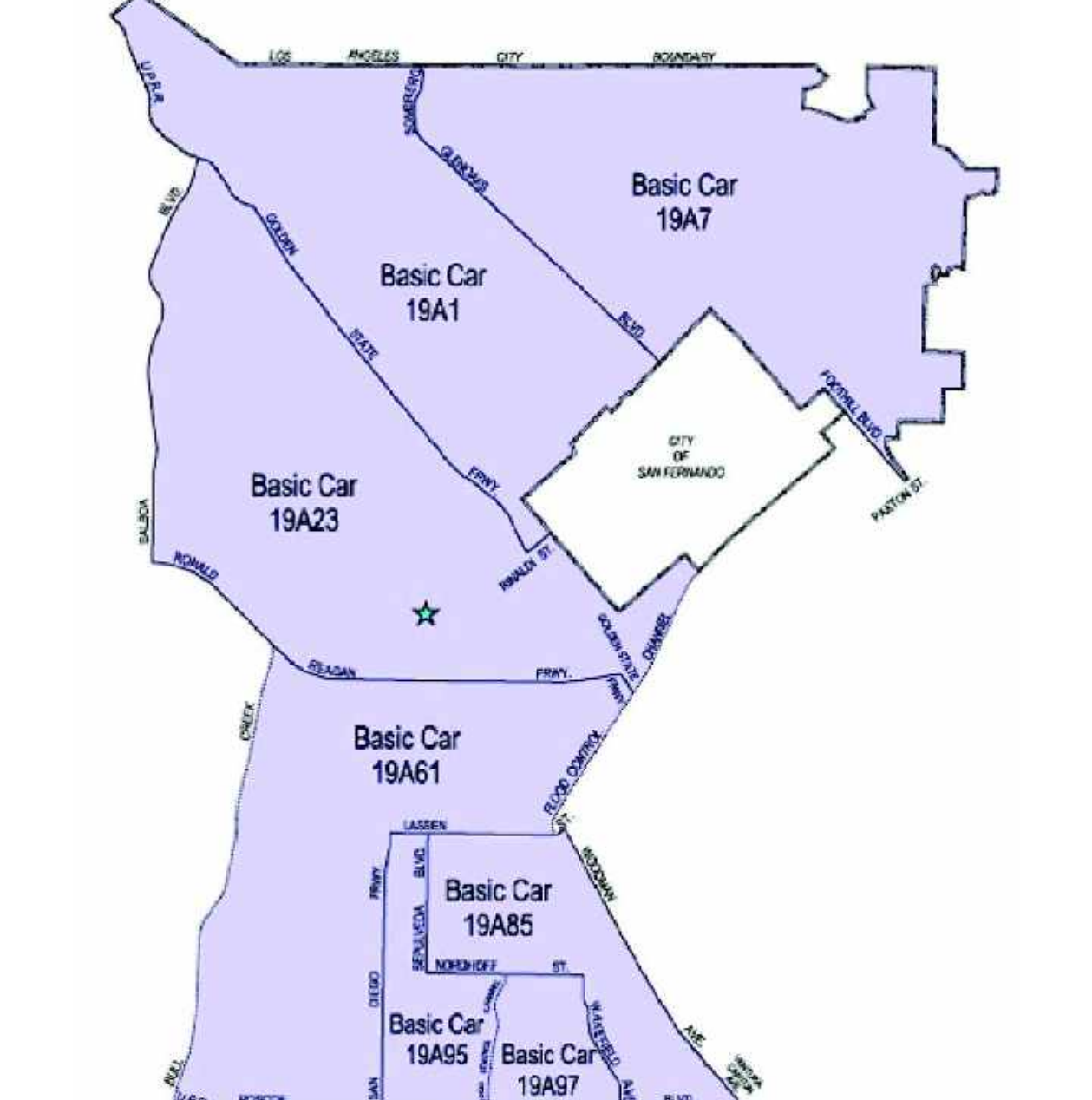


Exhibit K.1-16

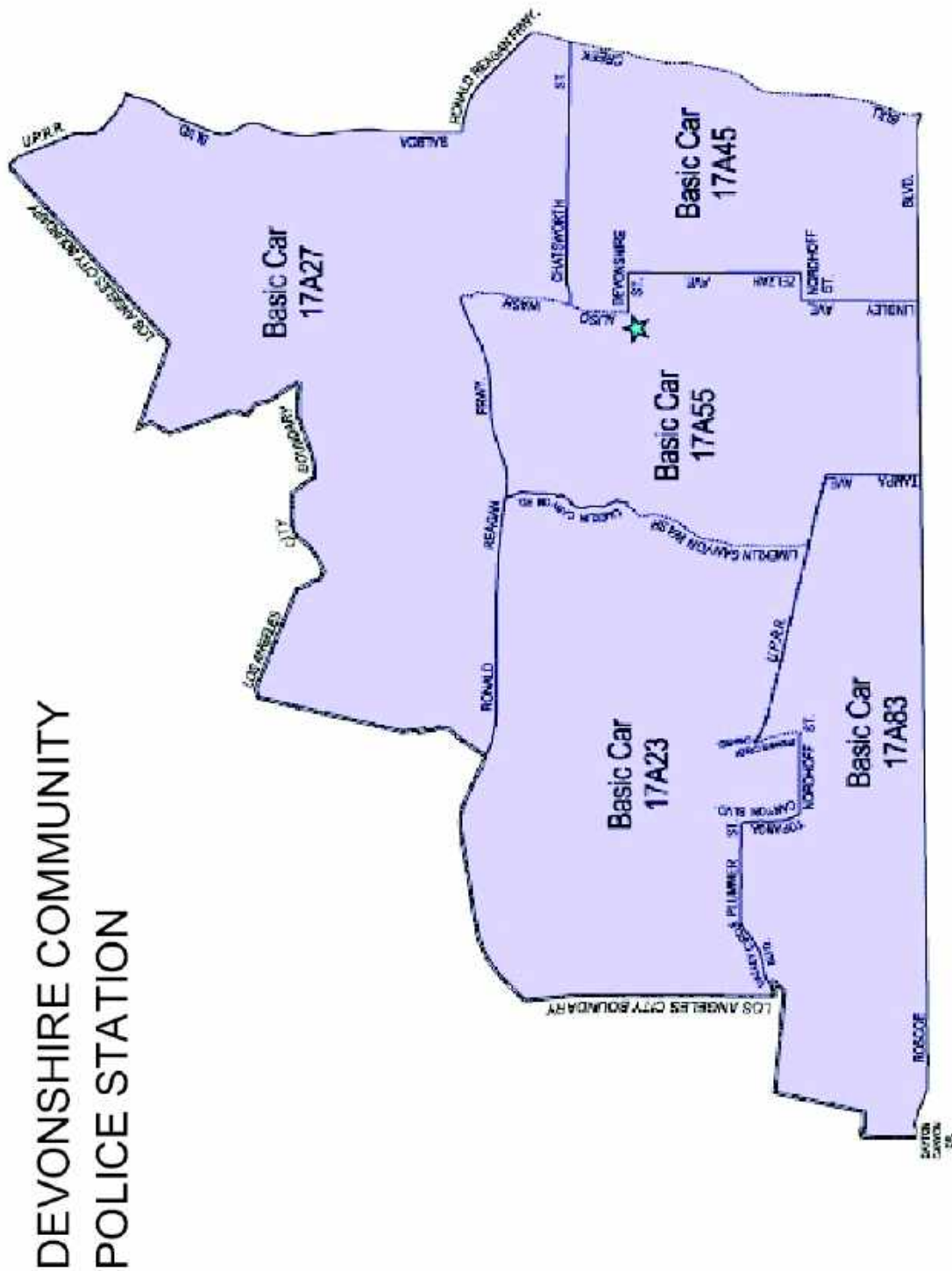


Exhibit K.1-18



| | | |
|--|-------------|--|
| | W Vernon Av | |
|--|-------------|--|

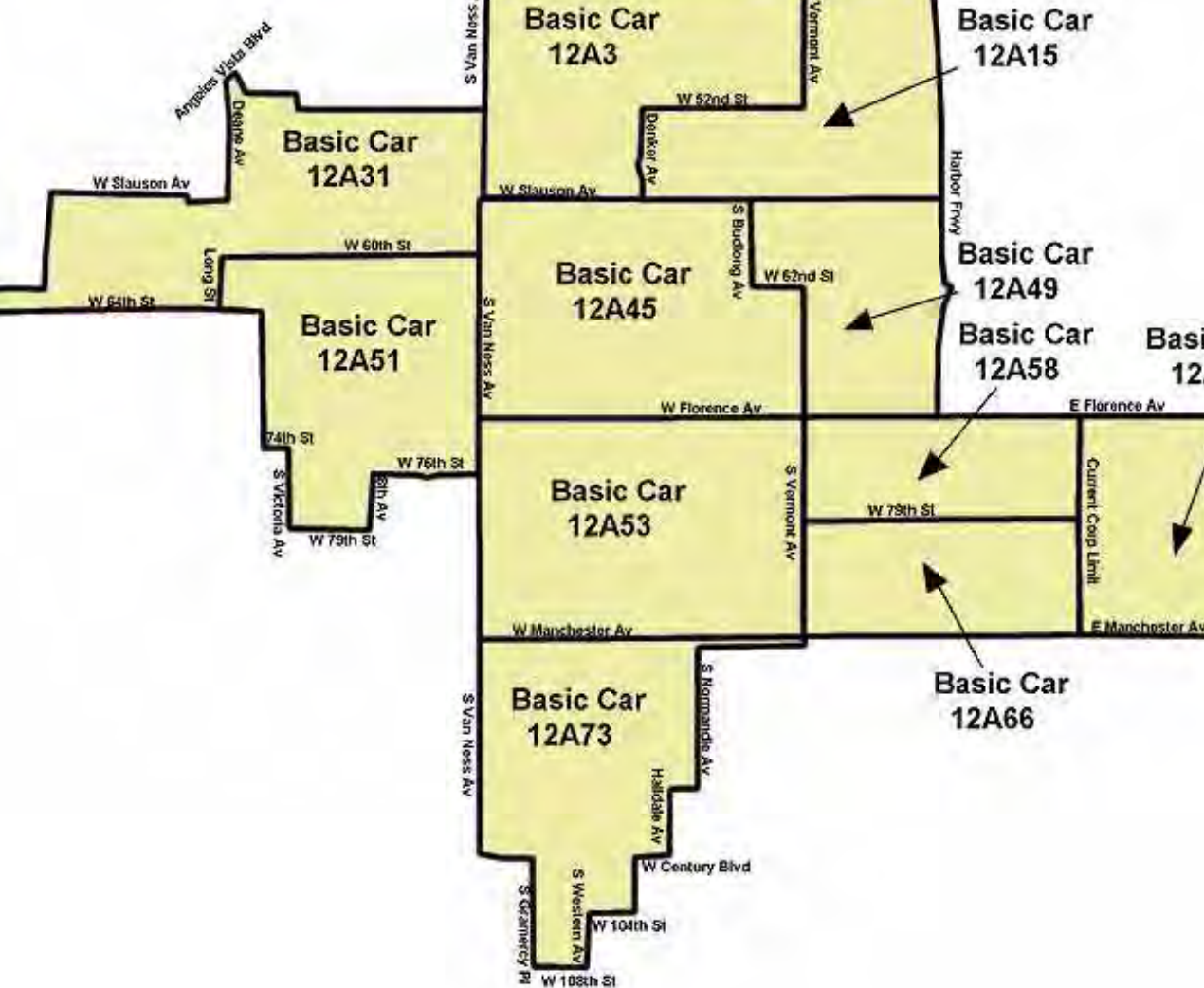
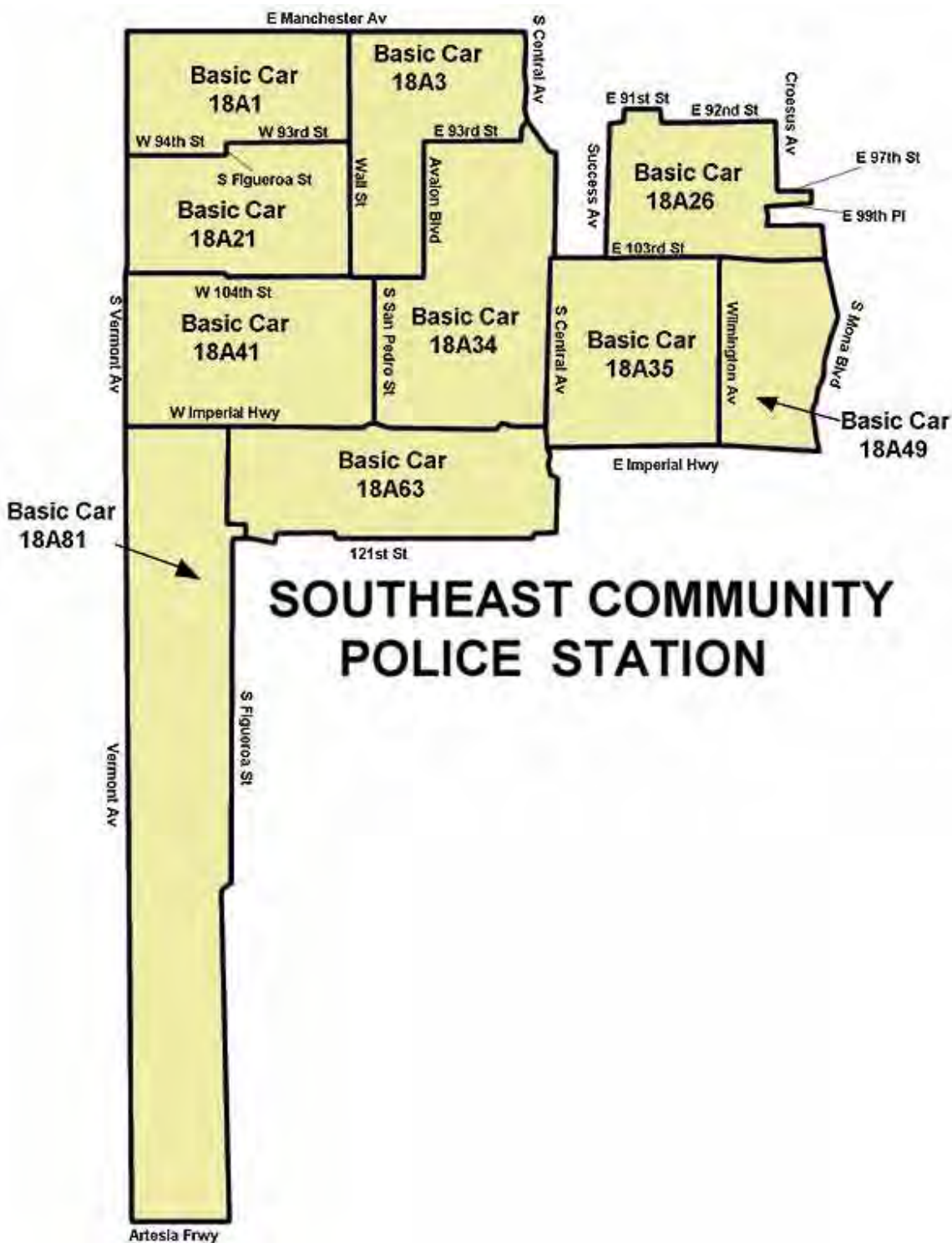


Exhibit K.1-20



K.2. FIRE PROTECTION & EMERGENCY MEDICAL SERVICES

1. INITIAL STUDY SCREENING PROCESS

A. Initial Study Checklist Questions

- VII.e): For a project located within an airport land use plan or where such a plan has not been adopted, within two miles of a public airport or public use airport, would the project result in a safety hazard for people residing or working in the project area?
- VII.f): For a project within the vicinity of a private airstrip, would the project result in a safety hazard for people residing or working within the project area?
- VII.g): Would the project impair implementation of or physically interfere with an adopted emergency response plan or emergency evacuation plan?
- VII.h): Would the project expose people or structures to a significant risk of loss, injury or death involving wildland fires, including where wildlands are adjacent to urbanized areas or where residences are intermixed with wildlands?
- XIII.a.i): Would the project result in substantial adverse physical impacts associated with the provision of new or physically altered governmental facilities, need for new or physically altered governmental facilities, the construction of which could cause significant environmental impacts, in order to maintain acceptable service ratios, response times or other performance objectives for fire protection?

B. Introduction

Within the City of Los Angeles, fire prevention and suppression services and emergency medical services are provided by the Los Angeles Fire Department (LAFD). The LAFD operates more than 100 fire stations grouped into 18 battalions and three divisions. Equipment includes engines, trucks, paramedic engines, crash units, hazardous materials response and decontamination units, foam carriers, rescue ambulances, helicopters, and boats.

New development projects in the City may increase the demand for fire protection and emergency medical services. The LAFD evaluates new project impacts on a project-by-project basis. Beyond the standards in the Los Angeles Fire Code, consideration is given to project size and components, required fire-flow, response time and distance for engine and truck companies, fire hydrant sizing and placement standards, access, and potential to use or store hazardous

materials. Risk of upset impacts due to potentially hazardous or explosive materials are discussed in F.1. RISK OF UPSET/EMERGENCY PREPAREDNESS.

C. Screening Criteria

- Would the project be located farther from an engine or truck company than the maximum response distances, based on the project's proposed land use(s), as indicated in the following chart?

| Land Use | Maximum Response Distance (miles) | |
|---|-----------------------------------|---------------|
| | Engine Company | Truck Company |
| Neighborhood Land Uses | | |
| Low Density Residential/High Density Residential/Neighborhood | 1.50 | 1.50 |
| Regional Land Uses | | |
| Commercial Industrial/Commercial | 1.00 | 1.50 |
| Commercial and Industrial Centers | | |
| High Density Commercial/High Density Industrial | 0.75 | 1.00 |

Source: Los Angeles Fire Code, Los Angeles Municipal Code (LAMC), Section 57.09.07.

- Is the project located in a brush fire hazard area, hillside, or area with inadequate fire hydrant service or street access?
- Does the project involve the use, manufacture or storage of toxic, readily-combustible, or otherwise hazardous materials?
- Would the project's location provide for adequate LAFD access (e.g., adequate street/fire lane width--minimum 20 feet clear and unobstructed with an approved turn around, grade not exceeding 15 percent, dead-ends not exceeding 700 feet)?
- Are there any street intersections with a level of service (LOS) of E or F near the project site that would adversely impact response time?

A "yes" response to any of the preceding questions indicates further study in an expanded Initial Study, Negative Declaration, Mitigated Negative Declaration, or EIR may be required. Refer to the Significance Threshold for Fire Protection and Emergency Medical Services, and review the associated Methodology to Determine Significance, as appropriate.

A "no" response to all of the preceding questions indicates that there would normally be no significant impact on Fire Protection and Emergency Medical Services from the proposed project.

D. Evaluation of Screening Criteria

Review the project description, site characteristics, Exhibit K.2-1 and the following Environmental and Public Facilities Maps:

- Fire Department Truck and Engine Company Service Areas for Neighborhood Land Uses, Regional Land Uses, and Commercial and Industrial Centers in the City of Los Angeles;
- Brush Fire Hazard Areas;
- Selected Wildfire Hazard Areas; and
- Inadequate Fire Hydrant Service Areas.

To calculate the response distance to the nearest engine and truck companies, begin by using the maps to locate the fire stations nearest to the project site. The response distance is the actual travel distance, which would be required, not the direct distance point-to-point. All stations listed in Exhibit K.2-1 are engine companies or Task Forces. All Task Force stations include an engine company and a truck company.

Intersection LOS can be determined through a traffic study (see L.1. INTERSECTION CAPACITY) or through consultation with the Los Angeles Department of Transportation (LADOT). Consider intersections on the path between the fire station and project site, focusing on intersections that provide access to the project.

Also, determine areas with inadequate access in consultation with the LAFD, City Planning Department, and Bureau of Engineering. Finally, check the project description for evidence of use, manufacture or storage of toxic, readily combustible, or otherwise hazardous materials.

2. DETERMINATION OF SIGNIFICANCE

A. Significance Threshold

A project would normally have a significant impact on fire protection if it requires the addition of a new fire station or the expansion, consolidation or relocation of an existing facility to maintain service.

B. Methodology to Determine SignificanceEnvironmental Setting

In a description of the environmental setting, include the following information:

- Description (including response distances) and map of LAFD facilities that serve the project (for assistance, see Exhibit K.2-1). Identify intersections at LOS E or F that provide access to the project;
- Discussion of fire hydrants and fire-flow levels serving the project site (for assistance, contact the Los Angeles Department of Water and Power (DWP)); and
- Description of existing brush fire potential and existing street facilities (e.g., substandard street width).

Project Impacts

Consider the description of the proposed land use, fire-related needs (e.g., use of hazardous materials), any project design features which would reduce or increase the demand for fire protection services, and whether the project site meets the recommended response time and distance requirements. Also, evaluate the site conditions and surrounding area for substandard street width, adequacy of fire hydrant service, brush fire hazard areas, and hillside conditions. Consult with LAFD's Construction Services Unit to determine the project's effect on fire protection and emergency medical services. Specifically evaluate the need for a new fire station or expansion, relocation, or consolidation of an existing facility to accommodate increased demand.

Cumulative Impacts

Identify the related projects, which would be served by the same LAFD facilities as the proposed project. Consider the characteristics of the related projects in terms of: land uses; response time and distance for fire companies; toxic, readily combustible, or otherwise hazardous materials; and site location (substandard street width, adequacy of fire hydrant service, brush fire hazard areas, and hillside conditions). Based on consultation with LAFD's Construction Services Unit, determine the cumulative effect on fire protection and emergency medical services. Specifically evaluate the need for a new fire station or expansion, relocation, or consolidation of an existing facility to accommodate increased demand.

Sample Mitigation Measures

Potential mitigation measures include the following:

- Provide and maintain fire-retardant landscaping and/or an irrigated buffer zone;
- Prohibit structures in fire hazard areas;
- Use construction and design features, which reduce fire potential and/or promote containment (e.g., increased spacing between buildings, fire-resistant landscaping); and
- Develop an emergency response plan.

3. DATA, RESOURCES, AND REFERENCES

City of Los Angeles Fire Department, Construction Services Unit, 200 North Main Street, Room 1000, Los Angeles, California 90012; Telephone: (213) 977-6354.

Los Angeles Fire Code. www.lafd.org/code.htm

Environmental and Public Facilities Maps (1996):

- Fire Department Truck and Engine Company Service Areas for Neighborhood Land Uses, Regional Land Uses, and Commercial and Industrial Centers in the City of Los Angeles;
- Brush Fire Hazard Areas;
- Selected Wildfire Hazard Areas; and
- Inadequate Fire Hydrant Service Areas.

Exhibit K.2-1
LOS ANGELES FIRE DEPARTMENT STATION LOCATIONS

| <u>Fire Station</u> | <u>Address</u> | <u>Equipment</u> | <u>Division</u> | <u>Battalion</u> |
|----------------------------|--|---|------------------------|-------------------------|
| 1 | 2230 Pasadena Avenue
Los Angeles, CA 90031 | Task Force, Rescue Ambulance, Food Services | 1 | 7 |
| 2 | 1962 E. Cesar Chavez Avenue
Los Angeles, CA 90033 | Task Force, Paramedic Ambulance | 1 | 7 HQ |
| 3 | 108 N. Freemont Avenue
Los Angeles, CA 90012 | Task Force, Rescue Ambulance, Bus, Light Utility, Hazardous Materials Response Unit | 1 HQ | 1 |
| 4 | 800 N. Main Street
Los Angeles, CA 90012 | Task Force, Squad, Rescue Ambulance, Command Post Utility | 1 | 1 |
| 5 | 8900 S. Emerson Avenue
Los Angeles, CA 90045 | Task Force, Paramedic Ambulance | 2 | 4 HQ |
| 6 | 326 N. Virgil Avenue
Los Angeles, CA 90004 | Engine Company, Paramedic Ambulance, Rescue Ambulance | 1 | 11 HQ |
| 8 | 11351 Tampa Avenue
Northridge, CA 91234 | Assessment Engine, Paramedic Engine, Brush Patrol | 3 | 15 |
| 9 | 430 E. 7th Street
Los Angeles, CA 90014 | Engine Company, Task Force, Rescue Ambulance | 1 | 1 HQ |
| 10 | 1335 S. Olive Street
Los Angeles, CA 90015 | Task Force, Rescue Ambulance, Paramedic Ambulance, Food Services | 1 | 1 |
| 11 | 1819 W. 7th Street
Los Angeles, CA 90057 | Task Force, Paramedic Ambulance, Rescue Ambulance | 1 | 11 |
| 12 | 5921 N. Figueroa Street
Los Angeles, CA 90042 | Task Force, Paramedic Ambulance | 1 | 2 |
| 13 | 1206 S. Vermont Avenue
Los Angeles, CA 90006 | Engine Company, Rescue Ambulance | 1 | 11 |
| 14 | 3401 S. Central Avenue
Los Angeles, CA 90011 | Task Force, Paramedic Ambulance, Rescue Ambulance | 2 | 3 |
| 15 | 915 W. Jefferson Boulevard
Los Angeles, CA 90007 | Task Force, Rescue Ambulance | 2 | 3 |
| 16 | 2011 N. Eastern Avenue
Los Angeles, CA 90032 | Assessment Engine, Rescue Ambulance | 1 | 7 |
| 17 | 1601 S. Santa Fe Avenue
Los Angeles, CA 90021 | Engine Company, Light Force, Paramedic Ambulance, Foam Tender, Hazardous Materials Decontamination Unit | 1 | 1 |

Exhibit K.2-1, continued
LOS ANGELES FIRE DEPARTMENT STATION LOCATIONS

| <u>Fire Station</u> | <u>Address</u> | <u>Equipment</u> | <u>Division</u> | <u>Battalion</u> |
|----------------------------|--|---|------------------------|-------------------------|
| 18 | 12050 Balboa Boulevard
Los Angeles, CA 91344 | Assessment Engine, Rescue Ambulance | 3 | 15 |
| 19 | 12229 Sunset Boulevard
Los Angeles, CA 90049 | Engine Company, Paramedic Ambulance,
Rescue Ambulance | 1 | 9 |
| 20 | 2144 Sunset Boulevard
Los Angeles, CA 90026 | Task Force, Paramedic Ambulance | 1 | 11 |
| 21 | 1187 E. 52nd Street
Los Angeles, CA 90011 | Engine Company, Paramedic Ambulance | 2 | 3 |
| 23 | 17281 Sunset Boulevard
Pacific Palisades, CA 90272 | Assessment Engine, Paramedic Ambulance,
Brush Patrol | 1 | 9 |
| 24 | 9411 Wentworth Street
Sunland, CA 91040 | Assessment Engine, Paramedic Ambulance,
Brush Patrol | 3 | 12 |
| 25 | 2927 Whittier Boulevard
Los Angeles, CA 90023 | Assessment Engine, Rescue Ambulance,
Arson Unit, Tunnel Utility | 1 | 7 |
| 26 | 2009 S. Western Avenue
Los Angeles, CA 90018 | Task Force, Paramedic Ambulance, Rescue
Ambulance | 2 | 3 |
| 27 | 1327 N. Cole Avenue
Los Angeles, CA 90028 | Task Force, Paramedic Ambulance, Rescue
Ambulance, Urban Search & Rescue | 1 | 5 HQ |
| 28 | 11641 Corbin Avenue
Porter Ranch, CA 91326 | Assessment Light Force, Rescue
Ambulance, Brush Patrol | 3 | 15 |
| 29 | 4029 W. Wilshire Boulevard
Los Angeles, CA 90010 | Task Force, Paramedic Ambulance, Rescue
Ambulance, Decon Tender | 1 | 11 |
| 33 | 6406 S. Main Street
Los Angeles, CA 90003 | Task Force, Paramedic Ambulance, Rescue
Ambulance | 2 HQ | 13 |
| 34 | 3661 7th Avenue
Los Angeles, CA 90018 | Engine Company, Paramedic Ambulance,
Rescue Ambulance | 2 | 3 |
| 35 | 1601 N. Hillhurst Avenue
Los Angeles, CA 90027 | Task Force, Paramedic Ambulance, Rescue
Ambulance, Brush Patrol | 1 | 5 |
| 36 | <u>Under Construction</u>
1005 N. Gaffey Street,
San Pedro, CA 90732 | | 2 | 6 |
| 37 | 1090 Veteran Avenue
Los Angeles, CA 90024 | Task Force, Paramedic Ambulance | 1 | 9 HQ |

Exhibit K.2-1, continued
LOS ANGELES FIRE DEPARTMENT STATION LOCATIONS

| <u>Fire Station</u> | <u>Address</u> | <u>Equipment</u> | <u>Division</u> | <u>Battalion</u> |
|----------------------------|---|--|------------------------|-------------------------|
| 38 | 124 E. "I" Street
Wilmington, CA 90744 | Task Force, Paramedic Ambulance, Haz-Mat Tender | 2 | 6 |
| 39 | 14415 Sylvan Street
Van Nuys, CA 91401 | Engine Company, Assessment Light Force, Paramedic Ambulance | 3 | 10 HQ |
| 40 | 330 Ferry Street
Terminal Island, CA 90731 | Assessment Engine, Rescue Ambulance, Rehab Air Tender | 2 | 6 |
| 41 | 1439 N. Gardner Street
Los Angeles, CA 90046 | Engine Company, Paramedic Ambulance, Rescue Ambulance, Brush Patrol | 1 | 5 |
| 42 | 2021 Colorado Boulevard
Los Angeles, CA 90041 | Assessment Engine, Rescue Ambulance | 1 | 2 |
| 43 | 10234 National Boulevard
Los Angeles, CA 90034 | Engine Company, Paramedic Ambulance | 2 | 18 |
| 44 | 1410 Cypress Avenue
Los Angeles, CA 90065 | Assessment Engine, Rescue Ambulance, Brush Patrol, Swift Water Rescue, Bicycle Medic | 1 | 2 |
| 46 | 4370 S. Hoover Street
Los Angeles, CA 90037 | Engine Company, Paramedic Ambulance, Rescue Ambulance, | 2 | 3 HQ |
| 47 | 4575 Huntington Dr South
Los Angeles, CA 90032 | Task Force, Paramedic Engine, Brush Patrol | 1 | 7 |
| 48 | 1601 S. Grand Avenue
San Pedro, CA 90731 | Assessment Engine, Light Force, Rescue Ambulance, Haz-Mat Squad | 2 | 6 |
| 49 | 400 Yacht Street, Berth 194
Wilmington, CA 90744 | Assessment Engine, Rescue Ambulance, Fireboats 3 & 4 | 2 | 6 HQ |
| 50 | 3036 Fletcher Drive
Los Angeles, CA 90065 | Assessment Engine, Light Force, Rescue Ambulance | 1 | 2 |
| 51 | 10435 Sepulveda Boulevard
Los Angeles, CA 90045 | Assessment Engine, Paramedic Ambulance | 2 | 4 |
| 52 | 4957 Melrose Avenue
Los Angeles, CA 90029 | Engine Company, Paramedic Ambulance | 1 | 5 |
| 55 | 4455 E. York Boulevard
Eagle Rock, CA 90041 | Engine Company, Paramedic Ambulance | 1 | 2 HQ |
| 56 | 2759 Rowena Avenue
Los Angeles, CA 90039 | Assessment Engine, Paramedic Ambulance, Heavy Rescue | 1 | 2 |

Exhibit K.2-1, continued
LOS ANGELES FIRE DEPARTMENT STATION LOCATIONS

| <u>Fire Station</u> | <u>Address</u> | <u>Equipment</u> | <u>Division</u> | <u>Battalion</u> |
|----------------------------|---|---|------------------------|-------------------------|
| 57 | 7800 S. Vermont Avenue
Los Angeles, CA 90044 | Engine Company, Paramedic Ambulance,
Rescue Ambulance | 2 | 13 HQ |
| 58 | 1556 S. Robertson Boulevard
Los Angeles, CA 90035 | Task Force, Paramedic Ambulance | 2 | 18 |
| 59 | 11505 Olympic Boulevard
Los Angeles, CA 90064 | Assessment Engine, Paramedic Ambulance,
Rehab Air Tender | 1 | 9 |
| 60 | 5320 Tujunga Avenue
North Hollywood, CA 91601 | Task Force, Paramedic Ambulance, Rescue
Ambulance, Foam Tender | 3 | 14 HQ |
| 61 | 5821 W. 3rd Street
Los Angeles, CA 90036 | Task Force, Paramedic Ambulance, Rescue
Ambulance | 2 | 18 |
| 62 | 3631 Centinela Avenue
Los Angeles, CA 90066 | Assessment Engine, Paramedic Ambulance,
Swift Water Rescue | 2 | 4 |
| 63 | 1930 Shell Avenue
Venice, CA 90291 | Task Force, Paramedic Ambulance | 2 | 4 |
| 64 | 118 W. 108th Street
Los Angeles, CA 90061 | Task Force, Paramedic Ambulance, Rescue
Ambulance | 2 | 13 |
| 65 | 1801 E. Century Boulevard
Los Angeles, CA 90002 | Engine Company, Paramedic Ambulance | 2 | 13 |
| 66 | 1909 W. Slauson Boulevard
Los Angeles, CA 90047 | Task Force, Paramedic Ambulance, Rescue
Ambulance | 2 | 13 |
| 68 | 5023 W. Washington Blvd
Los Angeles, CA 90016 | Engine Company, Paramedic Ambulance,
Rescue Ambulance | 2 | 18 HQ |
| 69 | 15045 Sunset Boulevard
Pacific Palisades, CA 90272 | Task Force, Paramedic Ambulance | 1 | 9 |
| 70 | 9861 Reseda Boulevard
Northridge, CA 91324 | Engine Company, Assessment Light Force,
Paramedic Ambulance, Haz-Mat Squad | 3 | 15 HQ |
| 71 | 107 S. Beverly Glen Blvd
Los Angeles, CA 90024 | Assessment Engine, Paramedic Ambulance | 1 | 9 |
| 72 | 6811 De Soto Avenue
Canoga Park, CA 91303 | Task Force, Paramedic Ambulance | 3 | 17 HQ |
| 73 | 7419 Reseda Boulevard
Reseda, CA 91335 | Engine Company, Assessment Light Force,
Paramedic Ambulance | 3 | 17 |

Exhibit K.2-1, continued
LOS ANGELES FIRE DEPARTMENT STATION LOCATIONS

| <u>Fire Station</u> | <u>Address</u> | <u>Equipment</u> | <u>Division</u> | <u>Battalion</u> |
|----------------------------|---|--|------------------------|-------------------------|
| 74 | 7777 Foothill Boulevard
Tujunga, CA 91042 | Engine Company, Assessment Light Force,
Paramedic Ambulance, Brush Patrol | 3 | 12 |
| 75 | 15345 San Fernando Mission
Mission Hills, CA 91340 | Engine Company, Assessment Light Force,
Paramedic Ambulance, Haz-Mat Tender | 3 | 12 |
| 76 | 3111 N. Cahuenga Boulevard
Los Angeles, CA 90068 | Assessment Engine, Rescue Ambulance | 1 | 5 |
| 77 | 8943 Glenoaks Boulevard
Sun Valley, CA 91352 | Assessment Engine, Rescue Ambulance | 3 | 12 |
| 78 | 4230 Coldwater Canyon Ave
Studio City, CA 91604 | Assessment Engine, Paramedic Ambulance | 3 | 14 |
| 79 | 18030 S. Vermont Avenue
Gardena, CA 90247 | Assessment Engine, Paramedic Ambulance | 2 | 13 |
| 80 | 6911 World Way West
Los Angeles, CA 90045 | Airport Crash Rescue, Airport Foam | 2 | 4 |
| 81 | 14123 Nordhoff Street
Arleta, CA 91331 | Assessment Engine, Paramedic Ambulance,
Rescue Ambulance | 3 | 12 |
| 82 | 1800 N. Bronson Avenue
Los Angeles, CA 90028 | Assessment Engine, Paramedic Ambulance | 1 | 5 |
| 83 | 5001 Balboa Boulevard
Encino, CA 91316 | Assessment Engine, Paramedic Ambulance,
Brush Patrol, Water Tender, Emergency
Lighting Trailer, Medical Supply Trailer | 3 | 10 |
| 84 | 5340 Canoga Avenue
Woodland Hills, CA 91364 | Assessment Engine, Paramedic Ambulance,
Brush Patrol | 3 | 17 |
| 85 | 1331 W. 253rd Street
Harbor City, CA 90710 | Task Force, Paramedic Ambulance, Urban
Search & Rescue, Medical Supply Trailer,
Emergency Lighting Trailer | 2 | 6 |
| 86 | 4305 Vineland Avenue
North Hollywood, CA 91602 | Assessment Engine, Paramedic Ambulance,
Urban Search & Rescue, Swift Water
Rescue, Water Tender | 3 | 14 |
| 87 | 10241 Balboa Boulevard
Northridge, CA 91324 | Assessment Engine, Paramedic Ambulance | 3 | 15 |
| 88 | 5101 N. Sepulveda Boulevard
Sherman Oaks, CA 91403 | Task Force, Paramedic Ambulance, Urban
Search & Rescue, Tractor Company,
Command Post Vehicle | 3 HQ | 10 |

Exhibit K.2-1, continued
LOS ANGELES FIRE DEPARTMENT STATION LOCATIONS

| <u>Fire Station</u> | <u>Address</u> | <u>Equipment</u> | <u>Division</u> | <u>Battalion</u> |
|----------------------------|--|---|------------------------|-------------------------|
| 89 | 7063 Laurel Canyon Blvd
North Hollywood, CA 91605 | Task Force, Paramedic Ambulance, Rescue Ambulance, Rehab Air Tender, Urban Search & Rescue | 3 | 14 |
| 90 | 7921 Woodley Avenue
Van Nuys, CA 91406 | Task Force, Paramedic Ambulance | 3 | 10 |
| 91 | 14430 Polk Street
Sylmar, CA 91342 | Assessment Engine, Paramedic Ambulance, Rescue Ambulance | 3 | 12 |
| 92 | 10556 W. Pico Boulevard
Los Angeles, CA 90064 | Engine Company, Assessment Light Force, Paramedic Ambulance | 2 | 18 |
| 93 | 19059 Ventura Boulevard
Tarzana, CA 91356 | Task Force, Paramedic Ambulance | 3 | 17 |
| 94 | 4470 Coliseum Street
Los Angeles, CA 90016 | Task Force, Paramedic Ambulance, Rescue Ambulance, Brush Patrol | 2 | 18 |
| 95 | 10010 International Road
Los Angeles, CA 90045 | Task Force, Paramedic Ambulance, Haz-Mat Squad | 2 | 4 |
| 96 | 21800 Marilla Street
Chatsworth, CA 91311 | Engine Company, Assessment Light Force, Paramedic Ambulance | 3 | 15 |
| 97 | 8021 Mulholland Drive
Los Angeles, CA 90046 | Assessment Engine, Paramedic Ambulance | 3 | 14 |
| 98 | 13035 Van Nuys Boulevard
Pacoima, CA 91331 | Engine Company, Assessment Light Force, Paramedic Ambulance, Rescue Ambulance, Decon Tender | 3 | 12 HQ |
| 99 | 14145 Mulholland Drive
Beverly Hills, CA 90210 | Assessment Engine, Paramedic Ambulance, Brush Patrol, Arson Investigation Unit | 3 | 10 |
| 100 | 6751 Louise Avenue
Van Nuys, CA 91406 | Engine Company, Paramedic Ambulance, Foam Tender, Swift Water Rescue | 3 | 17 |
| 101 | 1414 25th Street
San Pedro, CA 90732 | Engine Company, Paramedic Ambulance, Foam Tender | 2 | 6 |
| 102 | 13200 Burbank Boulevard
Van Nuys, CA 91401 | Light Force, Paramedic Ambulance | 3 | 14 |
| 103 | 18143 Parthenia Street
Northridge, CA 91324 | Assessment Engine, Paramedic Ambulance | 3 | 15 |
| 104 | 8349 Winnetka Avenue
Canoga Park, CA 91306 | Engine Company, Paramedic Ambulance | 3 | 15 |

Exhibit K.2-1, continued
LOS ANGELES FIRE DEPARTMENT STATION LOCATIONS

| <u>Fire Station</u> | <u>Address</u> | <u>Equipment</u> | <u>Division</u> | <u>Battalion</u> |
|----------------------------|--|--|------------------------|-------------------------|
| 105 | 6345 Fallbrook Avenue
Woodland Hills, CA 91364 | Engine Company, Assessment Light Force,
Paramedic Ambulance | 3 | 17 |
| 106 | 23004 Roscoe Boulevard
West Hills, CA 91304 | Assessment Engine, Rescue Ambulance,
Fuel Tender | 3 | 17 |
| 107 | 20225 Devonshire Street
Chatsworth, CA 91311 | Engine Company, Paramedic Ambulance | 3 | 15 |
| 108 | 12520 Mulholland Drive
Beverly Hills, CA 90210 | Assessment Engine, Rescue Ambulance | 3 | 14 |
| 109 | 16500 Mulholland Drive
Los Angeles, CA 90049 | Assessment Engine, Rescue Ambulance,
Brush Patrol | 3 | 10 |
| 110 | 2945 Miner St. Berth 44-A
San Pedro, CA 90731 | Fireboats & SCUBA Operations | 2 | 6 |
| 111 | 954 S. Seaside Avenue,
Berth 260
San Pedro, CA 90731 | Fireboat | 2 | 6 |
| 112 | 444 South Harbor Blvd.
San Pedro, CA 90731 | Engine Company, Paramedic Ambulance,
Fireboats | 2 | 6 |
| 114 | 8060 Balboa Place
Van Nuys, CA 91406 | Air Operations, Crash Rescue, Airport
Foam | 3 | 10 |

HQ means Headquarters

Source: LAFD, 1994 & 2003. 2006.

K.3. PUBLIC SCHOOLS

1. INITIAL STUDY SCREENING PROCESS

A. Initial Study Checklist Question

XIII.c): Would the project result in substantial adverse physical impacts associated with the provision of new or physically altered governmental facilities, need for new or physically altered governmental facilities, the construction of which could cause significant environmental impacts, in order to maintain acceptable service ratios, response times or other performance objectives for schools?

B. Introduction

Within the City of Los Angeles, the Los Angeles Unified School District (LAUSD) provides public education for over 900,000 total students in all programs. The school district educates students in grades K-12 at 557 schools. There are 429 elementary schools; 76 middle schools; and 52 high schools.¹ The LAUSD also offers a number of other schools and centers. Additionally, the LAUSD provides public education partially or entirely within 26 incorporated Los Angeles County cities.

School service needs are related to the size of the residential population, the geographic area served, and community characteristics. Projects that affect these factors (e.g. by increasing residential population in an area) may increase the demand for public school facilities.

C. Screening Criteria

Would the project result in a net increase of at least 75 residential units, 100,000 square feet (sf) of commercial floor area or 200,000 sf of industrial floor area?

A "yes" response to the preceding question indicates further study in an expanded Initial Study,

¹ For an accounting of the number see LAUSD website at www.lausd.k12.ca/lausd/offices/office-of-Communications/ and look for fingertip facts. LAUSD, *fingertip facts: 2002-2003*, December 2002

Negative Declaration, Mitigated Negative Declaration or EIR may be required. Refer to the Significance Threshold for Public Schools, and review the associated Methodology to Determine Significance, as appropriate.

A "no" response to the preceding question indicates that there would normally be no significant impact on Public Schools from the proposed project.

D. Evaluation of Screening Criteria

Review the description of the proposed project and determine the type of land use(s) proposed (i.e., commercial, industrial, residential), and the size of the project (i.e., number of units, square footage). Compare this information to the Screening Criteria.

2. DETERMINATION OF SIGNIFICANCE

A. Significance Threshold

The determination of significance shall be made on a case-by-case basis, considering the following factors:

- The population increase resulting from the proposed project, based on the increase in residential units or square footage of non-residential floor area;
- The demand for school services anticipated at the time of project buildout compared to the expected level of service available. Consider, as applicable, scheduled improvements to LAUSD services (facilities, equipment and personnel) and the project's proportional contribution to the demand;
- Whether (and the degree to which) accommodation of the increased demand would require construction of new facilities, a major reorganization of students or classrooms, major revisions to the school calendar (such as year-round sessions), or other actions which would create a temporary or permanent impact on the school(s); and
- Whether the project includes features that would reduce the demand for school services (e.g., on-site school facilities or direct support to LAUSD).

B. Methodology to Determine Significance

Environmental Setting

In a description of the environmental setting, include the following information:

- Identify the name, location and description of schools serving the project site (including capacity, enrollment and operating characteristics). Use Exhibits K.3-1 through K.3-9, or contact LAUSD Master Planning & Demographics Branch, Office of the Chief Facilities Executive for assistance and to confirm the accuracy of data; and
- Describe the population and geographic area served, as well as community characteristics.

Project Impacts

Review the description of the project and surrounding area. Determine the net population increase resulting from the project, and identify the public schools that would be used by the project residents. LAUSD has prepared student generation factors in order to estimate the number of students expected from various residential development (reproduced in Exhibit K.3-10). Evaluate the demand for public schools anticipated at the time of project buildout, compared to the expected level of service available. Consider, as applicable, scheduled improvements (renovation, expansion, or addition) to schools serving the project and the project's proportional contribution to the demand. As necessary, consult with the LAUSD. Evaluate project features, which would reduce the demand for services (e.g., on-site school facilities or direct support to the LAUSD).

Cumulative Impacts

Identify the related projects, which would be served by the same schools as the proposed project. Consider the characteristics of the related projects in terms of size, location, and type of land uses. Determine the net population increase resulting from the related projects. As above, evaluate the cumulative demand for services anticipated at the time of project buildout compared to the expected level of service available. Consider, as applicable, scheduled improvements (renovation, expansion, or addition). As necessary, consult with LAUSD. As feasible, evaluate known features of the related projects (e.g., on-site school facilities or direct support to the LAUSD), which would reduce the expected cumulative demand for public

education services. Consider the combined impact of the proposed and related projects and the project's proportional contribution to the cumulative demand for public education services.

Sample Mitigation Measures

Potential mitigation measures include the following:

- Provide on-site school amenities; and
- Provide direct support to the LAUSD, including land, equipment, funding, etc. Facilities Office of the Chief Executive Master Planning & Demographics Branch.

3. DATA, RESOURCES, AND REFERENCES

LAUSD, 355 S. Grand Ave., 31st FLR. Los Angeles, 90012; can be contacted at: (213) 633-7606 or <http://www.lausd.net>.

Environmental and Public Facilities Maps (1996):

- Elementary Schools;
- Middle Schools; and
- High Schools.

Exhibit K.3-1

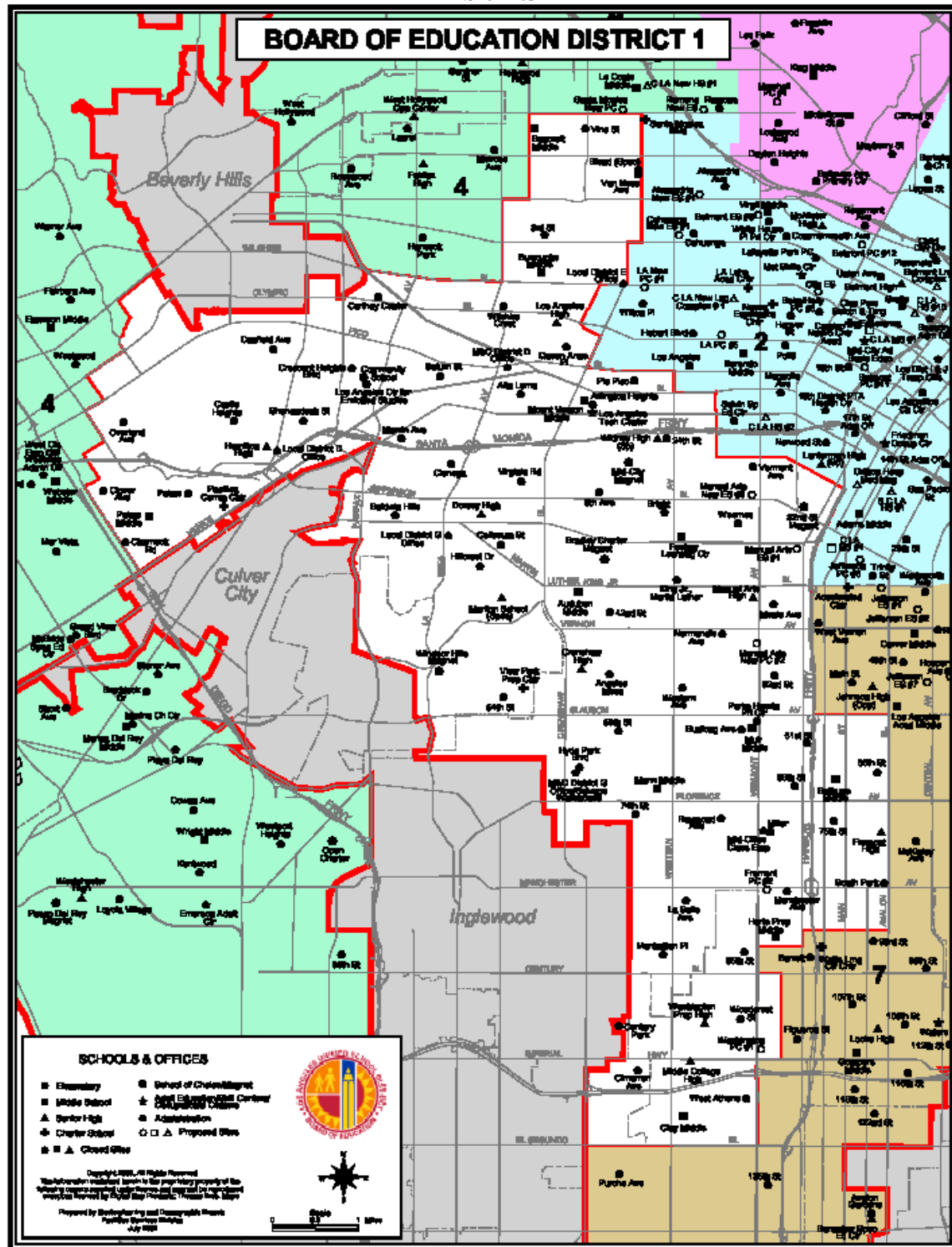


Exhibit K.3-2

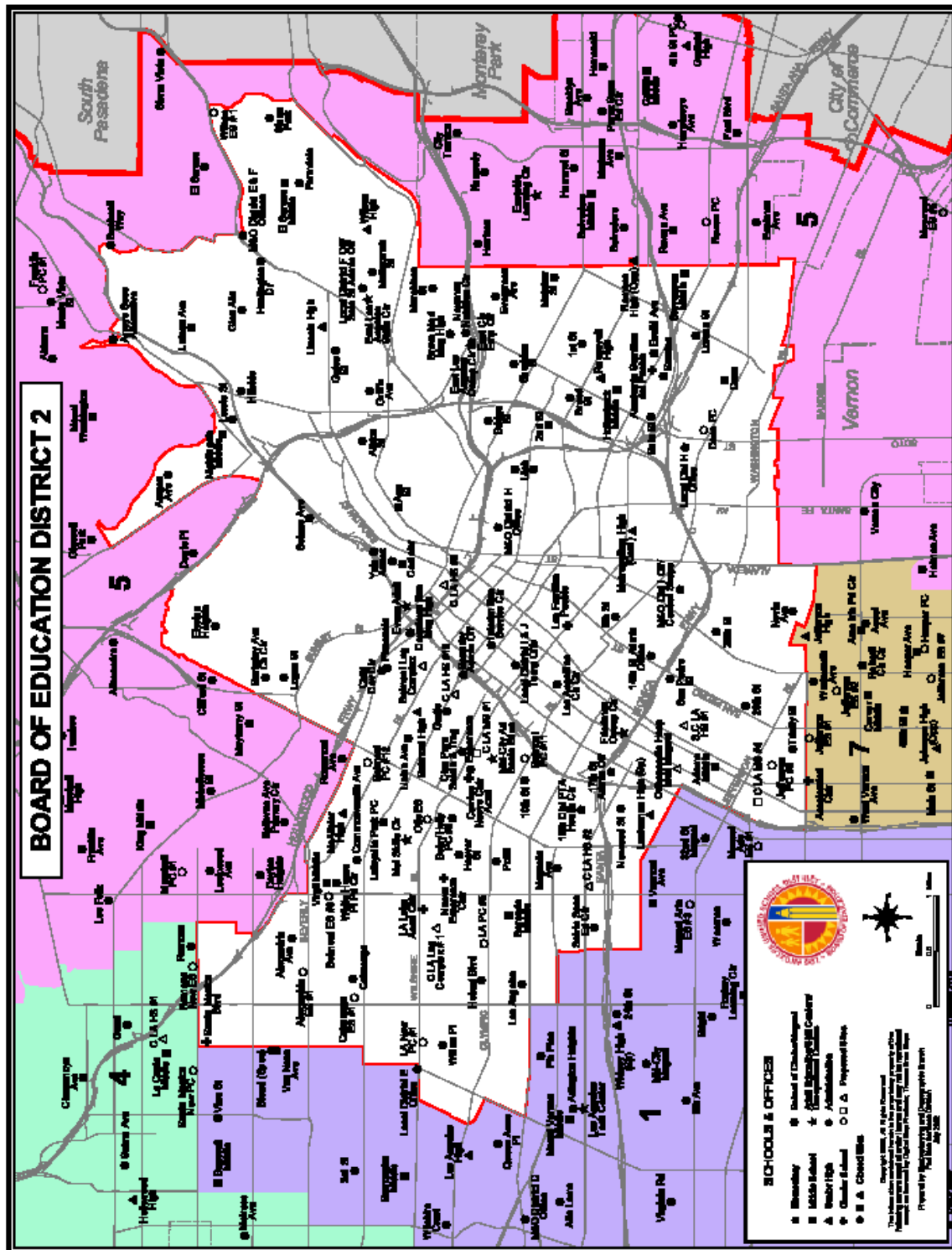


Exhibit K.3-3

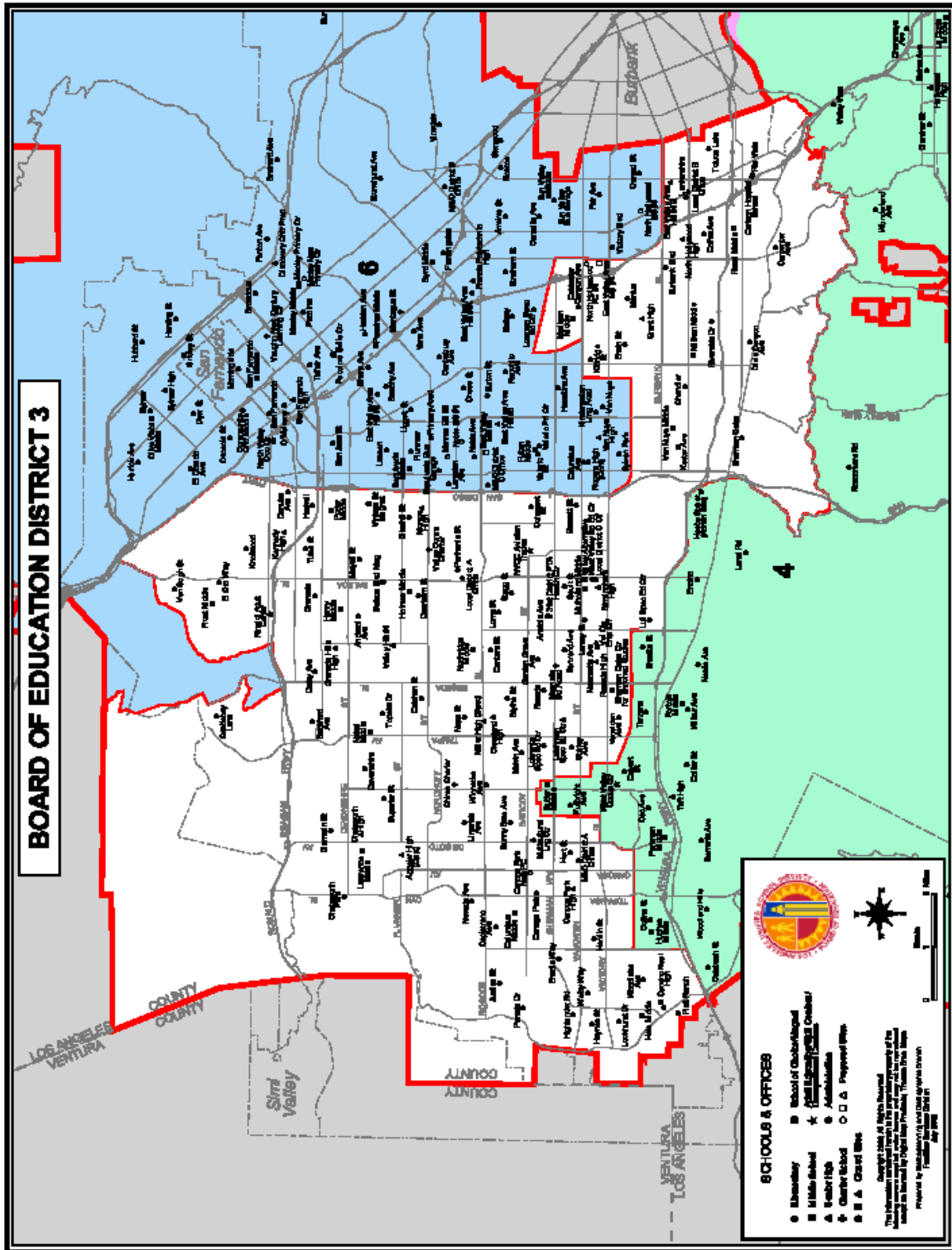


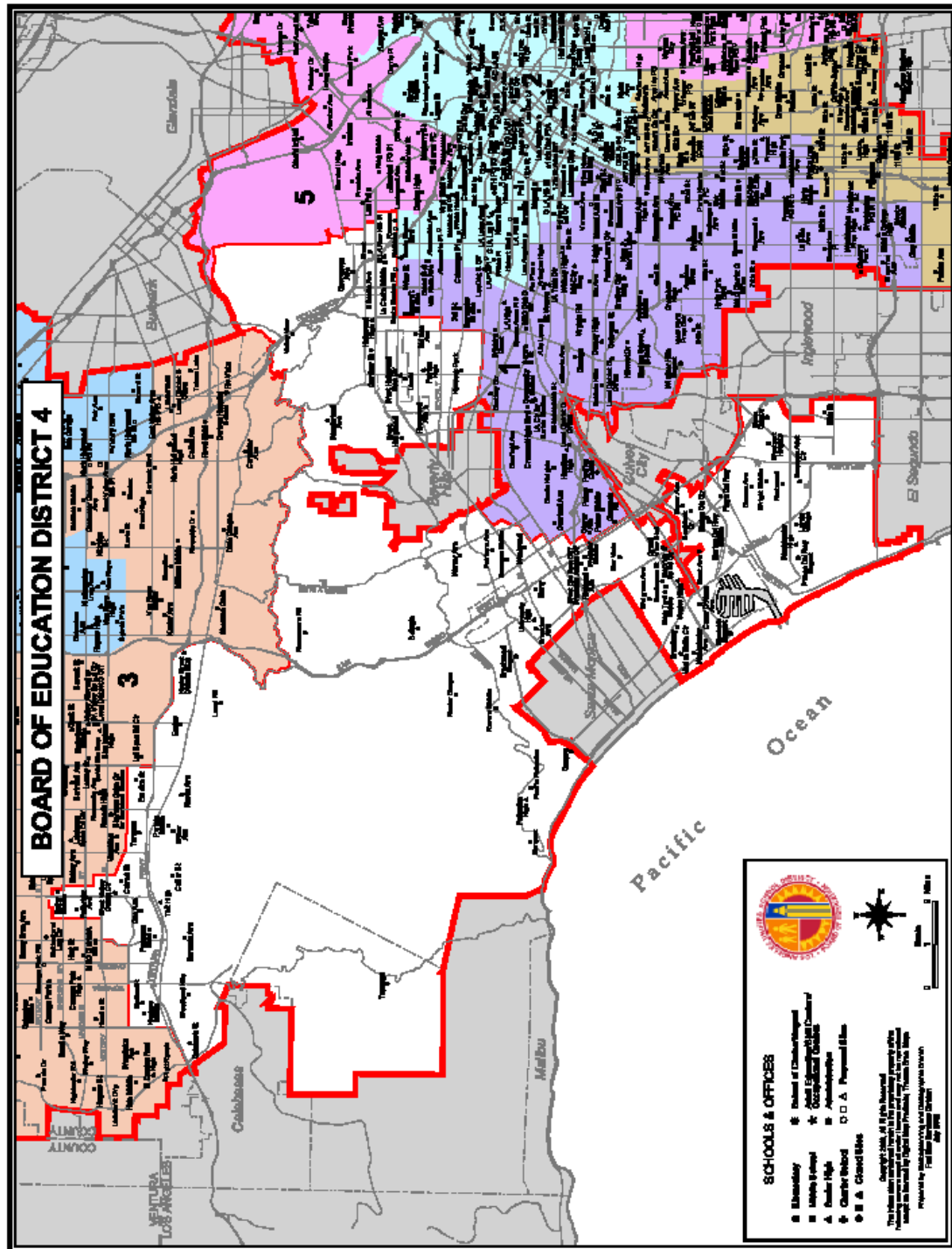
Exhibit K.3-4

Exhibit K.3-5

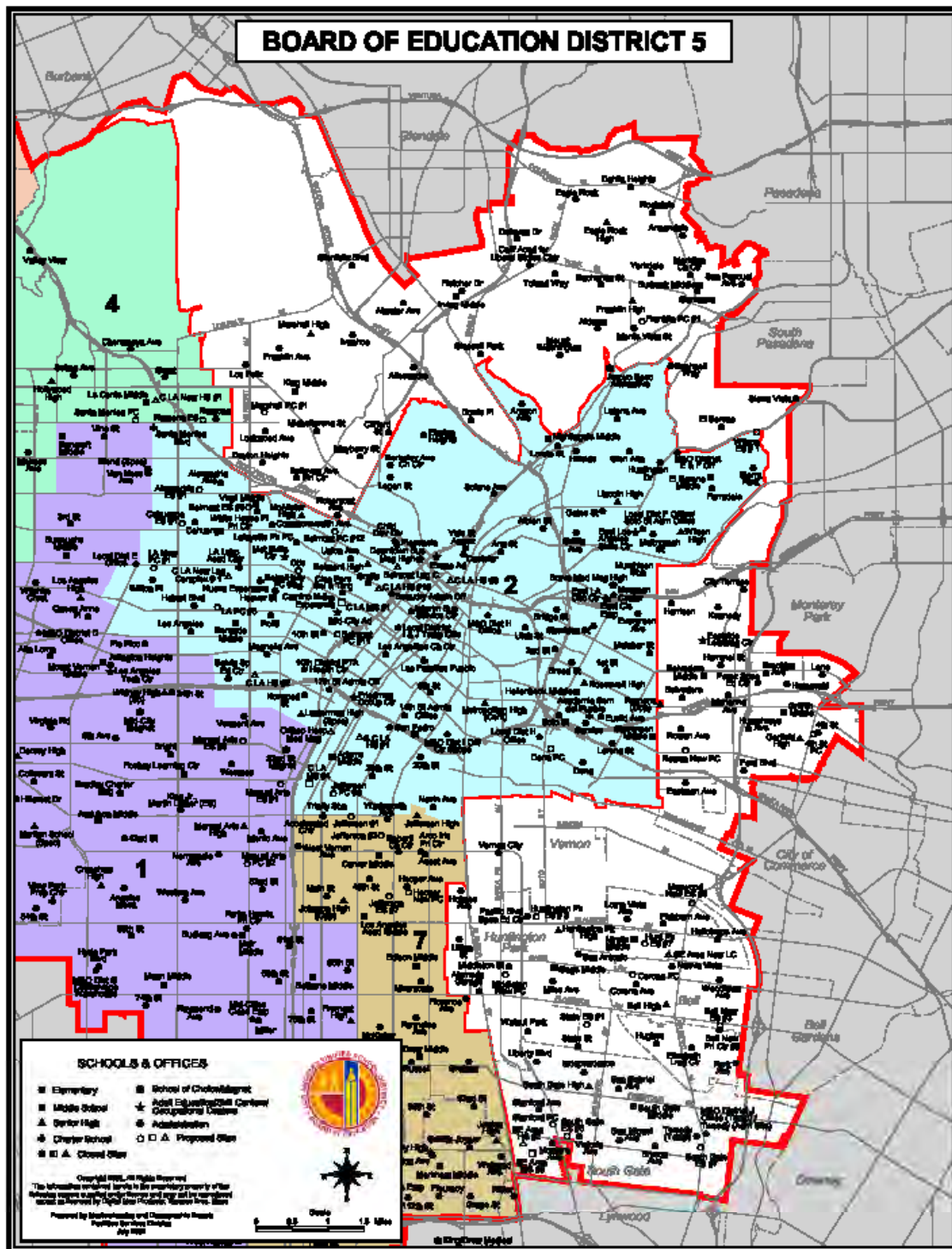


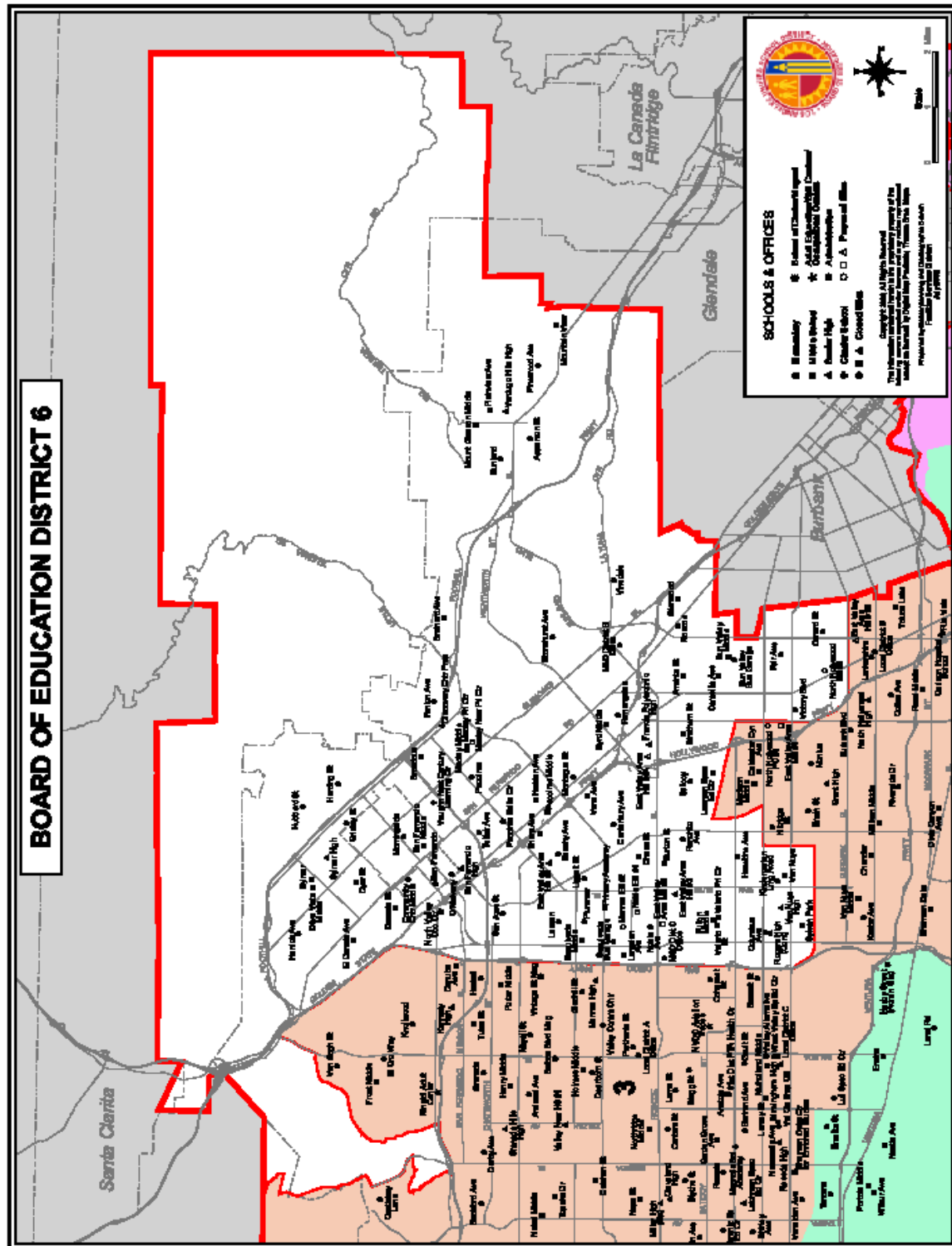
Exhibit K.3-6

Exhibit K.3-7

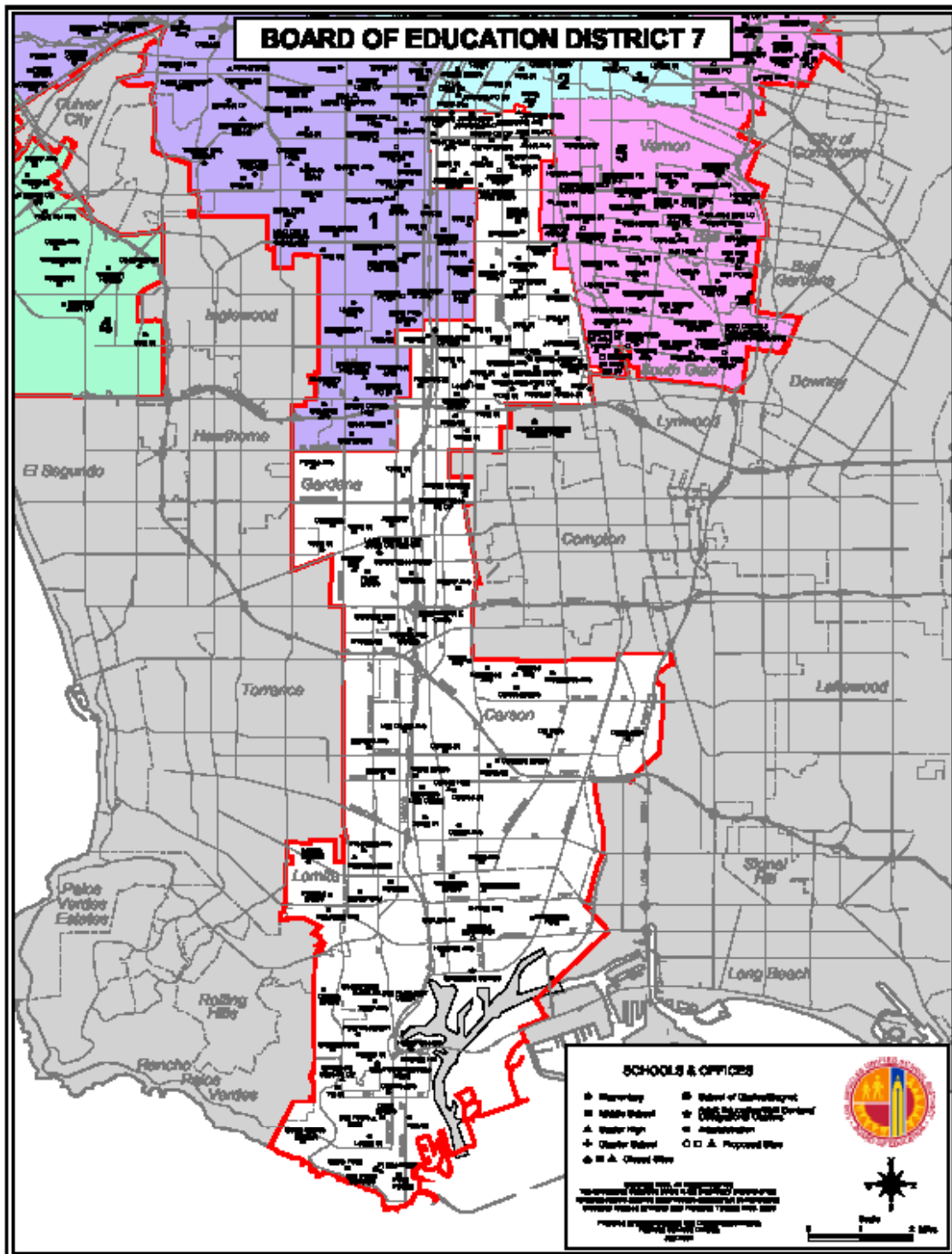


Exhibit K.3-8**ELEMENTARY**

| Name | Address | Calendar | Capacity | |
|---------------------|---|----------|------------|-----------|
| | | | 2 Semester | Operating |
| 107TH ST EL | 147 E 107TH ST LOS ANGELES, CA 90003 | 4 TRK | 1047 | 1341 |
| 109TH ST EL | 10915 S MC KINLEY AVE LOS ANGELES, CA 90059 | 1 TRK | 540 | 540 |
| 10TH ST EL | 1000 GRATTAN ST LOS ANGELES, CA 90015 | 3 TRK | 1210 | 1768 |
| 112TH ST EL | 1265 E 112TH ST LOS ANGELES, CA 90059 | 1 TRK | 821 | 821 |
| 116TH ST EL | 11610 STANFORD AVE LOS ANGELES, CA 90059 | 1 TRK | 597 | 597 |
| 118TH ST EL | 144 E 118TH ST LOS ANGELES, CA 90061 | 1 TRK | 934 | 934 |
| 122ND ST EL | 405 E 122ND ST LOS ANGELES, CA 90061 | 1 TRK | 977 | 977 |
| 135TH ST EL | 801 W 135TH ST GARDENA, CA 90247 | 3 TRK | 721 | 1037 |
| 153RD ST EL | 1605 W 153RD ST GARDENA, CA 90247 | 1 TRK | 727 | 727 |
| 156TH ST EL | 2100 W 156TH ST GARDENA, CA 90249 | 1 TRK | 412 | 412 |
| 15TH ST EL | 1527 S MESA ST SAN PEDRO, CA 90731 | 4 TRK | 740 | 949 |
| 186TH ST EL | 1581 W 186TH ST GARDENA, CA 90248 | 1 TRK | 962 | 962 |
| 1ST EL | 2820 E FIRST ST LOS ANGELES, CA 90033 | 1 TRK | 874 | 874 |
| 20TH ST EL | 1353 E 20TH ST LOS ANGELES, CA 90011 | 3 TRK | 728 | 1063 |
| 232ND PL EL | 23240 ARCHIBALD AVE CARSON, CA 90745 | 1 TRK | 543 | 543 |
| 24TH ST EL | 2055 W 24TH ST LOS ANGELES, CA 90018 | 3 TRK | 1179 | 1662 |
| 28TH ST EL | 2807 STANFORD AVE LOS ANGELES, CA 90011 | 3 TRK | 1479 | 2179 |
| 2ND ST EL | 1942 E SECOND ST LOS ANGELES, CA 90033 | 1 TRK | 802 | 802 |
| 3RD ST EL | 201 S JUNE ST LOS ANGELES, CA 90004 | 1 TRK | 831 | 831 |
| 36 th ST | 1771 W. 36 th ST LOS ANGELES, CA 90018 | | 866 | |
| 42ND ST EL | 4231 FOURTH AVE LOS ANGELES, CA 90008 | 1 TRK | 807 | 807 |
| 49TH ST EL | 750 E 49TH ST LOS ANGELES, CA 90011 | 3 TRK | 1315 | 1947 |
| 4TH ST EL | 420 S AMALIA AVE LOS ANGELES, CA 90022 | 3 TRK | 849 | 1235 |
| 52ND ST EL | 816 W 51ST ST LOS ANGELES, CA 90037 | 3 TRK | 1071 | 1534 |
| 54TH ST EL | 5501 S EILEEN AVE LOS ANGELES, CA 90043 | 4 TRK | 567 | 703 |
| 59TH ST EL | 5939 SECOND AVE LOS ANGELES, CA 90043 | 1 TRK | 529 | 529 |
| 61ST ST EL | 6020 S FIGUEROA ST LOS ANGELES, CA 90003 | 4 TRK | 958 | 1207 |
| 66TH ST EL | 6600 S SAN PEDRO ST LOS ANGELES, CA 90003 | 4 TRK | 1124 | 1420 |
| 68TH ST EL | 612 W 68TH ST LOS ANGELES, CA 90044 | 4 TRK | 967 | 1243 |
| 6TH AVE EL | 3109 SIXTH AVE LOS ANGELES, CA 90018 | 3 TRK | 822 | 1138 |
| 74TH ST EL | 2112 W 74TH ST LOS ANGELES, CA 90047 | 1 TRK | 865 | 865 |
| 75TH ST EL | 142 W 75TH ST LOS ANGELES, CA 90003 | 4 TRK | 1475 | 1878 |
| 7TH ST EL | 1570 W SEVENTH ST SAN PEDRO, CA 90732 | 1 TRK | 580 | 580 |
| 92ND ST EL | 9211 GRAPE ST LOS ANGELES, CA 90002 | 3 TRK | 840 | 1181 |
| 93RD ST EL | 330 E 93RD ST LOS ANGELES, CA 90003 | 4 TRK | 1263 | 1609 |
| 95TH ST EL | 1109 W 96TH ST LOS ANGELES, CA 90044 | 4 TRK | 1249 | 1575 |

Exhibit K.3-8**ELEMENTARY**

| Name | Address | Calendar | Capacity | |
|-------------------|---|----------|------------|-----------|
| | | | 2 Semester | Operating |
| 96TH ST EL | 1471 E 96TH ST LOS ANGELES, CA 90002 | 1 TRK | 1021 | 1021 |
| 98TH ST EL | 5431 W 98TH ST LOS ANGELES, CA 90045 | 1 TRK | 409 | 409 |
| 99TH ST EL | 9900 S WADSWORTH AVE LOS ANGELES, CA 90002 | 1 TRK | 799 | 799 |
| 9TH ST EL | 820 TOWNE AVE LOS ANGELES, CA 90021 | 1 TRK | 529 | 529 |
| ALBION EL | 322 S AVE 18 LOS ANGELES, CA 90031 | 1 TRK | 585 | 585 |
| ALDAMA EL | 632 N AVE 50 LOS ANGELES, CA 90042 | 4 TRK | 691 | 875 |
| ALEXANDRIA EL | 4211 OAKWOOD AVE LOS ANGELES, CA 90004 | 3 TRK | 1277 | 1857 |
| ALLESANDRO EL | 2210 RIVERSIDE DR LOS ANGELES, CA 90039 | 3 TRK | 437 | 619 |
| ALTA LOMA EL | 1745 VINEYARD AVE LOS ANGELES, CA 90019 | 3 TRK | 790 | 1131 |
| AMBLER EL | 319 E SHERMAN DR CARSON, CA 90746 | 1 TRK | 583 | 583 |
| AMESTOY EL | 1048 W 149TH ST GARDENA, CA 90247 | 1 TRK | 915 | 915 |
| ANATOLA EL | 7364 ANATOLA AVE VAN NUYS, CA 91406 | 1 TRK | 564 | 564 |
| ANDASOL EL | 10126 ENCINO AVE NORTHRIDGE, CA 91325 | 1 TRK | 633 | 633 |
| ANGELES MESA EL | 2611 W 52ND ST LOS ANGELES, CA 90043 | 1 TRK | 811 | 811 |
| ANN EL | 126 E BLOOM ST LOS ANGELES, CA 90012 | 1 TRK | 408 | 408 |
| ANNALEE EL | 19410 S ANNALEE AVE CARSON, CA 90746 | 1 TRK | 594 | 594 |
| ANNANDALE EL | 6125 POPPY PEAK DR LOS ANGELES, CA 90042 | 1 TRK | 459 | 459 |
| APPERSON EL | 10233 WOODWARD AVE SUNLAND, CA 91040 | 1 TRK | 604 | 604 |
| ARAGON EL | 1118 ARAGON AVE LOS ANGELES, CA 90065 | 3 TRK | 615 | 887 |
| ARLINGTON HTS EL | 1717 SEVENTH AVE LOS ANGELES, CA 90019 | 4 TRK | 868 | 1117 |
| ARMINTA EL | 11530 STRATHERN ST NO HOLLYWOOD, CA 91605 | 3 TRK | 808 | 1181 |
| ASCOT EL | 1447 E 45TH ST LOS ANGELES, CA 90011 | 3 TRK | 963 | 1391 |
| ATWATER EL | 3271 SILVER LAKE BLVD LOS ANGELES, CA 90039 | 1 TRK | 573 | 573 |
| AVALON GARDENS EL | 13940 S SAN PEDRO ST LOS ANGELES, CA 90061 | 1 TRK | 382 | 382 |
| BALDWIN HILLS EL | 5421 RODEO RD LOS ANGELES, CA 90016 | 1 TRK | 616 | 616 |
| BANDINI EL | 425 N BANDINI ST SAN PEDRO, CA 90731 | 1 TRK | 512 | 512 |
| BARRETT EL | 419 W 98TH ST LOS ANGELES, CA 90003 | 1 TRK | 1295 | 1295 |
| BARTON HILL EL | 423 N PACIFIC AVE SAN PEDRO, CA 90731 | 4 TRK | 713 | 897 |
| BASSETT EL | 15756 BASSETT ST VAN NUYS, CA 91406 | 4 TRK | 1045 | 1361 |
| BEACHY EL | 9757 BEACHY AVE PACOIMA, CA 91331 | 4 TRK | 766 | 927 |
| BECKFORD EL | 19130 TULSA ST NORTHRIDGE, CA 91326 | 1 TRK | 661 | 661 |
| BEETHOVEN EL | 3711 BEETHOVEN ST LOS ANGELES, CA 90066 | 1 TRK | 458 | 458 |
| BELVEDERE EL | 3724 E FIRST ST LOS ANGELES, CA 90063 | 4 TRK | 1250 | 1621 |
| BERTRAND EL | 7021 BERTRAND AVE RESEDA, CA 91335 | 1 TRK | 549 | 549 |
| BLYTHE EL | 18730 BLYTHE ST RESEDA, CA 91335 | 1 TRK | 662 | 662 |
| BONITA EL | 21929 BONITA ST CARSON, CA 90745 | 1 TRK | 787 | 787 |
| BRADDOCK DRIVE EL | 4711 INGLEWOOD BLVD CULVER CITY, CA 90230 | 1 TRK | 722 | 722 |

Exhibit K.3-8**ELEMENTARY**

| Name | Address | Calendar | Capacity | |
|-------------------|--|----------|------------|-----------|
| | | | 2 Semester | Operating |
| BRAINARD EL | 11407 BRAINARD AVE LAKE VIEW TERRACE, CA 91342 | 1 TRK | 425 | 425 |
| BREED EL | 2226 E THIRD ST LOS ANGELES, CA 90033 | 1 TRK | 855 | 855 |
| BRIDGE EL | 605 N BOYLE AVE LOS ANGELES, CA 90033 | 1 TRK | 539 | 539 |
| BRIGHT EL | 1771 W 36TH ST LOS ANGELES, CA 90018 | 1 TRK | 899 | 899 |
| BROAD AVE EL | 24815 BROAD AVE WILMINGTON, CA 90744 | 4 TRK | 993 | 1269 |
| BROADACRES EL | 19424 S BROADACRES AVE CARSON, CA 90746 | 1 TRK | 545 | 545 |
| BROADOUS EL | 12561 FILMORE ST PACOIMA, CA 91331 | 4 TRK | 872 | 1076 |
| BROADWAY EL | 1015 LINCOLN BLVD VENICE, CA 90291 | 1 TRK | 628 | 628 |
| BROCKTON EL | 1309 ARMACOST AVE LOS ANGELES, CA 90025 | 1 TRK | 377 | 377 |
| BROOKLYN AVE EL | 4620 CESAR CHAVEZ AVE LOS ANGELES, CA 90022 | 1 TRK | 774 | 774 |
| BRYSON EL | 4470 MISSOURI AVE SOUTH GATE, CA 90280 | 3 TRK | 800 | 1175 |
| BUCHANAN EL | 5024 BUCHANAN ST LOS ANGELES, CA 90042 | 3 TRK | 603 | 875 |
| BUDLONG EL | 5940 S BUDLONG AVE LOS ANGELES, CA 90044 | 1 TRK | 1517 | 1517 |
| BURBANK EL | 12215 ALBERS ST NO HOLLYWOOD, CA 91607 | 4 TRK | 509 | 625 |
| BURTON EL | 8111 CALHOUN AVE PANORAMA CITY, CA 91402 | 4 TRK | 719 | 890 |
| BUSHNELL WAY EL | 5507 BUSHNELL WAY LOS ANGELES, CA 90042 | 1 TRK | 711 | 711 |
| CABRILLO EL | 732 S CABRILLO AVE SAN PEDRO, CA 90731 | 4 TRK | 574 | 730 |
| CAHUENGA EL | 220 S HOBART BLVD LOS ANGELES, CA 90004 | 3 TRK | 885 | 1281 |
| CALABASH EL | 23055 EUGENE ST WOODLAND HILLS, CA 91364 | 1 TRK | 421 | 421 |
| CALAHAN EL | 18722 KNAPP ST NORTHRIDGE, CA 91324 | 1 TRK | 512 | 512 |
| CALVERT EL | 19850 DELANO ST WOODLAND HILLS, CA 91367 | 1 TRK | 621 | 621 |
| CAMELLIA EL | 7451 CAMELLIA AVE NO HOLLYWOOD, CA 91605 | 3 TRK | 1002 | 1450 |
| CANFIELD EL | 9233 AIRDROME ST LOS ANGELES, CA 90035 | 1 TRK | 446 | 446 |
| CANOGA PARK EL | 7438 TOPANGA CYN BLVD CANOGA PARK, CA 91303 | 3 TRK | 1004 | 1432 |
| CANTARA EL | 17950 CANTARA ST RESEDA, CA 91335 | 1 TRK | 790 | 790 |
| CANTERBURY EL | 13670 MONTAGUE ST PACOIMA, CA 91331 | 1 TRK | 997 | 997 |
| CANYON EL | 421 ENTRADA DR SANTA MONICA, CA 90402 | 1 TRK | 429 | 429 |
| CAPISTRANO EL | 8118 CAPISTRANO AVE CANOGA PARK, CA 91304 | 1 TRK | 590 | 590 |
| CAROLDALE | 22424 CAROLDALE AVE, CARSON CA 90745 | 1 TRK | 987 | 987 |
| CARPENTER EL | 3909 CARPENTER AVE STUDIO CITY, CA 91604 | 1 TRK | 971 | 971 |
| CARSON EL | 161 E CARSON ST CARSON, CA 90745 | 4 TRK | 816 | 1004 |
| CARTHAY CENTER EL | 6351 W OLYMPIC BLVD LOS ANGELES, CA 90048 | 1 TRK | 559 | 559 |
| CASTELAR EL | 840 YALE ST LOS ANGELES, CA 90012 | 1 TRK | 937 | 937 |
| CASTLE HTS EL | 9755 CATTARAUGUS AVE LOS ANGELES, CA 90034 | 1 TRK | 650 | 650 |
| CASTLEBAY LN EL | 19010 CASTLEBAY LN NORTHRIDGE, CA 91326 | 1 TRK | 877 | 877 |
| CATSKILL EL | 23536 CATSKILL AVE CARSON, CA 90745 | 1 TRK | 943 | 943 |
| CENTURY PK EL | 10935 S SPINNING AVE INGLEWOOD, CA 90303 | 1 TRK | 942 | 942 |

Exhibit K.3-8**ELEMENTARY**

| Name | Address | Calendar | Capacity | |
|--------------------|---|----------|------------|-----------|
| | | | 2 Semester | Operating |
| CHANDLER EL | 14030 WEDDINGTON ST VAN NUYS, CA 91401 | 1 TRK | 652 | 652 |
| CHAPMAN EL | 1947 MARINE AVE GARDENA, CA 90249 | 1 TRK | 526 | 526 |
| CHARNOCK ROAD EL | 11133 CHARNOCK RD LOS ANGELES, CA 90034 | 1 TRK | 667 | 667 |
| CHASE EL | 14041 CHASE ST PANORAMA CITY, CA 91402 | 1 TRK | 972 | 972 |
| CHATSWORTH EL | 22005 DEVONSHIRE ST CHATSWORTH, CA 91311 | 1 TRK | 512 | 512 |
| CHEREMOYA EL | 6017 FRANKLIN AVE LOS ANGELES, CA 90028 | 4 TRK | 457 | 598 |
| CIENEGA EL | 2611 S ORANGE DR LOS ANGELES, CA 90016 | 4 TRK | 837 | 1041 |
| CIMARRON EL | 11559 CIMARRON AVE HAWTHORNE, CA 90250 | 1 TRK | 600 | 600 |
| CITY TERRACE EL | 4350 CITY TERRACE DR LOS ANGELES, CA 90063 | 1 TRK | 597 | 597 |
| CLARA PRIM CENTER- | 4504 ASCOT AVE, LOS ANGELES, CA 90011 | | | |
| CLIFFORD EL | 2150 DUANE ST LOS ANGELES, CA 90039 | 1 TRK | 241 | 241 |
| CLOVER EL | 11020 CLOVER AVE LOS ANGELES, CA 90034 | 1 TRK | 576 | 576 |
| COEUR D ALENE EL | 810 COEUR D'ALENE AVE VENICE, CA 90291 | 1 TRK | 458 | 458 |
| COHASSET EL | 15810 SATICOY ST VAN NUYS, CA 91406 | 1 TRK | 887 | 887 |
| COLDWATER CYN EL | 6850 COLDWATER CYN AVE NO HOLLYWOOD, CA | 3 TRK | 1016 | 1484 |
| COLFAX EL | 11724 ADDISON ST NO HOLLYWOOD, CA 91607 | 1 TRK | 594 | 594 |
| COLISEUM EL | 4400 COLISEUM ST LOS ANGELES, CA 90016 | 1 TRK | 450 | 450 |
| COLUMBUS AVE EL | 6700 COLUMBUS AVE VAN NUYS, CA 91405 | 4 TRK | 571 | 732 |
| COMMONWEALTH EL | 215 S COMMONWEALTH AVE LOS ANGELES, CA 90004 | 3 TRK | 609 | 871 |
| COMPTON EL | 1515 E 104TH ST LOS ANGELES, CA 90002 | 1 TRK | 585 | 585 |
| CORONA EL | 3825 BELL AVE BELL, CA 90201 | 3 TRK | 1337 | 1924 |
| COWAN EL | 7615 COWAN AVE LOS ANGELES, CA 90045 | 1 TRK | 588 | 588 |
| CRESCENT HEIGHTS | 1661 S. CRESCENT HEIGHTS, LOS ANGELES, CA 90035 | 1 TRK | 332 | 332 |
| CRESTWOOD ST EL | 1946 W CRESTWOOD ST RANCHO PALOS VERDES, CA 90275 | 1 TRK | 559 | 559 |
| DACOTAH | 1314 DACOTAH ST, LOS ANGELES, CA 90023 | | NEW | NEW |
| DAHLIA HTS EL | 5063 FLORISTAN AVE LOS ANGELES, CA 90041 | 1 TRK | 434 | 434 |
| DANUBE EL | 11220 DANUBE AVE GRANADA HILLS, CA 91344 | 1 TRK | 491 | 491 |
| DARBY EL | 10818 DARBY AVE NORTHRIDGE, CA 91326 | 1 TRK | 649 | 649 |
| DAYTON HEIGHTS EL | 607 N WESTMORELAND AVE LOS ANGELES, CA 90004 | 4 TRK | 847 | 1051 |
| DEARBORN EL | 9240 WISH AVE NORTHRIDGE, CA 91325 | 1 TRK | 628 | 628 |
| DEL AMO EL | 21228 WATER ST CARSON, CA 90745 | 1 TRK | 574 | 574 |
| DELEVAN DRIVE EL | 4168 W AVE 42 LOS ANGELES, CA 90065 | 1 TRK | 588 | 588 |
| DENA EL | 1314 DACOTAH ST LOS ANGELES, CA 90023 | 3 TRK | 805 | 1125 |
| DENKER EL | 1620 W 162ND ST GARDENA, CA 90247 | 4 TRK | 945 | 1199 |
| DIXIE CANYON EL | 4220 DIXIE CANYON AVE SHERMAN OAKS, CA 91423 | 1 TRK | 697 | 697 |
| DOLORES EL | 22526 DOLORES ST CARSON, CA 90745 | 1 TRK | 916 | 916 |
| DOMINGUEZ EL | 21250 SANTA FE AVE LONG BEACH, CA 90810 | 1 TRK | 767 | 767 |

Exhibit K.3-8**ELEMENTARY**

| Name | Address | Calendar | Capacity | |
|--------------------|---|----------|------------|-----------|
| | | | 2 Semester | Operating |
| DORRIS PLACE EL | 2225 DORRIS PL LOS ANGELES, CA 90031 | 1 TRK | 660 | 660 |
| DYER EL | 14500 DYER ST SYLMAR, CA 91342 | 4 TRK | 954 | 1230 |
| EAGLE ROCK EL | 2057 FAIR PARK AVE LOS ANGELES, CA 90041 | 1 TRK | 1045 | 1045 |
| EASTMAN EL | 4112 E OLYMPIC BLVD LOS ANGELES, CA 90023 | 1 TRK | 1573 | 1573 |
| EL DORADO EL | 12749 EL DORADO AVE SYLMAR, CA 91342 | 1 TRK | 813 | 813 |
| ELIZABETH | 4811 ELIZABETH ST, CUDAHY, CA 90201 | 3 TRK | 2348 | |
| EL ORO EL | 12230 EL ORO WAY GRANADA HILLS, CA 91344 | 1 TRK | 582 | 582 |
| EL SERENO EL | 3838 ROSEMEAD AVE LOS ANGELES, CA 90032 | 1 TRK | 756 | 756 |
| ELYSIAN HEIGHTS EL | 1562 BAXTER ST LOS ANGELES, CA 90026 | 1 TRK | 468 | 468 |
| EMELITA EL | 17931 HATTERAS ST ENCINO, CA 91316 | 1 TRK | 618 | 618 |
| ENCINO EL | 16941 ADDISON ST ENCINO, CA 91316 | 1 TRK | 665 | 665 |
| ERWIN EL | 13400 ERWIN ST VAN NUYS, CA 91401 | 1 TRK | 1218 | 1218 |
| ESHELMAN EL | 25902 ESHELMAN AVE LOMITA, CA 90717 | 4 TRK | 657 | 768 |
| ESPERANZA EL | 680 LITTLE ST LOS ANGELES, CA 90017 | 3 TRK | 821 | 1141 |
| EUCLID EL | 806 EUCLID AVE LOS ANGELES, CA 90023 | 1 TRK | 857 | 857 |
| EVERGREEN EL | 2730 GANAHL ST LOS ANGELES, CA 90033 | 1 TRK | 1263 | 1263 |
| FAIR EL | 6501 FAIR AVE NO HOLLYWOOD, CA 91606 | 3 TRK | 1263 | 1821 |
| FAIRBURN EL | 1403 FAIRBURN AVE LOS ANGELES, CA 90024 | 1 TRK | 444 | 444 |
| FARMDALE EL | 2660 RUTH SWIGGETT DR LOS ANGELES, CA 90032 | 1 TRK | 863 | 863 |
| FENTON EL | 11828 GAIN ST LAKE VIEW TERRACE, CA 91342 | OTHER | | 931 |
| FERNANGELES EL | 12001 ART ST SUN VALLEY, CA 91352 | 3 TRK | 1019 | 1457 |
| FIGUEROA EL | 510 W 111TH ST LOS ANGELES, CA 90044 | 3 TRK | 722 | 989 |
| FISHBURN EL | 5701 FISHBURN AVE MAYWOOD, CA 90270 | 3 TRK | 921 | 1314 |
| FLETCHER DR EL | 3350 FLETCHER DR LOS ANGELES, CA 90065 | 3 TRK | 780 | 1101 |
| FLORENCE EL | 7211 BELL AVE LOS ANGELES, CA 90001 | 3 TRK | 947 | 1345 |
| FLOURNOY EL | 1630 E 111TH ST LOS ANGELES, CA 90059 | 1 TRK | 907 | 907 |
| FORD BLVD EL | 1112 S FORD BLVD LOS ANGELES, CA 90022 | 1 TRK | 1519 | 1519 |
| FRANKLIN EL | 1910 N COMMONWEALTH AVE LOS ANGELES, CA 90027 | 1 TRK | 562 | 562 |
| FRIES EL | 1301 FRIES AVE WILMINGTON, CA 90744 | 3 TRK | 873 | 1281 |
| FULLBRIGHT EL | 6940 FULLBRIGHT AVE CANOGA PARK, CA 91306 | 1 TRK | 660 | 660 |
| GARDEN GROVE EL | 18141 VALERIO ST RESEDA, CA 91335 | 1 TRK | 534 | 534 |
| GARDENA EL | 647 W GARDENA BLVD GARDENA, CA 90247 | 4 TRK | 746 | 950 |
| GARDNER EL | 7450 HAWTHORN AVE LOS ANGELES, CA 90046 | 1 TRK | 608 | 608 |
| GARVANZA EL | 317 N AVE 62 LOS ANGELES, CA 90042 | 4 TRK | 573 | 684 |
| GATES EL | 3333 MANITOU AVE LOS ANGELES, CA 90031 | 3 TRK | 820 | 1181 |
| GAULT EL | 17000 GAULT ST VAN NUYS, CA 91406 | 1 TRK | 579 | 579 |
| GERMAIN EL | 20730 GERMAIN ST CHATSWORTH, CA 91311 | 1 TRK | 918 | 918 |

Exhibit K.3-8**ELEMENTARY**

| Name | Address | Calendar | Capacity | |
|--------------------|--|----------|------------|-----------|
| | | | 2 Semester | Operating |
| GLASSELL PARK EL | 2211 W AVE 30 LOS ANGELES, CA 90065 | 4 TRK | 767 | 971 |
| GLEDHILL EL | 16030 GLEDHILL ST NORTH HILLS, CA 91343 | 1 TRK | 801 | 801 |
| GLEN ALTA EL | 3410 SIERRA ST LOS ANGELES, CA 90031 | 1 TRK | 458 | 458 |
| GLENFELIZ BLVD EL | 3955 GLENFELIZ BLVD LOS ANGELES, CA 90039 | 1 TRK | 695 | 695 |
| GLENWOOD EL | 8001 LEDGE AVE SUN VALLEY, CA 91352 | 1 TRK | 798 | 798 |
| GRAHAM EL | 8407 S FIR AVE LOS ANGELES, CA 90001 | 3 TRK | 1004 | 1487 |
| GRANADA EL | 17170 TRIBUNE ST GRANADA HILLS, CA 91344 | 1 TRK | 625 | 625 |
| GRAND VIEW EL | 3951 GRAND VIEW BLVD LOS ANGELES, CA 90066 | 1 TRK | 847 | 847 |
| GRANT EL | 1530 N WILTON PL LOS ANGELES, CA 90028 | 3 TRK | 1090 | 1575 |
| GRAPE EL | 1940 E 111TH ST LOS ANGELES, CA 90059 | 1 TRK | 764 | 764 |
| GRATTS EL | 309 LUCAS AVE LOS ANGELES, CA 90017 | 3 TRK | 717 | 1053 |
| GRIDLEY EL | 1907 EIGHTH ST SAN FERNANDO, CA 91340 | 3 TRK | 815 | 1208 |
| GRIFFIN EL | 2025 GRIFFIN AVE LOS ANGELES, CA 90031 | 1 TRK | 748 | 748 |
| GRIFFITH JOYNER EL | 1963 E 103RD ST LOS ANGELES, CA 90002 | 1 TRK | 1201 | 1201 |
| GULF EL | 828 W "L" ST WILMINGTON, CA 90744 | 3 TRK | 1049 | 1497 |
| HADDON EL | 10115 HADDON AVE PACOIMA, CA 91331 | 3 TRK | 1071 | 1554 |
| HALLDALE EL | 21514 HALLDALE AVE TORRANCE, CA 90501 | 1 TRK | 722 | 722 |
| HAMASAKI EL | 4865 E FIRST ST LOS ANGELES, CA 90022 | 1 TRK | 651 | 651 |
| HAMLIN EL | 22627 HAMLIN ST CANOGA PARK, CA 91307 | 1 TRK | 591 | 591 |
| HAMMEL EL | 438 N BRANNICK AVE LOS ANGELES, CA 90063 | 1 TRK | 1101 | 1101 |
| HANCOCK PARK EL | 408 S FAIRFAX AVE LOS ANGELES, CA 90036 | 1 TRK | 788 | 788 |
| HARBOR CITY EL | 1508 W 254TH ST HARBOR CITY, CA 90710 | 3 TRK | 570 | 792 |
| HARDING EL | 13060 HARDING ST SYLMAR, CA 91342 | 1 TRK | 825 | 825 |
| HARRISON | 3529 CITY TERRACE DRIVE, LOS ANGELES, CA 90063 | 1 TRK | 1455 | 1455 |
| HART ST EL | 21040 HART ST CANOGA PARK, CA 91303 | 4 TRK | 873 | 1077 |
| HASKELL EL | 15850 TULSA ST GRANADA HILLS, CA 91344 | 1 TRK | 494 | 494 |
| HAWAIIAN EL | 540 HAWAIIAN AVE WILMINGTON, CA 90744 | 4 TRK | 1037 | 1333 |
| HAYNES EL | 6624 LOCKHURST DR WEST HILLS, CA 91307 | 1 TRK | 423 | 423 |
| HAZELTINE EL | 7150 HAZELTINE AVE VAN NUYS, CA 91405 | 3 TRK | 944 | 1359 |
| HELIOTROPE EL | 5911 WOODLAWN AVE MAYWOOD, CA 90270 | 3 TRK | 1029 | 1514 |
| HERRICK EL | 13350 HERRICK AVE SYLMAR, CA 91342 | 1 TRK | 839 | 839 |
| HILLCREST DR EL | 4041 HILLCREST DR LOS ANGELES, CA 90008 | 4 TRK | 947 | 1216 |
| HILLSIDE EL | 120 E AVE 35 LOS ANGELES, CA 90031 | 3 TRK | 554 | 761 |
| HOBART BLVD EL | 980 S HOBART BLVD LOS ANGELES, CA 90006 | 3 TRK | 1457 | 2103 |
| HOLMES EL | 5108 HOLMES AVE LOS ANGELES, CA 90058 | 1 TRK | 589 | 589 |
| HOOPER EL | 1225 E 52ND ST LOS ANGELES, CA 90011 | 3 TRK | 1486 | 2142 |
| HOOVER EL | 2726 FRANCIS AVE LOS ANGELES, CA 90005 | 3 TRK | 1548 | 2273 |

Exhibit K.3-8**ELEMENTARY**

| Name | Address | Calendar | Capacity | |
|------------------|---|----------|------------|-----------|
| | | | 2 Semester | Operating |
| HUBBARD EL | 13325 HUBBARD ST SYLMAR, CA 91342 | 1 TRK | 1062 | 1062 |
| HUGHES EL | 4242 CLARA ST CUDAHY, CA 90201 | 3 TRK | 1071 | 1529 |
| HUMPHREYS EL | 500 S HUMPHREYS AVE LOS ANGELES, CA 90022 | 1 TRK | 1046 | 1046 |
| HUNTINGTON DR EL | 4435 N HUNTINGTON DR LOS ANGELES, CA 90032 | 1 TRK | 817 | 817 |
| HYDE PARK EL | 3140 HYDE PARK BLVD LOS ANGELES, CA 90043 | 4 TRK | 884 | 1133 |
| INDEPENDENCE EL | 8435 VICTORIA AVE SOUTH GATE, CA 90280 | 3 TRK | 796 | 1161 |
| IVANHOE EL | 2828 HERKIMER ST LOS ANGELES, CA 90039 | 1 TRK | 424 | 424 |
| JUSTICE EL | 23350 JUSTICE ST CANOGA PARK, CA 91304 | 1 TRK | 606 | 606 |
| KENNEDY EL | 4010 E RAMBOZ DRIVE LOS ANGELES, CA 90063 | 1 TRK | 868 | 868 |
| KENTER CANYON EL | 645 N KENTER AVE LOS ANGELES, CA 90049 | 1 TRK | 500 | 500 |
| KENTWOOD EL | 8401 EMERSON AVE LOS ANGELES, CA 90045 | 1 TRK | 521 | 521 |
| KESTER EL | 5353 KESTER AVE VAN NUYS, CA 91411 | 1 TRK | 780 | 780 |
| KING JR EL | 3989 S HOBART BLVD LOS ANGELES, CA 90062 | 1 TRK | 1109 | 1109 |
| KITTRIDGE EL | 13619 KITTRIDGE ST VAN NUYS, CA 91401 | 3 TRK | 906 | 1294 |
| KNOLLWOOD EL | 11822 GERALD AVE GRANADA HILLS, CA 91344 | 1 TRK | 639 | 639 |
| LA SALLE EL | 8715 LA SALLE AVE LOS ANGELES, CA 90047 | 1 TRK | 1159 | 1159 |
| LANAI EL | 4241 LANAI RD ENCINO, CA 91436 | 1 TRK | 541 | 541 |
| LANE EL | 1500 CESAR CHAVEZ AVE MONTEREY PARK, CA 91754 | 1 TRK | 576 | 576 |
| LA NEW #3 | 1211 SOUTH HOBART BLVD, LOS ANGELES, CA 90006 | | NEW | NEW |
| LANGDON EL | 8817 LANGDON AVE NORTH HILLS, CA 91343 | 3 TRK | 1125 | 1672 |
| LANKERSHIM EL | 5250 BAKMAN AVE NO HOLLYWOOD, CA 91601 | 4 TRK | 736 | 940 |
| LASSEN EL | 15017 SUPERIOR ST NORTH HILLS, CA 91343 | 1 TRK | 785 | 785 |
| LATONA EL | 4312 BERENICE AVE LOS ANGELES, CA 90031 | 3 TRK | 419 | 561 |
| LAUREL EL | 925 N HAYWORTH AVE LOS ANGELES, CA 90046 | 1 TRK | 499 | 499 |
| LEAPWOOD EL | 19302 LEAPWOOD AVE CARSON, CA 90746 | 1 TRK | 586 | 586 |
| LELAND EL | 2120 S LELAND ST SAN PEDRO, CA 90731 | 1 TRK | 755 | 755 |
| LEMAY EL | 17520 VANOWEN ST VAN NUYS, CA 91406 | 1 TRK | 439 | 439 |
| LIBERTY EL | 2728 LIBERTY BLVD SOUTH GATE, CA 90280 | 3 TRK | 961 | 1369 |
| LIGGETT EL | 9373 MOONBEAM AVE PANORAMA CITY, CA 91402 | 3 TRK | 1010 | 1443 |
| LILLIAN EL | 5909 LILLIAN ST LOS ANGELES, CA 90001 | 1 TRK | 781 | 781 |
| LIMERICK EL | 8530 LIMERICK AVE CANOGA PARK, CA 91306 | 1 TRK | 1175 | 1175 |
| LOCKHURST EL | 6170 LOCKHURST DR WOODLAND HILLS, CA 91367 | 1 TRK | 615 | 615 |
| LOCKWOOD EL | 4345 LOCKWOOD AVE LOS ANGELES, CA 90029 | 3 TRK | 813 | 1154 |
| LOGAN EL | 1711 W MONTANA ST LOS ANGELES, CA 90026 | 4 TRK | 1164 | 1465 |
| LOMA VISTA EL | 3629 E 58TH ST MAYWOOD, CA 90270 | 3 TRK | 1242 | 1785 |
| LORENA EL | 1015 S LORENA ST LOS ANGELES, CA 90023 | 1 TRK | 959 | 959 |
| LORETO EL | 3408 ARROYO SECO AVE LOS ANGELES, CA 90065 | 3 TRK | 534 | 756 |

Exhibit K.3-8**ELEMENTARY**

| Name | Address | Calendar | Capacity | |
|-------------------|--|----------|------------|-----------|
| | | | 2 Semester | Operating |
| LORNE EL | 17440 LORNE ST NORTHRIDGE, CA 91325 | 1 TRK | 481 | 481 |
| LOS ANGELES EL | 1211 S HOBART BLVD LOS ANGELES, CA 90006 | 3 TRK | 907 | 1300 |
| LOS FELIZ EL | 1740 N NEW HAMPSHIRE AVE LOS ANGELES, CA 90027 | 1 TRK | 849 | 849 |
| LOYOLA VILLAGE EL | 8821 VILLANOVA AVE LOS ANGELES, CA 90045 | 1 TRK | 432 | 432 |
| MACLAY PRIMARY | 12513 GAIN ST, PACOIMA, CA 91331 | 4 TRK | 300 | |
| MAGNOLIA EL | 1626 S ORCHARD AVE LOS ANGELES, CA 90006 | 3 TRK | 1332 | 1919 |
| MAIN ST EL | 129 E 53RD ST LOS ANGELES, CA 90011 | 3 TRK | 1125 | 1623 |
| MALABAR EL | 3200 E MALABAR ST LOS ANGELES, CA 90063 | 1 TRK | 1106 | 1106 |
| MANCHESTER EL | 661 W 87TH ST LOS ANGELES, CA 90044 | 3 TRK | 1242 | 1785 |
| MANHATTAN EL | 1850 W 96TH ST LOS ANGELES, CA 90047 | 1 TRK | 887 | 887 |
| MAR VISTA EL | 3330 GRANVILLE AVE LOS ANGELES, CA 90066 | 1 TRK | 760 | 760 |
| MARIANNA EL | 4215 E GLEASON ST LOS ANGELES, CA 90063 | 1 TRK | 548 | 548 |
| MARQUEZ EL | 16821 MARQUEZ AVE PACIFIC PALISADES, CA 90272 | 1 TRK | 790 | 790 |
| MARVIN EL | 2411 MARVIN AVE LOS ANGELES, CA 90016 | 4 TRK | 834 | 1038 |
| MAYALL EL | 16701 MAYALL ST NORTH HILLS, CA 91343 | 1 TRK | 657 | 657 |
| MAYBERRY EL | 2414 MAYBERRY ST LOS ANGELES, CA 90026 | 1 TRK | 500 | 500 |
| MC KINLEY EL | 7812 MC KINLEY AVE LOS ANGELES, CA 90001 | 1 TRK | 1007 | 1007 |
| MELROSE EL | 731 N DETROIT ST LOS ANGELES, CA 90046 | 1 TRK | 376 | 376 |
| MELVIN EL | 7700 MELVIN AVE RESEDA, CA 91335 | 1 TRK | 743 | 743 |
| MENLO EL | 4156 MENLO AVE LOS ANGELES, CA 90037 | 3 TRK | 985 | 1393 |
| MEYLER EL | 1123 W 223RD ST TORRANCE, CA 90502 | 4 TRK | 1052 | 1326 |
| MICHELTORENA EL | 1511 MICHELTORENA ST LOS ANGELES, CA 90026 | 4 TRK | 670 | 811 |
| MIDDLETON EL | 6537 MALABAR ST HUNTINGTON PARK, CA 90255 | 3 TRK | 1393 | 2044 |
| MILES EL | 6720 MILES AVE HUNTINGTON PARK, CA 90255 | 3 TRK | 1792 | 2596 |
| MILLER EL | 830 W 77TH ST LOS ANGELES, CA 90044 | 3 TRK | 951 | 1359 |
| MIRAMONTE EL | 1400 E 68TH ST LOS ANGELES, CA 90001 | 3 TRK | 1533 | 2253 |
| MONLUX EL | 6051 BELLAIRE AVE NO HOLLYWOOD, CA 91606 | 1 TRK | 762 | 762 |
| MONTAGUE EL | 13000 MONTAGUE ST PACOIMA, CA 91331 | OTHER | 8 | 1132 |
| MONTARA AVE EL | 10018 MONTARA AVE SOUTH GATE, CA 90280 | 3 TRK | 635 | 897 |
| MONTE VISTA EL | 5423 MONTE VISTA ST LOS ANGELES, CA 90042 | 4 TRK | 698 | 869 |
| MORNINGSIDE EL | 576 N MACLAY AVE SAN FERNANDO, CA 91340 | 3 TRK | 847 | 1260 |
| MOUNTAIN VIEW EL | 6410 OLCOTT ST TUJUNGA, CA 91042 | 1 TRK | 775 | 775 |
| MT WASHINGTON EL | 3981 SAN RAFAEL AVE LOS ANGELES, CA 90065 | 1 TRK | 434 | 434 |
| MULTNOMAH EL | 2101 N INDIANA AVE LOS ANGELES, CA 90032 | 1 TRK | 564 | 564 |
| MURCHISON EL | 1501 MURCHISON ST LOS ANGELES, CA 90033 | 1 TRK | 940 | 940 |
| NAPA EL | 19010 NAPA ST NORTHRIDGE, CA 91324 | 4 TRK | 731 | 919 |
| NESTLE EL | 5060 NESTLE AVE TARZANA, CA 91356 | 1 TRK | 598 | 598 |

Exhibit K.3-8**ELEMENTARY**

| Name | Address | Calendar | Capacity | |
|-------------------|--|----------|------------|-----------|
| | | | 2 Semester | Operating |
| NEVADA EL | 22120 CHASE ST CANOGA PARK, CA 91304 | 1 TRK | 788 | 788 |
| NEVIN EL | 1569 E 32ND ST LOS ANGELES, CA 90011 | 3 TRK | 613 | 840 |
| NEWCASTLE EL | 6520 NEWCASTLE AVE RESEDA, CA 91335 | 1 TRK | 500 | 500 |
| NOBLE EL | 8329 NOBLE AVE NORTH HILLS, CA 91343 | 3 TRK | 1211 | 1799 |
| NORMANDIE EL | 4505 S RAYMOND AVE LOS ANGELES, CA 90037 | 4 TRK | 1162 | 1483 |
| NORMONT EL | 1001 W 253RD ST HARBOR CITY, CA 90710 | 4 TRK | 503 | 634 |
| NORWOOD EL | 2020 OAK ST LOS ANGELES, CA 90007 | 4 TRK | 963 | 1219 |
| NUEVA VISTA EL | 4412 RANDOLPH ST BELL, CA 90201 | 3 TRK | 1017 | 1470 |
| O MELVENY EL | 728 WOODWORTH ST SAN FERNANDO, CA 91340 | 4 TRK | 726 | 907 |
| OSCEOLA EL | 14940 OSCEOLA ST SYLMAR, CA 91342 | 4 TRK | 459 | 550 |
| OVERLAND EL | 10650 ASHBY AVE LOS ANGELES, CA 90064 | 1 TRK | 620 | 620 |
| OXNARD EL | 10912 OXNARD ST NO HOLLYWOOD, CA 91606 | 3 TRK | 843 | 1211 |
| PACIFIC PALISADES | 800 VIA DE LA PAZ PACIFIC PALISADES, CA 90272 | 1 TRK | 513 | 513 |
| PACOIMA EL | 11016 NORRIS AVE PACOIMA, CA 91331 | OTHER | 1340 | 1663 |
| PALMS EL | 3520 MOTOR AVE LOS ANGELES, CA 90034 | 1 TRK | 600 | 600 |
| PARK AVE EL | 5027 LIVE OAK ST CUDAHY, CA 90201 | 3 TRK | 817 | 1157 |
| PARK WESTERN EL | 1214 PARK WESTERN PL SAN PEDRO, CA 90732 | 1 TRK | 416 | 416 |
| PARMELEE EL | 1338 E 76TH PL LOS ANGELES, CA 90001 | 3 TRK | 1107 | 1632 |
| PARTHENIA EL | 16825 NAPA ST NORTH HILLS, CA 91343 | 4 TRK | 747 | 951 |
| PIO PICO | 1512 So. ARLINGTON AVE, LOS ANGELES, CA. 91042 | 3 TRK | 1655 | |
| PINEWOOD EL | 10111 SILVERTON AVE TUJUNGA, CA 91042 | 1 TRK | 936 | 936 |
| PLAINVIEW EL | 10819 PLAINVIEW AVE TUJUNGA, CA 91042 | 1 TRK | 625 | 625 |
| PLASENCIA EL | 1321 CORTEZ ST LOS ANGELES, CA 90026 | 4 TRK | 1076 | 1377 |
| PLAYA DEL REY EL | 12221 JUNIETTE ST CULVER CITY, CA 90230 | 1 TRK | 323 | 323 |
| PLUMMER EL | 9340 NOBLE AVE NORTH HILLS, CA 91343 | 3 TRK | 1236 | 1782 |
| POINT FERMIN EL | 3333 KERCKHOFF AVE SAN PEDRO, CA 90731 | 1 TRK | 429 | 429 |
| POLITI EL | 2481 W 11TH ST LOS ANGELES, CA 90006 | 3 TRK | 871 | 1259 |
| POMELO EL | 7633 MARCH AVE CANOGA PARK, CA 91304 | 1 TRK | 892 | 892 |
| PRESIDENT EL | 1465 W 243RD ST HARBOR CITY, CA 90710 | 1 TRK | 699 | 699 |
| PURCHE EL | 13210 PURCHE AVE GARDENA, CA 90249 | 1 TRK | 732 | 732 |
| QUEEN ANNE EL | 1212 QUEEN ANNE PL, LOS ANGELES, CA 90019 | 1 TRK | 579 | 579 |
| RAMONA EL | 1133 N MARIPOSA AVE, LOS ANGELES, CA 90029 | 3 TRK | 1006 | 1479 |
| RANCHITO EL | 7940 RANCHITO AVE, PANORAMA CITY, CA 91402 | 3 TRK | 548 | 770 |
| RAYMOND AVE EL | 7511 RAYMOND AVE LOS ANGELES, CA 90044 | 4 TRK | 851 | 1085 |
| RESEDA EL | 7265 AMIGO AVE RESEDA, CA 91335 | 1 TRK | 601 | 601 |
| RICHLAND EL | 11562 RICHLAND AVE LOS ANGELES, CA 90064 | 1 TRK | 516 | 516 |
| RIO VISTA EL | 4243 SATSUMA AVE NO HOLLYWOOD, CA 91602 | 1 TRK | 518 | 518 |

Exhibit K.3-8**ELEMENTARY**

| Name | Address | Calendar | Capacity | |
|-------------------|---|----------|------------|-----------|
| | | | 2 Semester | Operating |
| RITTER EL | 11108 WATTS AVE LOS ANGELES, CA 90059 | 1 TRK | 493 | 493 |
| RIVERSIDE EL | 13061 RIVERSIDE DR SHERMAN OAKS, CA 91423 | 1 TRK | 898 | 898 |
| ROCKDALE EL | 1303 YOSEMITE DR LOS ANGELES, CA 90041 | 1 TRK | 376 | 376 |
| ROSCOE EL | 10765 STRATHERN ST SUN VALLEY, CA 91352 | 3 TRK | 851 | 1227 |
| ROSCOMARE EL | 2425 ROSCOMARE RD LOS ANGELES, CA 90077 | 1 TRK | 569 | 569 |
| ROSEMONT EL | 421 N ROSEMONT AVE LOS ANGELES, CA 90026 | 3 TRK | 1071 | 1591 |
| ROSEWOOD EL | 503 N CROFT AVE LOS ANGELES, CA 90048 | 1 TRK | 624 | 624 |
| ROWAN EL | 600 S ROWAN AVE LOS ANGELES, CA 90023 | 3 TRK | 1135 | 1658 |
| RUSSELL EL | 1263 E FIRESTONE BLVD LOS ANGELES, CA 90001 | 3 TRK | 1017 | 1450 |
| SAN ANTONIO ELEM | 6222 STATE ST HUNTINGTON PARK, CA 90255 | 3 TRK | 473 | 633 |
| SAN FERNANDO EL | 1130 MOTT ST SAN FERNANDO, CA 91340 | 4 TRK | 832 | 1081 |
| SAN GABRIEL EL | 8628 SAN GABRIEL AVE SOUTH GATE, CA 90280 | 3 TRK | 760 | 1056 |
| SAN JOSE EL | 14928 CLYMER ST MISSION HILLS, CA 91345 | 1 TRK | 786 | 786 |
| SAN MIGUEL EL | 9801 SAN MIGUEL AVE SOUTH GATE, CA 90280 | 3 TRK | 1033 | 1471 |
| SAN PASCUAL EL | 815 SAN PASCUAL AVE LOS ANGELES, CA 90042 | 1 TRK | 487 | 487 |
| SAN PEDRO EL | 1635 S SAN PEDRO ST LOS ANGELES, CA 90015 | 4 TRK | 689 | 860 |
| SANTA MONICA COMM | 1022 N VAN NESS AVE LOS ANGELES, CA 90038 | 3 TRK | 1003 | 1488 |
| SATICOY EL | 7850 ETHEL AVE NO HOLLYWOOD, CA 91605 | 1 TRK | 851 | 851 |
| SATURN EL | 5360 SATURN ST LOS ANGELES, CA 90019 | 4 TRK | 735 | 948 |
| SELMA EL | 6611 SELMA AVE LOS ANGELES, CA 90028 | 1 TRK | 749 | 749 |
| SERRANIA EL | 5014 SERRANIA AVE WOODLAND HILLS, CA 91364 | 1 TRK | 842 | 842 |
| SHARP EL | 13800 PIERCE ST PACOIMA, CA 91331 | 4 TRK | 954 | 1215 |
| SHENANDOAH EL | 2450 SHENANDOAH ST LOS ANGELES, CA 90034 | 1 TRK | 985 | 985 |
| SHERIDAN ST EL | 416 N CORNWELL ST LOS ANGELES, CA 90033 | 1 TRK | 1506 | 1506 |
| SHERMAN OAKS EL | 14755 GREENLEAF ST SHERMAN OAKS, CA 91403 | 1 TRK | 1052 | 1052 |
| SHIRLEY EL | 19452 HART ST RESEDA, CA 91335 | 1 TRK | 989 | 989 |
| SHORT EL | 12814 MAXELLA AVE LOS ANGELES, CA 90066 | 1 TRK | 646 | 646 |
| SIERRA PARK EL | 3170 BUDAU AVE LOS ANGELES, CA 90032 | 4 TRK | 1009 | 1290 |
| SIERRA VISTA EL | 4342 ALPHA ST LOS ANGELES, CA 90032 | 1 TRK | 399 | 399 |
| SOLANO EL | 615 SOLANO AVE LOS ANGELES, CA 90012 | 1 TRK | 298 | 298 |
| SOTO EL | 1020 S SOTO ST LOS ANGELES, CA 90023 | 1 TRK | 510 | 510 |
| SOUTH PARK EL | 8510 TOWNE AVE LOS ANGELES, CA 90003 | 4 TRK | 919 | 1175 |
| STAGG EL | 7839 AMESTOY AVE VAN NUYS, CA 91406 | 1 TRK | 547 | 547 |
| STANFORD EL | 2833 ILLINOIS AVE SOUTH GATE, CA 90280 | 3 TRK | 1246 | 1794 |
| STATE EL | 3211 SANTA ANA ST SOUTH GATE, CA 90280 | 3 TRK | 1105 | 1585 |
| STERRY EL | 1730 CORINTH AVE LOS ANGELES, CA 90025 | 1 TRK | 455 | 455 |
| STONEHURST EL | 9851 STONEHURST AVE SUN VALLEY, CA 91352 | 1 TRK | 476 | 476 |

Exhibit K.3-8**ELEMENTARY**

| Name | Address | Calendar | Capacity | |
|----------------|---|----------|------------|-----------|
| | | | 2 Semester | Operating |
| STONER EL | 11735 BRADDOCK DR CULVER CITY, CA 90230 | 1 TRK | 706 | 706 |
| STRATHERN EL | 7939 ST CLAIR AVE NO HOLLYWOOD, CA 91605 | 3 TRK | 965 | 1378 |
| SUNLAND EL | 8350 HILLROSE ST SUNLAND, CA 91040 | 1 TRK | 761 | 761 |
| SUNNY BRAE EL | 20620 ARMINTA ST WINNETKA, CA 91306 | 1 TRK | 959 | 959 |
| SUNRISE EL | 2821 E SEVENTH ST LOS ANGELES, CA 90023 | 1 TRK | 710 | 710 |
| SUPERIOR EL | 9756 OSO AVE CHATSWORTH, CA 91311 | 1 TRK | 595 | 595 |
| SYLMAR EL | 13291 PHILLIPPI AVE SYLMAR, CA 91342 | 3 TRK | 816 | 1157 |
| SYLVAN PARK EL | 6238 NOBLE AVE VAN NUYS, CA 91411 | 3 TRK | 902 | 1310 |
| TAPER EL | 1824 TAPER AVE SAN PEDRO, CA 90731 | 1 TRK | 761 | 761 |
| TARZANA EL | 5726 TOPEKA DR TARZANA, CA 91356 | 1 TRK | 629 | 629 |
| TELFAIR EL | 10975 TELFAIR AVE PACOIMA, CA 91331 | 1 TRK | 1320 | 1320 |
| TOLAND WAY EL | 4545 TOLAND WAY LOS ANGELES, CA 90041 | 1 TRK | 591 | 591 |
| TOLUCA LAKE EL | 4840 CAHUENGA BLVD NO HOLLYWOOD, CA 91601 | 1 TRK | 803 | 803 |
| TOPANGA EL | 141 N TOPANGA BLVD TOPANGA, CA 90290 | 1 TRK | 428 | 428 |
| TOPEKA DR EL | 9815 TOPEKA DR NORTHRIDGE, CA 91324 | 1 TRK | 713 | 713 |
| TOWNE EL | 18924 TOWNE AVE CARSON, CA 90746 | 1 TRK | 583 | 583 |
| TRINITY EL | 3736 TRINITY ST LOS ANGELES, CA 90011 | 3 TRK | 1279 | 1866 |
| TULSA EL | 10900 HAYVENHURST AVE GRANADA HILLS, CA 91344 | 1 TRK | 616 | 616 |
| TWEEDY EL | 9515 PINEHURST AVE SOUTH GATE, CA 90280 | 3 TRK | 596 | 896 |
| UNION EL | 150 S BURLINGTON AVE LOS ANGELES, CA 90057 | 3 TRK | 1434 | 2020 |
| UTAH EL | 255 N CLARENCE ST LOS ANGELES, CA 90033 | 1 TRK | 825 | 825 |
| VALERIO EL | 15035 VALERIO ST VAN NUYS, CA 91405 | 4 TRK | 1092 | 1418 |
| VALLEY VIEW EL | 6921 WOODROW WILSON DR LOS ANGELES, CA 90068 | 1 TRK | 288 | 288 |
| VAN DEENE EL | 826 W JAVELIN ST TORRANCE, CA 90502 | 1 TRK | 569 | 569 |
| VAN GOGH EL | 17160 VAN GOGH ST GRANADA HILLS, CA 91344 | 1 TRK | 530 | 530 |
| VAN NESS EL | 501 N VAN NESS AVE LOS ANGELES, CA 90004 | 4 TRK | 472 | 563 |
| VAN NUYS EL | 6464 SYLMAR AVE VAN NUYS, CA 91401 | 3 TRK | 641 | 916 |
| VANALDEN EL | 19019 DELANO ST RESEDA, CA 91335 | 1 TRK | 626 | 626 |
| VAUGHN | 13330 VAUGHN ST, SAN FERNANDO, CA 91340 | | 1070 | |
| VENA EL | 9377 VENA AVE PACOIMA, CA 91331 | 1 TRK | 685 | 685 |
| VERMONT EL | 1435 W 27TH ST LOS ANGELES, CA 90007 | 4 TRK | 1235 | 1601 |
| VERNON CITY EL | 2360 E VERNON AVE LOS ANGELES, CA 90058 | 1 TRK | 299 | 299 |
| VICTORIA EL | 3320 MISSOURI AVE SOUTH GATE, CA 90280 | 3 TRK | 1151 | 1676 |
| VICTORY EL | 6315 RADFORD AVE NO HOLLYWOOD, CA 91606 | 3 TRK | 1089 | 1557 |
| VINE EL | 955 N VINE ST LOS ANGELES, CA 90038 | 3 TRK | 760 | 1076 |
| VINEDALE EL | 10150 LA TUNA CANYON RD SUN VALLEY, CA 91352 | 1 TRK | 505 | 505 |
| VIRGINIA EL | 2925 VIRGINIA RD LOS ANGELES, CA 90016 | 1 TRK | 633 | 633 |

Exhibit K.3-8**ELEMENTARY**

| Name | Address | Calendar | Capacity | |
|-------------------|--|----------|------------|-----------|
| | | | 2 Semester | Operating |
| WADSWORTH EL | 981 E 41ST ST LOS ANGELES, CA 90011 | 3 TRK | 1173 | 1711 |
| WALGROVE EL | 1630 WALGROVE AVE LOS ANGELES, CA 90066 | 1 TRK | 595 | 595 |
| WALNUT PARK EL | 2642 OLIVE ST HUNTINGTON PARK, CA 90255 | 3 TRK | 1078 | 1563 |
| WARNER EL | 615 HOLMBY AVE LOS ANGELES, CA 90024 | 1 TRK | 741 | 741 |
| WEEMES EL | 1260 W 36TH PL LOS ANGELES, CA 90007 | 4 TRK | 1412 | 1822 |
| WEIGAND EL | 10401 WEIGAND AVE LOS ANGELES, CA 90002 | 3 TRK | 433 | 595 |
| WELBY EL | 23456 WELBY WAY CANOGA PARK, CA 91307 | 1 TRK | 534 | 534 |
| WEST ATHENS EL | 1110 W 119TH ST LOS ANGELES, CA 90044 | 4 TRK | 956 | 1212 |
| WEST HOLLYWOOD | 970 N HAMMOND ST WEST HOLLYWOOD, CA 90069 | 1 TRK | 366 | 366 |
| WEST VERNON EL | 4312 S GRAND AVE LOS ANGELES, CA 90037 | 3 TRK | 1083 | 1561 |
| WESTERN EL | 1724 W 53RD ST LOS ANGELES, CA 90062 | 1 TRK | 1053 | 1053 |
| WESTMINSTER EL | 1010 ABBOT KINNEY BLVD VENICE, CA 90291 | 1 TRK | 564 | 564 |
| WESTPORT HTS EL | 6011 W 79TH ST LOS ANGELES, CA 90045 | 1 TRK | 620 | 620 |
| WESTWOOD EL | 2050 SELBY AVE LOS ANGELES, CA 90025 | 1 TRK | 877 | 877 |
| WHITE HOUSE PLACE | 108 SO. BIMINI PLACE, LOS ANGELES, CA 90004 | 3 TRK | 328 | |
| WHITE POINT EL | 1410 SILVIUS AVE SAN PEDRO, CA 90731 | 1 TRK | 548 | 548 |
| WILBUR EL | 5213 CREBS AVE TARZANA, CA 91356 | 1 TRK | 821 | 821 |
| WILMINGTON PK EL | 1140 MAHAR AVE WILMINGTON, CA 90744 | 1 TRK | 1303 | 1303 |
| WILSHIRE CREST EL | 5241 W OLYMPIC BLVD LOS ANGELES, CA 90036 | 1 TRK | 825 | 825 |
| WILTON PL EL | 745 S WILTON PL LOS ANGELES, CA 90005 | 3 TRK | 1051 | 1519 |
| WINNETKA EL | 8240 WINNETKA AVE CANOGA PARK, CA 91306 | 1 TRK | 687 | 687 |
| WONDERLAND EL | 8510 WONDERLAND AVE LOS ANGELES, CA 90046 | 1 TRK | 232 | 232 |
| WOODCREST EL | 1151 W 109TH ST LOS ANGELES, CA 90044 | 3 TRK | 1140 | 1665 |
| WOODLAKE EL | 23231 HATTERAS ST WOODLAND HILLS, CA 91367 | 1 TRK | 710 | 710 |
| WOODLAND HILLS EL | 22201 SAN MIGUEL ST WOODLAND HILLS, CA 91364 | 1 TRK | 746 | 746 |
| WOODLAWN EL | 6314 WOODLAWN AVE BELL, CA 90201 | 3 TRK | 944 | 1332 |
| YORKDALE EL | 5657 MERIDIAN ST LOS ANGELES, CA 90042 | 1 TRK | 691 | 691 |
| | | | | |

Exhibit K.3-8

MIDDLE

| Name | Address | Calendar | Capacity | |
|---------------|--|----------|------------|-----------|
| | | | 2 Semester | Operating |
| ADAMS MS | 151 W 30TH ST LOS ANGELES, CA 90007 | 3 TRK | 2400 | 3360 |
| AUDUBON MS | 4120 11TH AVE LOS ANGELES, CA 90008 | 1 TRK | 2400 | 2400 |
| BANCROFT MS | 929 N LAS PALMAS AVE LOS ANGELES, CA 90038 | 1 TRK | 2036 | 2036 |
| BELVEDERE MS | 312 N RECORD AVE LOS ANGELES, CA 90063 | 1 TRK | 2754 | 2754 |
| BERENDO MS | 1157 S BERENDO ST LOS ANGELES, CA 90006 | 3 TRK | 2400 | 3360 |
| BETHUNE MS | 155 W 69TH ST LOS ANGELES, CA 90003 | 3 TRK | 2400 | 3360 |
| BURBANK MS | 6460 N FIGUEROA ST LOS ANGELES, CA 90042 | 3 TRK | 2400 | 3360 |
| BURROUGHS MS | 600 S MC CADDEN PL LOS ANGELES, CA 90005 | 1 TRK | 2400 | 2400 |
| BYRD MS | 9171 TELFAIR AVE SUN VALLEY, CA 91352 | 4 TRK | 2226 | 2771 |
| CARNEGIE MS | 21820 BONITA ST CARSON, CA 90745 | 1 TRK | 2400 | 2400 |
| CARVER MS | 4410 MC KINLEY AVE LOS ANGELES, CA 90011 | 3 TRK | 2394 | 3333 |
| CLAY MS | 12226 S WESTERN AVE LOS ANGELES, CA 90047 | 1 TRK | 2400 | 2400 |
| COLUMBUS MS | 22250 ELKWOOD ST CANOGA PARK, CA 91304 | 1 TRK | 2230 | 2230 |
| CURTISS MS | 1254 E HELMICK ST CARSON, CA 90746 | 1 TRK | 2268 | 2268 |
| DANA MS | 1501 S CABRILLO AVE SAN PEDRO, CA 90731 | 1 TRK | 2400 | 2400 |
| DODSON MS | 28014 MONTEREINA DR SAN PEDRO, CA 90732 | 1 TRK | 2400 | 2400 |
| DREW MS | 8511 COMPTON AVE LOS ANGELES, CA 90001 | 3 TRK | 2400 | 3360 |
| EDISON MS | 6500 HOOPER AVE LOS ANGELES, CA 90001 | 3 TRK | 2400 | 3360 |
| EL SERENO MS | 2839 N EASTERN AVE LOS ANGELES, CA 90032 | 1 TRK | 2544 | 2544 |
| EMERSON MS | 1650 SELBY AVE LOS ANGELES, CA 90024 | 1 TRK | 2003 | 2003 |
| FLEMING MS | 25425 WALNUT ST LOMITA, CA 90717 | 1 TRK | 2400 | 2400 |
| FOSHAY | 3751 SOUTH HARVARD, LOS ANGELES, CA 900218 | 3 TRK | 2838 | |
| FROST MS | 12314 BRADFORD PL GRANADA HILLS, CA 91344 | 1 TRK | 2163 | 2163 |
| FULTON MS | 7477 KESTER AVE VAN NUYS, CA 91405 | 1 TRK | 2434 | 2434 |
| GAGE MS | 2880 E GAGE AVE HUNTINGTON PARK, CA 90255 | 3 TRK | 3104 | 3823 |
| GOMPERS MS | 234 E 112TH ST LOS ANGELES, CA 90061 | 1 TRK | 2400 | 2400 |
| GRIFFITH MS | 4765 E FOURTH ST LOS ANGELES, CA 90022 | 1 TRK | 2400 | 2400 |
| HALE MS | 23830 CALIFA ST WOODLAND HILLS, CA 91367 | 1 TRK | 2801 | 2801 |
| HARTE PREP MS | 9301 S HOOVER ST LOS ANGELES, CA 90044 | 1 TRK | 2400 | 2400 |
| HENRY MS | 17340 SAN JOSE ST GRANADA HILLS, CA 91344 | 1 TRK | 1703 | 1703 |
| HOLLENBECK MS | 2510 E SIXTH ST LOS ANGELES, CA 90023 | 1 TRK | 2977 | 2977 |
| HOLMES MS | 9351 PASO ROBLES AVE NORTHRIDGE, CA 91325 | 1 TRK | 1718 | 1718 |
| IRVING MS | 3010 ESTARA AVE LOS ANGELES, CA 90065 | 1 TRK | 2400 | 2400 |
| KING MS | 4201 FOUNTAIN AVE LOS ANGELES, CA 90029 | 3 TRK | 2400 | 3360 |
| LAWRENCE MS | 10100 VARIEL AVE CHATSWORTH, CA 91311 | 1 TRK | 2400 | 2400 |
| LE CONTE MS | 1316 N BRONSON AVE HOLLYWOOD, CA 90028 | 3 TRK | 2400 | 3360 |

Exhibit K.3-8

MIDDLE

| Name | Address | Calendar | Capacity | |
|---------------------|--|----------|------------|-----------|
| | | | 2 Semester | Operating |
| LOS ANGELES ACAD MS | 644 E 56TH ST LOS ANGELES, CA 90011 | 3 TRK | 2400 | 3360 |
| MACLAY MS | 12540 PIERCE AVE PACOIMA, CA 91331 | 4 TRK | 2387 | 2993 |
| MADISON MS | 13000 HART ST NO HOLLYWOOD, CA 91605 | 1 TRK | 2431 | 2431 |
| MANN MS | 7001 S ST ANDREWS PL LOS ANGELES, CA 90047 | 1 TRK | 2400 | 2400 |
| MARINA DEL REY MS | 12500 BRADDOCK DR LOS ANGELES, CA 90066 | 1 TRK | 2018 | 2018 |
| MARK TWAIN MS | 2224 WALGROVE AVE LOS ANGELES, CA 90066 | 1 TRK | 2079 | 2079 |
| MARKHAM MS | 1650 E 104TH ST LOS ANGELES, CA 90002 | 1 TRK | 2400 | 2400 |
| MILLIKAN MS | 5041 SUNNYSLOPE AVE SHERMAN OAKS, CA 91423 | 1 TRK | 2327 | 2327 |
| MOUNT GLEASON MS | 10965 MT GLEASON AVE SUNLAND, CA 91040 | 1 TRK | 2074 | 2074 |
| MOUNT VERNON MS | 4066 W 17TH ST LOS ANGELES, CA 90019 | 1 TRK | 2400 | 2400 |
| MUIR MS | 5929 S VERMONT AVE LOS ANGELES, CA 90044 | 4 TRK | 2400 | 3360 |
| MULHOLLAND MS | 17120 VANOWEN ST VAN NUYS, CA 91406 | 1 TRK | 2400 | 2400 |
| NIGHTINGALE MS | 3311 N FIGUEROA ST LOS ANGELES, CA 90065 | 1 TRK | 2400 | 2400 |
| NIMITZ MS | 6021 CARMELITA AVE HUNTINGTON PARK, CA 90255 | 3 TRK | 3232 | 3993 |
| NOBEL MS | 9950 TAMPA AVE NORTHRIDGE, CA 91324 | 1 TRK | 2400 | 2400 |
| NORTHRIDGE MS | 17960 CHASE ST NORTHRIDGE, CA 91325 | 1 TRK | 2131 | 2131 |
| OLIVE VISTA MS | 14600 TYLER ST SYLMAR, CA 91342 | 1 TRK | 2400 | 2400 |
| PACOIMA MS | 9919 LAUREL CANYON BLVD PACOIMA, CA 91331 | 1 TRK | 2400 | 2400 |
| PALMS MS | 10860 WOODBINE ST LOS ANGELES, CA 90034 | 1 TRK | 2400 | 2400 |
| PARKMAN MS | 20800 BURBANK BLVD WOODLAND HILLS, CA 91367 | 1 TRK | 1742 | 1742 |
| PEARY MS | 1415 W GARDENA BLVD GARDENA, CA 90247 | 4 TRK | 2400 | 3072 |
| PORTER MS | 15960 KINGSBURY ST GRANADA HILLS, CA 91344 | 1 TRK | 2400 | 2400 |
| PORTOLA MS | 18720 LINNET ST TARZANA, CA 91356 | 1 TRK | 2463 | 2463 |
| REED MS | 4525 IRVINE AVE NO HOLLYWOOD, CA 91602 | 3 TRK | 2400 | 3360 |
| REVERE MS | 1450 ALLENFORD AVE LOS ANGELES, CA 90049 | 1 TRK | 2400 | 2400 |
| SAN FERNANDO MS | 130 N BRAND BLVD SAN FERNANDO, CA 91340 | 1 TRK | 2400 | 2400 |
| SEPULVEDA MS | 15330 PLUMMER ST NORTH HILLS, CA 91343 | 3 TRK | 2400 | 3360 |
| SOUTH GATE MS | 4100 FIRESTONE BLVD SOUTH GATE, CA 90280 | 3 TRK | 3376 | 4110 |
| STEVENSON MS | 725 S INDIANA ST LOS ANGELES, CA 90023 | 1 TRK | 2400 | 2400 |
| SUN VALLEY MS | 7330 BAKMAN AVE SUN VALLEY, CA 91352 | 3 TRK | 2400 | 3360 |
| SUTTER MS | 7330 WINNETKA AVE CANOGA PARK, CA 91306 | 1 TRK | 2400 | 2400 |
| VAN NUYS MS | 5435 VESPER AVE VAN NUYS, CA 91411 | 1 TRK | 2400 | 2400 |
| VIRGIL MS | 152 N VERMONT AVE LOS ANGELES, CA 90004 | 3 TRK | 2400 | 3360 |
| WEBSTER MS | 11330 W GRAHAM PL LOS ANGELES, CA 90064 | 1 TRK | 2075 | 2075 |
| WHITE MS | 22102 S FIGUEROA ST CARSON, CA 90745 | 1 TRK | 2400 | 2400 |
| WILMINGTON MS | 1700 GULF AVE WILMINGTON, CA 90744 | 1 TRK | 2400 | 2400 |
| WRIGHT MS | 6550 W 80TH ST LOS ANGELES, CA 90045 | 1 TRK | 2130 | 2130 |

Exhibit K.3-8**SENIOR**

| Name | Address | Calendar | Capacity | |
|---------------------|--|----------|------------|-----------|
| | | | 2 Semester | Operating |
| BANNING SH | 1527 LAKME AVE WILMINGTON, CA 90744 | 1 TRK | 3314 | 3314 |
| BELL SH | 4328 BELL AVE BELL, CA 90201 | 3 TRK | 3172 | 4447 |
| BELMONT SH | 1575 W 2ND ST LOS ANGELES, CA 90026 | 3 TRK | 3177 | 4425 |
| BIRMINGHAM SH | 17000 HAYNES ST VAN NUYS, CA 91406 | 1 TRK | 3776 | 3776 |
| CANOGA PARK SH | 6850 TOPANGA CYN BLVD CANOGA PARK, CA 91303 | 1 TRK | 2588 | 2588 |
| CARSON SH | 22328 S MAIN ST CARSON, CA 90745 | 1 TRK | 3600 | 3600 |
| CHATSWORTH SH | 10027 LURLINE AVE CHATSWORTH, CA 91311 | 1 TRK | 3600 | 3600 |
| CLEVELAND SH | 8140 VANALDEN AVE RESEDA, CA 91335 | 1 TRK | 3698 | 3698 |
| CRENSHAW SH | 5010 11TH AVE LOS ANGELES, CA 90043 | 1 TRK | 3236 | 3236 |
| DORSEY SH | 3537 FARMDALE AVE LOS ANGELES, CA 90016 | 1 TRK | 2320 | 2320 |
| EAGLE ROCK HS | 1750 YOSEMITE DR LOS ANGELES, CA 90041 | 1 TRK | 2883 | 2883 |
| EL CAMINO REAL SH | 5440 VALLEY CIRCLE BLVD WOODLAND HILLS, CA 91367 | 1 TRK | 3885 | 3885 |
| FAIRFAX SH | 7850 MELROSE AVE LOS ANGELES, CA 90046 | 1 TRK | 3238 | 3238 |
| FRANKLIN SH | 820 N AVE 54 LOS ANGELES, CA 90042 | 3 TRK | 2783 | 3844 |
| FREMONT SH | 7676 S SAN PEDRO ST LOS ANGELES, CA 90003 | 3 TRK | 3450 | 4853 |
| GARDENA SH | 1301 W 182ND ST GARDENA, CA 90248 | 1 TRK | 3600 | 3600 |
| GARFIELD SH | 5101 E SIXTH ST LOS ANGELES, CA 90022 | 3 TRK | 3600 | 5040 |
| GRANADA HILLS SH | 10535 ZELZAH AVE GRANADA HILLS, CA 91344 | 1 TRK | 3905 | 3905 |
| GRANT SH | 13000 OXNARD ST VAN NUYS, CA 91401 | 1 TRK | 3600 | 3600 |
| HAMILTON SH-COMPLEX | 2955 S ROBERTSON BLVD LOS ANGELES, CA 90034 | 1 TRK | 2813 | 2813 |
| HOLLYWOOD SH | 1521 N HIGHLAND AVE LOS ANGELES, CA 90028 | 3 TRK | 2283 | 3205 |
| HUNTINGTON PARK SH | 6020 MILES AVE HUNTINGTON PARK, CA 90255 | 3 TRK | 3177 | 4437 |
| JEFFERSON SH | 1319 E 41ST ST LOS ANGELES, CA 90011 | 3 TRK | 2551 | 3542 |
| JORDAN SH | 2265 E 103RD ST LOS ANGELES, CA 90002 | 1 TRK | 2449 | 2449 |
| KENNEDY SH | 11254 GOTHIC AVE GRANADA HILLS, CA 91344 | 1 TRK | 3238 | 3238 |
| LINCOLN SH | 3501 N BROADWAY LOS ANGELES, CA 90031 | 1 TRK | 3078 | 3078 |
| LOCKE SH | 325 E 111TH ST LOS ANGELES, CA 90061 | 1 TRK | 3586 | 3586 |
| LOS ANGELES SH | 4650 W OLYMPIC BLVD LOS ANGELES, CA 90019 | 3 TRK | 3508 | 4931 |
| MANUAL ARTS SH | 4131 S VERMONT AVE LOS ANGELES, CA 90037 | 3 TRK | 2908 | 4050 |
| MARSHALL SH | 3939 TRACY ST LOS ANGELES, CA 90027 | 3 TRK | 3586 | 5045 |
| MONROE SH | 9229 HASKELL AVE NORTH HILLS, CA 91343 | 3 TRK | 3600 | 5040 |
| NARBONNE SH | 24300 S WESTERN AVE HARBOR CITY, CA 90710 | 1 TRK | 3524 | 3524 |
| NO HOLLYWOOD | 5231 COLFAX AVE NO HOLLYWOOD, CA 91601 | 3 TRK | 3415 | 4766 |
| PALISADES CHRTR | 15777 BOWDOIN ST PACIFIC PALISADES, CA 90272 | 1 TRK | 2760 | 2760 |
| POLYTECHNIC SH | 12431 ROSCOE BLVD SUN VALLEY, CA 91352 | 3 TRK | 2859 | 3981 |

Exhibit K.3-8**SENIOR**

| Name | Address | Calendar | Capacity | |
|--------------------|---|----------|------------|-----------|
| | | | 2 Semester | Operating |
| RESEDA SH | 18230 KITTRIDGE ST RESEDA, CA 91335 | 1 TRK | 3528 | 3528 |
| ROOSEVELT SH | 456 S MATHEWS ST LOS ANGELES, CA 90033 | 3 TRK | 4246 | 5420 |
| SAN FERNANDO | 11133 O'MELVENY AVE SAN FERNANDO, CA 91340 | 3 TRK | 3841 | 5181 |
| SAN PEDRO SH | 1001 W 15TH ST SAN PEDRO, CA 90731 | 1 TRK | 3514 | 3514 |
| SOUTH GATE SH | 3351 FIRESTONE BLVD SOUTH GATE, CA 90280 | 3 TRK | 3401 | 4764 |
| SYLMAR SH | 13050 BORDEN AVE SYLMAR, CA 91342 | 1 TRK | 3571 | 3571 |
| TAFT SH | 5461 WINNETKA AVE WOODLAND HILLS, CA 91364 | 1 TRK | 3712 | 3712 |
| UNIVERSITY SH | 11800 TEXAS AVE LOS ANGELES, CA 90025 | 1 TRK | 2600 | 2600 |
| VAN NUYS SH | 6535 CEDROS AVE VAN NUYS, CA 91411 | 3 TRK | 4040 | 5420 |
| VENICE SH | 13000 VENICE BLVD LOS ANGELES, CA 90066 | 1 TRK | 3235 | 3235 |
| VERDUGO HILLS SH | 10625 PLAINVIEW AVE TUJUNGA, CA 91042 | 1 TRK | 2411 | 2411 |
| WASHINGTON PREP SH | 10860 S DENKER AVE LOS ANGELES, CA 90047 | 3 TRK | 2831 | 3940 |
| WESTCHESTER SH | 7400 W MANCHESTER AVE LOS ANGELES, CA 90045 | 1 TRK | 3546 | 3546 |
| WILSON SH | 4500 MULTNOMAH ST LOS ANGELES, CA 90032 | 1 TRK | 2921 | 2921 |

Exhibit K.3-8**CONTINUATION HIGH SCHOOLS**

| Name | Address | Calendar |
|---------------------|---|----------|
| ADDAMS HS | 16341 DONMETZ ST GRANADA HILLS, CA 91344 | 1 TRK |
| ANGEL'S GATE HS | 3200 S ALMA ST SAN PEDRO, CA 90731 | 1 TRK |
| AVALON HS | 1425 N AVALON BLVD WILMINGTON, CA 90744 | 1 TRK |
| BOYLE HEIGHTS HS | 544 S MATHEWS ST LOS ANGELES, CA 90033 | CONTIN |
| CENTRAL HS | 716 E 14TH ST LOS ANGELES, CA 90021 | CONTIN |
| CHEVIOT HILLS HS | 9200 CATTARAUGUS AVE LOS ANGELES, CA 90034 | 1 TRK |
| DEL REY HS | 8701 PARK HILL DR LOS ANGELES, CA 90045 | 1 TRK |
| DOUGLAS HS | 10500 LINDLEY AVE NORTHRIDGE, CA 91326 | 1 TRK |
| EAGLE TREE CONTN HS | 22628 S MAIN ST CARSON, CA 90745 | 1 TRK |
| EARHART HS | 5355 COLFAX AVE NO HOLLYWOOD, CA 91601 | CONTIN |
| EINSTEIN HS | 15938 TUPPER ST NORTH HILLS, CA 91343 | CONTIN |
| ELLINGTON HS | 1541 W 110TH ST LOS ANGELES, CA 90047 | CONTIN |
| EVERGREEN HS | 13101 DRONFIELD AVE SYLMAR, CA 91342 | 1 TRK |
| GREY HS | 6510 ETIWANDA AVE RESEDA, CA 91335 | 1 TRK |
| HIGHLAND PARK HS | 928 N AVE 53 LOS ANGELES, CA 90042 | CONTIN |
| HOPE HS | 7840 TOWNE AVE LOS ANGELES, CA 90003 | CONTIN |
| INDEPENDENCE HS | 6501 BALBOA BLVD VAN NUYS, CA 91406 | 1 TRK |
| INDIAN SPRINGS HS | 1441 S BARRINGTON AVE LOS ANGELES, CA 90025 | 1 TRK |

Exhibit K.3-8**CONTINUATION HIGH SCHOOLS**

| Name | Address | Calendar |
|--------------------|--|----------|
| LEONIS HS | 5445 MANTON AVE WOODLAND HILLS, CA 91367 | 1 TRK |
| LEWIS HS | 12508 WICKS ST SUN VALLEY, CA 91352 | CONTIN |
| LONDON HS | 12924 OXNARD ST VAN NUYS, CA 91401 | 1 TRK |
| METROPOLITAN HS | 727 S WILSON ST LOS ANGELES, CA 90021 | CONTIN |
| MISSION HS | 11015 O'MELVENY AVE SAN FERNANDO, CA 91340 | CONTIN |
| MONETA HS | 1230 W 177TH ST GARDENA, CA 90248 | 1 TRK |
| MONTEREY HS | 466 S FRASER AVE LOS ANGELES, CA 90022 | CONTIN |
| MT LUKENS HS | 7705 SUMMITROSE ST TUJUNGA, CA 91042 | 1 TRK |
| NEWMARK HS | 134 WITMER ST LOS ANGELES, CA 90026 | CONTIN |
| ODYSSEY HS | 8693 DEARBORN AVE SOUTH GATE, CA 90280 | CONTIN |
| OWENSMOUTH HS | 6921 JORDAN AVE CANOGA PARK, CA 91303 | 1 TRK |
| PATTON HS | 24514 S WESTERN AVE HARBOR CITY, CA 90710 | 1 TRK |
| PHOENIX HS | 12971 ZANJA ST LOS ANGELES, CA 90066 | 1 TRK |
| PUEBLO DE L.A. HS | 2506 ALTA ST LOS ANGELES, CA 90031 | 1 TRK |
| RODIA HS | 2315 E 103RD ST LOS ANGELES, CA 90002 | 1 TRK |
| ROGERS HS | 15141 LEMAY ST VAN NUYS, CA 91405 | CONTIN |
| SAN ANTONIO HS | 2861 RANDOLPH ST HUNTINGTON PARK, CA 90255 | CONTIN |
| STONEY POINT HS | 10010 DE SOTO AVE CHATSWORTH, CA 91311 | 1 TRK |
| TEMESCAL CANYON HS | 777 TEMESCAL CYN. RD PACIFIC PALISADES, CA 90272 | 1 TRK |
| THOREAU HS | 5429 QUAKERTOWN AVE WOODLAND HILLS, CA 91364 | 1 TRK |
| TRUTH HS | 11015 S AVALON BLVD LOS ANGELES, CA 90061 | 1 TRK |
| VIEW PARK CONTN HS | 4701 RODEO RD LOS ANGELES, CA 90016 | 1 TRK |
| WHITMAN HS | 7795 ROSEWOOD AVE LOS ANGELES, CA 90036 | CONTIN |
| YOUNG HS | 3051 W 52ND ST LOS ANGELES, CA 90043 | 1 TRK |

Exhibit K.3-8**NEW & CONTINUATION MULTI-TRACK YEAR-ROUND SCHOOL *ELEMENTARY***

| Name | Address |
|---------|---------------------|
| 10TH ST | HAZELTINE AVE |
| 20TH ST | HELIOTROPE AVE |
| 24TH ST | HILLCREST DRIVE |
| 28TH ST | HOBART BOULEVARD |
| 49TH ST | HOOPER AVE |
| 52ND ST | HOOVER ST |
| 66TH ST | HUGHES |
| 68TH ST | HYDE PARK BOULEVARD |
| 75TH ST | KITTRIDGE ST |

Exhibit K.3-8**NEW & CONTINUATION MULTI-TRACK YEAR-ROUND SCHOOL *ELEMENTARY***

| Name | Address |
|-------------------|-------------------|
| 92ND ST | LANGDON AVE |
| 95TH ST | LANKERSHIM |
| 107TH ST | LATONA AVE |
| ALDAMA | LIBERTY BOULEVARD |
| ALEXANDRIA AVE | LILLIAN ST |
| ALLESANDRO | LOCKWOOD AVE |
| ALTA LOMA | LOGAN ST |
| ARAGON AVE | LOMA VISTA AVE |
| ARLINGTON HEIGHTS | LORETO ST |
| ARMINTA ST | LOS ANGELES |
| ASCOT AVE | LOS FELIZ |
| BASSETT ST | MAGNOLIA |
| BEACHY AVE | MAIN ST |
| BROAD AVE | MANCHESTER AVE |
| BROADOUS | MENLO AVE |
| BRYSON AVE | MIDDLETON ST |
| BUCHANAN ST | MILES AVE |
| CAHUENGA | MILLER |
| CAMELIA AVE | MIRAMONTE |
| CANOGA PARK | MONTAGUE ST |
| CHEREMOYA AVE | MONTARA AVE |
| CIENEGA | MONTE VISTA ST |
| COLDWATER CANYON | MORNINGSIDE |
| COMMONWEALTH AVE. | NAPA ST |
| CORONA AVE | NEVIN AVE |
| DAYTON HEIGHTS | NOBLE AVE |
| DYER ST | NORMONT |
| ESPERANZA | NORWOOD ST |
| FAIR AVE | NUEVA VISTA |
| FENTON AVE | O'MELVENY |
| FERNANGELES | OSCEOLA ST |
| FIGUEROA ST | OXNARD ST |
| FISHBURN AVE | PACOIMA |
| FLETCHER DRIVE | PARK AVE |
| FLORENCE AVE | PARMELEE AVE |
| FRIES AVE | PLACENTIA |
| GARDENA | PLUMMER |
| GARVANZA | POLITI |

Exhibit K.3-8**NEW & CONTINUATION MULTI-TRACK YEAR-ROUND SCHOOL *ELEMENTARY***

| Name | Address |
|----------------|--------------------|
| GATES ST | RAMONA |
| GLASSELL PARK | RANCHITO AVE |
| GRAHAM | RAYMOND AVE |
| GRANT | ROSCOE |
| GRATTS | ROSEMONT AVE |
| GRIDLEY ST | RUSSELL |
| GULF AVE | SAN ANTONIO |
| HADDON AVE | SAN FERNANDO |
| HAWAIIAN AVE | SAN GABRIEL AVE |
| SAN MIGUEL AVE | SANTA MONICA BLVD. |
| SATURN ST | SHARP AVE |
| STANFORD AVE | STATE ST |
| STRATHERN ST | SYLMAR |
| SYLVAN PARK | TRINITY ST |
| TWEEDY | UNION AVE |
| VALERIO ST | VAN NESS AVE |
| VAN NUYS | VERMONT AVE |
| VICTORIA AVE | VICTORY BOULEVARD |
| VINE ST | WADSWORTH AVE |
| WALNUT PARK | WEEMES |
| WEIGAND AVE | WEST VERNON AVE |
| WILTON PLACE | WOODCREST |
| WOODLAWN AVE | |

NEW & CONTINUATION MULTI-TRACK YEAR-ROUND SCHOOL *MIDDLE SCHOOL*

| NAME | ADDRESS |
|--------------|------------|
| ADAMS | BERENDO |
| BETHUNE | BYRD |
| CARVER | DREW |
| EDISON | GAGE |
| LE CONTE | MACLAY |
| MOUNT VERNON | NIMITZ |
| SOUTH GATE | SUN VALLEY |
| VIRGIL | |

Exhibit K.3-8**NEW & CONTINUATION MULTI-TRACK YEAR-ROUND SCHOOL SENIOR HIGH SCHOOL**

| NAME | ADDRESS |
|-----------------|-------------|
| BELL | BELMONT |
| FRANKLIN | FREMONT |
| GARFIELD | HOLLYWOOD |
| HUNTINGTON PARK | JEFFERSON |
| LOS ANGELES | MANUAL ARTS |

| NEW & CONTINUATION MULTI-TRACK YEAR-ROUND SCHOOL SENIOR HIGH SCHOOL | | | | |
|---|------------|--|--|--|
| NAME | ADDRESS | | | |
| | | | | |
| MARSHALL | MONROE | | | |
| POLYTECHNIC | ROOSEVELT | | | |
| SAN FERNANDO | SOUTH GATE | | | |
| WASHINGTON PREP | | | | |

SPAN SCHOOLS (NOT MAGNETS)

| Name | Address | Calendar | Capacity | |
|----------------|--|----------|------------|-----------|
| | | | 2 Semester | Operating |
| CAROLDALE LRNG | 22424 CAROLDALE AVE CARSON, CA 90745 | 1 | 1433 | 1433 |
| ELIZABETH LC | 4811 ELIZABETH ST CUDAHY, CA 90201 | 3 | 2279 | 3198 |
| FOSHAY LC | 3751 S HARVARD BLVD LOS ANGELES, CA 90018 | 3 TRK | 2582 | 3600 |
| HARRISON EL | 3529 CITY TERRACE DR LOS ANGELES, CA 90063 | 3 TRK | 929 | 1311 |
| PIO PICO EL | 1512 S ARLINGTON AVE LOS ANGELES, CA 90019 | 3 TRK | 1850 | 2592 |
| VAUGHN EL | 13330 VAUGHN ST SAN FERNANDO, CA 91340 | OTHER | 8 | 652 |

PRIMARY CENTER

| Name | Address | Calendar | Capacity | |
|----------------------|---|----------|------------|-----------|
| | | | 2 Semester | Operating |
| ARCO IRIS PRIMRY CTR | 4504 ASCOT AVE LOS ANGELES, CA 90011 | 3 TRK | 140 | 200 |
| BELL #3 NEW PC | 7326 S WILCOX AVE CUDAHY, CA 90201 | 4 TRK | 240 | 320 |
| BELLEVUE PRIMARY SCH | 610 N MICHELTORENA ST LOS ANGELES, CA 90026 | 4 TRK | 275 | 340 |
| KINDERGARTEN LRN ACD | 6555 SYLMAR AVE VAN NUYS, CA 91401 | 3 TRK | 225 | 305 |
| LAFAYETTE PARK PC | 310 S LAFAYETTE PARK PL LOS ANGELES, CA 90057 | 3 TRK | 240 | 340 |
| MACARTHUR PARK PC | 2300 W 7TH ST LOS ANGELES, CA 90057 | 4 TRK | 260 | 390 |
| MACLAY PRIMARY CTR | 12513 GAIN ST PACOIMA, CA 91331 | 4 TRK | 245 | 305 |
| PARKS/HUERTA PRIMARY | 1020 W 58TH PL LOS ANGELES, CA 90044 | 1 TRK | 240 | 240 |
| PRIMARY ACADEMY | 9075 WILLIS AVE PANORAMA CITY, CA 91402 | 3 TRK | 330 | 490 |
| VALERIO NEW PC | 14935 VALERIO ST VAN NUYS, CA 91405 | 4 TRK | 292 | 332 |
| WHITE HSE PL PRIMARY | 108 S BIMINI PL LOS ANGELES, CA 90004 | 3 TRK | 200 | 300 |

Exhibit K.3-8**MAGNET-SELF CONTAINED (ELEM)**

| Name | Address | Calendar | Capacity | |
|----------------------|--|----------|----------|------|
| | | | Semester | Op. |
| BALBOA G/HA MAG | 17020 LABRADOR ST NORTHRIDGE, CA 91325 | 1 TRK | 677 | 677 |
| BRADLEY ENV/HUMAN MG | 3875 DUBLIN AVE LOS ANGELES, CA 90008 | 1 TRK | 710 | 710 |
| BRENTWOOD SCI MAG | 740 GRETN GREEN WAY LOS ANGELES, CA 90049 | 1 TRK | 1190 | 1190 |
| COMMUNITY MAGNET SCH | 11301 BELLAGIO RD LOS ANGELES, CA 90049 | 1 TRK | 424 | 424 |
| CRESCENT HTS EL | 1661 S CRESCENT HTS BLVD LOS ANGELES, CA 90035 | 1 TRK | 396 | 396 |
| LOMITA MATH/SCI MAG | 2211 W 247TH ST LOMITA, CA 90717 | 4 TRK | 1307 | 1307 |
| OPEN CHARTER MAG SCH | 5540 W 77TH ST LOS ANGELES, CA 90045 | 1 TRK | 384 | 384 |
| PASEO DEL REY NAT SC | 7751 PASEO DEL REY PLAYA DEL REY, CA 90293 | 1 TRK | 515 | 515 |
| S SHORES PER ARTS MG | 2060 W 35TH ST SAN PEDRO, CA 90732 | 1 TRK | 449 | 449 |
| VINTAGE MATH/SCI MAG | 15848 STARE ST NORTH HILLS, CA 91343 | 1 TRK | 679 | 679 |
| WINDSOR M/S AERO MAG | 5215 OVERDALE DR LOS ANGELES, CA 90043 | 1 TRK | 710 | 710 |

SPECIAL EDUCATION

| Name | Address | Calendar | Capacity | |
|-----------------------|---|----------|----------|-----------|
| | | | Semester | Operating |
| BANNEKER SP ED CTR | 14024 S SAN PEDRO ST LOS ANGELES, CA 90061 | 1 TRK | | |
| BLEND EL | 5210 CLINTON ST LOS ANGELES, CA 90004 | 1 TRK | | |
| CARLSON HSP SCH(K-12) | 10952 WHIPPLE ST NO HOLLYWOOD, CA 91602 | 1 TRK | | |
| LANTERMAN HS | 2328 ST JAMES PL LOS ANGELES, CA 90007 | 1 TRK | | |
| LEICHMAN SP ED CTR | 19034 GAULT ST RESEDA, CA 91335 | 1 TRK | | |
| LOKRANTZ SP ED CTR | 19451 WYANDOTTE ST RESEDA, CA 91335 | 1 TRK | | |
| LOWMAN SP ED CTR | 12827 SATICOY ST NO HOLLYWOOD, CA 91605 | 1 TRK | | |
| LULL SP ED CTR | 17551 MIRANDA ST ENCINO, CA 91316 | 1 TRK | | |
| MARLTON SCH | 4000 SANTO TOMAS DR LOS ANGELES, CA 90008 | 1 TRK | | |
| MCBRIDE SP ED CTR | 3960 CENTINELA AVE LOS ANGELES, CA 90066 | 1 TRK | | |
| MILLER HS | 8218 VANALDEN AVE RESEDA, CA 91335 | 1 TRK | | |
| PACIFIC BL SP ED CTR | 5714 PACIFIC BLVD HUNTINGTON PARK, CA 90255 | 1 TRK | | |
| PEREZ SP ED CTR | 4540 MICHIGAN AVE LOS ANGELES, CA 90022 | 1 TRK | | |
| SALVIN SP ED CTR | 1925 BUDLONG AVE LOS ANGELES, CA 90007 | 1 TRK | | |
| SELLERY SP ED CTR | 15805 S BUDLONG AVE GARDENA, CA 90247 | 1 TRK | | |
| WEST VALLEY SP ED | 6649 BALBOA BLVD VAN NUYS, CA 91406 | 1 TRK | | |
| WIDNEY HS | 2302 S GRAMERCY PL LOS ANGELES, CA 90018 | 1 TRK | | |
| WILLENBERG SP ED CTR | 308 WEYMOUTH AVE SAN PEDRO, CA 90732 | 1 TRK | | |

Exhibit K.3-8

OPPORTUNITY SCHOOLS/UNITS

| Name | Address | Calendar | Capacity | |
|----------------------|---|----------|----------|-----------|
| | | | Semester | Operating |
| AGGELER HS | 21050 PLUMMER ST CHATSWORTH, CA 91311 | CONTIN | | |
| MC ALISTER HS-CYESIS | 155 N OCCIDENTAL BLVD LOS ANGELES, CA 90026 | CONTIN | | |
| RILEY HS-CYESIS | 1524 E 103RD ST LOS ANGELES, CA 90022 | CONTIN | | |

SPAN MAGNET

| Name | Address | Calendar | Capacity | |
|----------------------|---|----------|----------|-----------|
| | | | Semester | Operating |
| 32ND/USC PER ART MAG | 822 W 32ND ST LOS ANGELES, CA 90007 | 1 TRK | 734 | 734 |
| ARROYO SECO MUSM SCI | 4805 SYCAMORE TERR LOS ANGELES, CA 90042 | 1 TRK | 542 | 542 |
| LACES MAG | 5931 W 18TH ST LOS ANGELES, CA 90035 | 1 TRK | 1618 | 1618 |
| MID-CITY MAGNET | 3150 W ADAMS BLVD LOS ANGELES, CA 90018 | 1 TRK | 370 | 370 |
| SOCES MAG | 18605 ERWIN ST RESEDA, CA 91335 | 1 TRK | 1780 | 1780 |
| VALLEY ALTERN MAG | 6701 BALBOA BLVD VAN NUYS, CA 91406 | 1 TRK | 576 | 576 |
| WESTSIDE LDRSHIP MAG | 104 ANCHORAGE ST MARINA DEL REY, CA 90292 | 1 TRK | 463 | 463 |

MAGNET-SELF CONTAINED SENIOR (SS)

| Name | Address | Calendar | Capacity | |
|-----------------------|--|----------|----------|-----------|
| | | | Semester | Operating |
| BRAVO MEDICAL MAG | 1200 N CORNWELL ST LOS ANGELES, CA 90033 | 1 TRK | 1709 | 1709 |
| DOWNTOWN BUSINESS MAG | 1081 W TEMPLE ST LOS ANGELES, CA 90012 | 1 TRK | 671 | 671 |

COMMUNITY DAY SCHOOL (T)

| Name | Address | Calendar | Capacity | |
|--------------------|--|----------|----------|-----------|
| | | | Semester | Operating |
| CDS COOPER | 2210 TAPER AVE SAN PEDRO, CA 90731 | 1 TRK | | |
| CDS JOHNSON | 333 E 54TH ST LOS ANGELES, CA 90011 | CONTIN | | |
| CDS WEST HOLLYWOOD | 1049 FAIRFAX AVE LOS ANGELES, CA 90046 | CONTIN | | |
| RAMONA HS | 231 S ALMA AVE LOS Angeles, CA 90063 | CONTIN | | |

Exhibit K.3-9

Revised

Los Angeles Unified School District
STUDENT GENERATION FACTORS

| TYPE | NO. OF
BEDROOMS | GENERATION FACTOR | | | | |
|---|--------------------|-------------------|------|-------------|-------------|------|
| | | ELEMENTARY | | JUNIOR HIGH | SENIOR HIGH | |
| | | K-6 | K-5 | 7-9 & 6-8 | 10-12 | 9-12 |
| Lower Income Areas | | | | | | |
| Single-family | 2 | .3 | .26 | .15 | .15 | .2 |
| | 3 or more | .6 | .52 | .25 | .25 | .34 |
| Townhouse | 1 | .0 | .0 | .0 | .0 | .0 |
| | 2 | .05 | .043 | .02 | .02 | .027 |
| | 3 or more | .2 | .17 | .1 | .1 | .14 |
| Medium Income Areas | | | | | | |
| Single-family | 2 | .25 | .22 | .1 | .1 | .14 |
| | 3 or more | .5 | .43 | .25 | .25 | .34 |
| Townhouse | 1 | .0 | .0 | .0 | .0 | .0 |
| | 2 | .04 | .035 | .02 | .02 | .027 |
| | 3 or more | .15 | .13 | .075 | .075 | .1 |
| Higher Income Areas | | | | | | |
| Single-family | 2 | .2 | .17 | .1 | .1 | .14 |
| | 3 or more | .4 | .35 | .2 | .2 | .27 |
| Townhouse | 1 | .0 | .0 | .0 | .0 | .0 |
| | 2 | .03 | .026 | .02 | .02 | .027 |
| | 3 or more | .075 | .065 | .03 | .03 | .04 |
| Multiple (Rented)
(Units that permit children) | | | | | | |
| | 1 | .0 | .0 | .0 | .0 | .0 |
| | 2 | .25 | .22 | .1 | .1 | .14 |
| | 3 or more | .6 | .52 | .2 | .2 | .27 |
| Multiple (Condominium) | | | | | | |
| | 1 | .0 | .0 | .0 | .0 | .0 |
| | 2 | .03 | .026 | .02 | .02 | .027 |
| | 3 or more | .05 | .043 | .02 | .02 | .027 |

K.4. RECREATION AND PARKS

1. INITIAL STUDY SCREENING PROCESS

A. Initial Study Checklist Questions

XIII.2.iv): Would the project result in substantial adverse physical impacts associated with the provision of new or physically altered governmental facilities, need for new or physically altered governmental facilities, the construction of which could cause significant environmental impacts, in order to maintain acceptable service ratios, response times or other performance objectives for parks?

XIV.a.): Would the project increase the use of existing neighborhood and regional parks or other recreational facilities such that substantial physical deterioration of the facility would occur or be accelerated?

XIV.b): Would the project include recreational facilities or require the construction or expansion of recreational facilities which might have a physical effect on the environment?

B. Introduction

Within the City of Los Angeles, the Department of Recreation and Parks operates over 16,000 acres of park land comprised of some 150 recreation centers and 386 park sites Citywide.¹ Facilities at neighborhood parks include softball, basketball, volleyball, table games, handicrafts, lawn games, small children's play areas and community buildings. In addition to the facilities at a neighborhood park, community parks provide baseball diamonds, combined football and soccer fields, tennis, handball courts, swimming pools, and picnic areas. In ocean areas outside the Los Angeles Harbor and at beaches, there are also other opportunities such as marine recreation (e.g., boating and waterside entertainment).

The Public Recreation Plan, a portion of the Service Systems Element, includes service standards and goals for recreational facilities and operations. The City is updating the 1980 plan as a part of current long-range planning efforts.

The Quimby Act allows California municipalities to require parkland dedications of new

¹ *Department of Recreation and Parks, Valley Region Informational Guide, and telephone interview, 2003.*

residential subdivisions, or to charge fees to developers in lieu of park land dedication. The City of Los Angeles enacted ordinances, which implement the Quimby Act and require dedications and fees for other types of permits and approvals.² The Quimby fee is based on the number of units and zoning for the project and site.

Service needs are related to the size of the population and geographic area served and community characteristics. Projects that affect these factors (e.g., by increasing residential population in an area) may increase the demand for recreation facilities.

C. Screening Criteria

- Would the project result in a net increase of 50 or more residential units that would adversely impact recreation and park services and/or facilities due to the project's proximity to, or expected usage of, those facilities or services?

A "yes" response to the preceding question indicates further study in an expanded Initial Study, Negative Declaration, Mitigated Negative Declaration or EIR may be required. Refer to the Significance Threshold for Recreation and Parks, and review the associated Methodology to Determine Significance, as appropriate.

A "no" response to the preceding question indicates that there would normally be no significant impact on Recreation and Parks from the proposed project.

D. Evaluation of Screening Criteria

Review the description of the proposed project and determine the number of net new residential units proposed. Compare this information to the Screening Criteria, considering the type of residential units proposed, the total size, and the project's proximity to recreation and park facilities.

2. DETERMINATION OF SIGNIFICANCE

A. Significance Threshold

² Refer to the following Sections of the Los Angeles Municipal Code (LAMC): Subdivision Requirements - 17.12 and 17.58; Zone Change requirements - 12.32 and 12.33; and Dwelling Unit Construction Tax - 21.10.3.

The determination of significance shall be made on a case-by-case basis, considering the following factors:

- The net population increase resulting from the proposed project;
- The demand for recreation and park services anticipated at the time of project buildout compared to the expected level of service available. Consider, as applicable, scheduled improvements to recreation and park services (renovation, expansion, or addition) and the project's proportional contribution to the demand; and
- Whether the project includes features that would reduce the demand for recreation and park services (e.g., on-site recreation facilities, land dedication or direct financial support to the Department of Recreation and Parks).³

B. Methodology to Determine Significance

Environmental Setting

In a description of the environmental setting, include the following information:

- The name, description, and location of recreation and park facilities serving the project and their respective acreage. Generally, this includes neighborhood parks and recreational sites within one mile of the project site, community parks and recreational sites within two miles and other park or recreational facilities or sites as appropriate. Refer to the Environmental and Public Facilities Maps, Community Parks, Neighborhood Parks, Regional Parks, and other Park Facilities, or contact the Department of Recreation and Parks, Planning and Development Office, as necessary; and
- Describe the population and geographic area served, as well as the community characteristics.

Project Impacts

Review the description of the project and surrounding area. Determine the net

³

The use of utility easements or transmission line right-of-way (ROW) for park or recreational facilities requires an agreement with the utility.

population increase resulting from the project and identify the recreational facilities that would be used by project residents. Evaluate the demand for recreational services anticipated at the time of project buildout compared to the expected level of service available. Consider, as applicable, scheduled improvements (renovation, expansion, or addition) and the project's proportional contribution to the demand. As necessary, consult with the Department of Recreation and Parks. Evaluate project features which would reduce the demand for services (e.g., on-site recreation facilities or direct support to the Department of Recreation and Parks).

Cumulative Impacts

Identify the related projects which would be served by the same recreational facilities as the proposed project. Consider the characteristics of the related projects in terms of size, location, and types of land uses. Determine the net population increase resulting from the related projects. As above, evaluate the cumulative demand for recreational facilities anticipated at the time of project buildout compared to the expected level of service available. Consider, as applicable, scheduled improvements (renovation, expansion or addition). As necessary, consult with the Department of Recreation and Parks. As feasible, evaluate known features of the related projects that would reduce the demand for recreation services (e.g., on-site recreation facilities or direct support to the Department of Recreation and Parks). Consider the combined impact of the related and proposed projects and the project's proportional contribution to the cumulative demand.

Sample Mitigation Measures

Potential mitigation measures include the following:

- Provide on-site recreational amenities; and
- Provide direct support to the Department of Recreation and Parks, including land, equipment, funding, etc.

3. DATA, RESOURCES, AND REFERENCES

Department of Recreation and Parks, Planning and Development Office; Telephone: (213) 485-5671.

Public Recreation Plan, a portion of the Public Facilities and Service Element, October 1980.

General Plan Framework Element, July 1996, re-adopted August 2001.

LAMC (Sections 17.12, 17.58, 12.32, 12.33, and 21.10.3).

Environmental and Public Facilities Maps (1996):

- Community Parks;
- Neighborhood Parks; and
- Regional Parks and Other Park Facilities.

The Quimby Act, California Government Code Section 66477, allows the legislative body of a city or county, by ordinance, to require the dedication of land or impose a requirement of the payment of fees in lieu thereof, or a combination of both, for park or recreational purposes as a condition to the approval of a tentative map or parcel map.

K.5. LIBRARIES

1. INITIAL STUDY SCREENING PROCESS

A. Initial Study Checklist Question

XIII.e): Would the project result in substantial adverse physical impacts associated with the provision of new or physically altered governmental facilities, need for new or physically altered governmental facilities, the construction of which could cause significant environmental impacts, in order to maintain acceptable service ratios, response times or other performance objectives for other public facilities?

B. Introduction

Within the City of Los Angeles, the Los Angeles Public Library (LAPL) System provides library services at the Central Library, eight regional branch libraries, 67 community branches and four bookmobiles. Approximately 6 million books and other materials comprise the City Library collection. The Central Library houses 2.2 million of these.¹

The Public Libraries Plan, an element of the City's General Plan, includes service standards and goals for library facilities and operations. In 1988, the Library adopted its own master plan for libraries and subsequently funded it through two bonds (1989 & 1998). The final phase of the library master plan will be completed in 2004 when the final bond libraries are opened. Current site selection criteria are listed in Exhibit K.5-1.

Service needs are related to the size of the population and geographic area served and community characteristics. Projects that affect these factors (e.g., by increasing residential population in an area) may increase the demand for service from the LAPL.

C. Screening Criteria

- Would the proposed project result in a net increase of 75 residential units or more?

¹ *LAPL, Public Relations Fact Sheet, provided by Robert Reagan, Public Information Director, December 29, 1994 and Los Angeles Public Library, 2003.*

A "yes" response to the preceding question indicates further study in an expanded Initial Study, Negative Declaration, Mitigated Negative Declaration or EIR may be required. Refer to the Significance Threshold for Libraries and review the associated Methodology to Determine Significance, as appropriate.

A "no" response to the preceding question indicates that there would normally be no significant impact on Libraries from the proposed project.

D. Evaluation of Screening Criteria

Review the description of the proposed project and determine the number of net new residential units proposed. Compare this information to the Screening Criteria.

2. DETERMINATION OF SIGNIFICANCE

A. Significance Threshold

The determination of significance shall be made on a case-by-case basis, considering the following factors:

- The net population increase resulting from the proposed project;
- The demand for library services anticipated at the time of project buildout compared to the expected level of service available. Consider, as applicable, scheduled improvements to library services (renovation, expansion, addition or relocation) and the project's proportional contribution to the demand; and
- Whether the project includes features that would reduce the demand for library services (e.g., on-site library facilities or direct support to the LAPL).

B. Methodology to Determine Significance

Environmental Setting

In a description of the environmental setting, include the following information:

- Name, location, and description of the LAPL facilities serving the project site, including capacity, population served, operating characteristics, and scheduled improvements. Generally, this includes libraries within two miles. If unknown, refer to the Environmental and Public Facilities Map, Los Angeles Public Libraries, or see Exhibit

K.5-2. (For information about improvements, contact the LAPL Library Construction Unit.); and

- Description of the population and geographic area served, as well as community characteristics.

Project Impacts

Review the description of the project and surrounding area. Determine the net population increase resulting from the project and identify the LAPL facilities that would be used by the project residents. Identify existing facilities and their capacities. Evaluate the demand for library services anticipated at the time of the project buildout compared to the expected level of service available. Consider, as applicable, scheduled improvements (renovation, expansion, or addition) and the project's proportional contribution to the demand. As necessary, consult with LAPL. Evaluate project features, which would reduce the demand for library services (e.g., on-site library facilities or direct support to LAPL). Describe any characteristics of the project area, such as a college or other library near the project site, that would reduce the demand for LAPL services.

Cumulative Impacts

Identify the related projects, which would be served by the same LAPL facilities as the proposed project. Consider the characteristics of the related projects in terms of size, location, and types of land uses. Determine the net population increase resulting from the related projects. As above, evaluate the cumulative demand for library services anticipated at the time of project buildout compared to the expected level of service available. Consider, as applicable, scheduled improvements (renovation, expansion, addition, or relocation). As necessary, consult with LAPL. As feasible, evaluate known features of the related projects (e.g., on-site library facilities or direct support to the LAPL), which would reduce the expected cumulative demand for library service. Consider the combined impact of the proposed and related projects and the project's proportional contribution to the cumulative demand.

Sample Mitigation Measures

Potential mitigation measures include the following:

- Provide on-site or other private library facilities; and
- Provide direct support to the LAPL, including land, equipment, materials, funding, etc.

3. DATA, RESOURCES, AND REFERENCES

LAPL, Branch Facilities Division; Telephone: (213) 228-7576.

The Environmental and Public Facilities Map (1996), Los Angeles Public Libraries, shows the location of LAPL facilities and their service radii.

Exhibit K.5-1
LOS ANGELES PUBLIC LIBRARY (LAPL)
Branch Facilities
Site Selection Criteria

1. Branch building size standards are:

| <u>Population Served</u> | <u>Size of Facility</u>
(sf) | <u>Property Required</u>
(sf) |
|---|--|---|
| Above 50,000 | 12,500 | 32,500 |
| Below 50,000 | 10,500 | 27,500 |
| Expansion or
Special Situations* | Special Size | |
| Regional Branch | Up to 20,000 | 52,000 |

*Due to available property size and configuration, architectural constraints or opportunities, or building code requirements, some facilities may differ from the recommended sizes.

2. Security conscious design located in retail center.
3. A one-story library building with interior layouts designed to accommodate:
 - Full access for the disabled;
 - Interior layouts designed to accommodate electronic technology;
 - Substantial shelving and seating capacities; and
 - To include a community meeting room.
4. Good visibility and street access.
5. Easily accessible by car, by bus and on foot.
6. Taking into consideration the relative locations of all schools served by the branch.
7. Taking into consideration the relative locations of neighboring branch libraries.

Exhibit K.5-2
LOS ANGELES PUBLIC LIBRARY (LAPL)
BRANCH FACILITIES

| Name & Address of Branch | Building Size
(In Square Feet) | | Branch Facilities Plan a |
|---|-----------------------------------|----------|---|
| | Existing | Proposed | |
| Angeles Mesa
2700 W. 52nd St. | 4,750 | 5,250 | Structurally reinforce and renovate existing historic building. |
| Arroyo Seco Regional
6145 N. Figueroa St. | 10,200 | 14,000 | New 2-story building on existing site. Open June 2003 |
| Ascot
120 W. Florence Ave.. | 6,642 | 10,500 | New building. Open April 2004 |
| Atwater Village
3379 Glendale Blvd. | 5,900 | ----- | New building (1989), meets standard. |
| Baldwin Hills
2906 S. La Brea Ave. | 5,278 | 12,000 | New building opened Feb 2002 |
| Benjamin Franklin
2200 E. First St. | 9,656 | 9,656 | New building. (1975), meets standard. |
| Brentwood
11820 San Vicente Blvd. | 3,463 | 10,500 | New 2-story building on existing site. (1994). |
| Cahuenga
4591 Santa Monica Blvd. | 10,621 | 12,000 | Structurally reinforce, renovate and expand on existing historic building. Obtain adjacent site. Provide parking. |
| Canoga Park
7260 Owensmouth Ave. | 6,469 | 12,500 | Grand opening, Aug 2004 |
| Chatsworth
Temp. Loc.*
10044 Old Depot Plaza Rd.. | 5,463 | 12,500 | Permanent location: 21052 Devonshire St., Grand opening Sept. 2004 |

**Exhibit K.5-2, continued
LAPL BRANCH FACILITIES**

| Name & Address of Branch | Building Size
(In Square Feet) | | Branch Facilities Plan a |
|---|-----------------------------------|----------|---|
| | Existing | Proposed | |
| Chinatown
639 N. Hill St. | 14,162
Leased | 14,500 | New building. Opened Feb. 2003 |
| Cypress Park
1150 Cypress Ave. | 3,080 | 10,750 | Opened Jan. 2003. |
| Eagle Rock
5027 Caspar Ave. | 12,411 | ----- | New building (1981); meets standard. |
| Echo Park
1410 W. Temple | 7,919 | 12,500 | Relocate. Obtain site for new building. |
| Edendale
2011 W. Sunset Blvd. | None | 12,500 | Grand opening Sept. 2004. |
| El Sereno
5226 Huntington Dr., S. | 4,274 | 10,500 | Grand opening Sept. 2004. |
| Encino -Tarzana
18231 Ventura Blvd. | 5,404 | 12,500 | New building on site. Opened April 2003. |
| Exposition Park ^b
3665 S. Vermont Ave. | 9,656 | 15,000 | Renovate. Long Range: Expand. Obtain adjacent site. |
| Fairfax 'Express Station'
Branch closed for remodeling
161 S. Gardner St. | 5,230 | 12,500 | Relocate. New building 75% complete. |
| Felipe de Neve
2820 W. Sixth St. | 7,761 | 9,000 | Structurally reinforce, renovate and expand on existing historic building. Provide parking. |
| Goldwyn-Hollywood Regional
1623 N. Ivar Ave. | 19,000 | ----- | New building (1986); meets standard. Long Range: Obtain site for parking. |

**Exhibit K.5-2, continued
LAPL BRANCH FACILITIES**

| Name & Address of Branch | Building Size
(In Square Feet) | | Branch Facilities Plan a |
|--|-----------------------------------|----------|---|
| | Existing | Proposed | |
| Granada Hills
10640 Petit Ave. | 11,310 | ----- | New building; expanded (1975); meets standard. Closed for Seismic repair. |
| Harbor Gateway-Harbor City
24000 Western Ave. | 6,300
Leased | 14,500 | Project in progress - bid and Award 45% Complete |
| Hyde Park
2205 Florence Ave. | 4,389 | 10,500 | Grand opening, Oct. 2004 |
| Jefferson
2211 W. Jefferson Blvd. | 2,980 | 9,000 | Renovate and expand. Obtain adjacent site for parking. |
| John C. Fremont
6121 Melrose Ave. | 4,276 | 8,000 | Structurally reinforce, renovate and expand on existing historic building. Obtain adjacent site. Provide parking. |
| John Muir
1005 W. 64th Street | 4,850 | 8,000 | Structurally reinforce, renovate and expand. Obtain adjacent site. Provide parking. |
| Junipero Serra
4607 S. Main St. | Leased
3,922 | 10,500 | Relocate. Obtain site for new building. |
| Lake View Terrace
12002 Osborne Street | 12,500 | | |
| La Biblioteca del Pueblo de
Lincoln Heights
2530 Workman St. | 7,072 | 10,500 | Structurally reinforce, renovate and expand on existing historic building. Provide parking. |
| Little Tokyo
203 S. Los Angeles St. | 2,500 | 12,500 | Construction 75% complete |
| Los Feliz
1874 Hillhurst Ave. | 2,250 | 10,500 | Relocate. Obtain site for new building. |

**Exhibit K.5-2, continued
LAPL BRANCH FACILITIES**

| Name & Address of Branch | Building Size
(In Square Feet) | | Branch Facilities Plan a |
|--|-----------------------------------|----------|--|
| | Existing | Proposed | |
| Winchester
7114 W. Manchester Ave. | 4,369 | 12,500 | Obtain site for new building. |
| Malabar
2801 Wabash Ave. | 1,168 | 6,000 | Structurally reinforce, renovate and expand historic building. |
| Mar Vista
12006 Venice Blvd. | 5,450 | 12,500 | Grand Opening, March 2003 |
| Mark Twain
9621 S. Figueroa St. | 4,342 | 9,900 | Grand opening, Jan. 2003. |
| Memorial
4625 W. Olympic Blvd. | 7,217 | 10,500 | Structurally reinforce, renovate and expand on existing historic building. Provide parking. |
| Mid Valley Regional &
Bookmobile Headquarters
16244 Nordhoff St. | 27,981 | ----- | New building on City-owned site. Complete. (1996). |
| North Hollywood Regional
5211 Tujunga Ave. | 12,597 | 15,150 | Expand on existing historic building to add a multipurpose meeting room & parking lot. Grand opening, November 2002. |
| Northridge
9051 Darby Ave. | 6,240 | 12,500 | New building on existing site. Grand opening, Dec. 2003. |
| Pacoima
13605 Van Nuys | 5,511 | 11,300 | New building on existing site. Grand opening, April 2002. |
| Palisades
861 Alma Real Dr. | 7,025 | 11,500 | New bldg. On existing site. Grand opening, Feb. 2002. |
| Palms-Rancho Park
2920 Overland Ave. | 6,342 | 10,500 | New building on existing site. Grand opening, Nov. 2002. |

**Exhibit K.5-2, continued
LAPL BRANCH FACILITIES**

| Name & Address of Branch | Building Size
(In Square Feet) | | Branch Facilities Plan a |
|--|-----------------------------------|----------|---|
| | Existing | Proposed | |
| Panorama City
14345 Roscoe Blvd. | 6,101 | 12,500 | New building on existing site. Obtain adjacent site. |
| Pico Union
1030 S. Alvarado | None | 12,500 | Grand opening, May 2004. |
| Pio Pico – Koreatown
694 S Oxford Ave | 18,000 | ----- | <i>New address</i> |
| Platt
23600 Victory Blvd. | 14,053 | ----- | New building on City-owned site. Complete (1995). |
| Playa Vista
6400 Playa Vista Dr. | None | 10,500 | New building on a site to be provided by the Playa Vista developer.
Grand opening, May 2004. |
| Porter Ranch
11371 Tampa Ave. | 12,300 | ----- | New building on City-owned site. Complete (1995). |
| R. L. Stevenson
803 Spence St. | 4,474 | 5,000 | Structurally reinforce, renovate and expand on existing historic building. |
| Robertson
1719 S. Robertson Blvd. | 3,505 | 10,500 | New 2-story building on existing site. |
| San Pedro Regional
931 S. Gaffey St. | 20,000 | ----- | New building (1983); meets standard. Long Range: Obtain adjacent site for added parking. Ceremony and Dedication, Jan. 2001 |
| Sherman Oaks
14245 Moorpark St. | None | 12,500 | Renovate and expand on existing site. Obtain adjacent site. Grand opening, May 2003. |
| Silver Lake, Ph. I
To be determined. | 5,230 | 10,500 | Project in site and land acquisition stage. |

**Exhibit K.5-2, continued
LAPL BRANCH FACILITIES**

| Name & Address of Branch | Building Size
(In Square Feet) | | Branch Facilities Plan a |
|--|-----------------------------------|----------|--|
| | Existing | Proposed | |
| Studio City
12511 Moorpark St. | 5,230 | 10,500 | New building on existing site. Obtain adjacent site. |
| Sun Valley
7935 Vineland Ave. | 5,230 | 12,500 | New building on existing site. Obtain adjacent site. Grand opening, Sept. 2003. |
| Sunland-Tujunga
7771 Foothill Blvd. | 4,500 | 10,500 | New building on existing site. Obtain adjacent City-owned site. |
| Sylmar
14561 Polk St. | 5,511 | 12,500 | New building on existing site. Obtain adjacent site. Grand opening, Sept. 2003. |
| Valley Plaza
12311 Vanowen St. | 5,450 | 10,500 | Renovate and expand on existing site. Grand opening, Jan. 2004. |
| Van Nuys
6250 Sylmar Ave. Mall | 12,814 | ----- | Renovate existing building and optimize parking lot. Transfer Valley Bookmobile Unit to Mid-Valley Regional Branch Library. Complete (1996). |
| Venice – Abbot Kinney
501 S. Venice Blvd. | 5,581 | 10,500 | Relocate. New building on City-owned site. |
| Vermont Square
1201 W. 48 th St. | 8,000 | ----- | Structurally reinforce and renovate existing historic building with small expansion. Complete (1996). |
| Vernon – Leon H. Washington
Jr Memorial
4505 S. Central Ave. | 10,325 | ----- | New building; meets standard. |
| Washington Irving
4117 W. Washington Blvd. | 3,918 | 10,500 | Relocate. Obtain site for new building. |

**Exhibit K.5-2, continued
LAPL BRANCH FACILITIES**

| Name & Address of Branch | Building Size
(In Square Feet) | | Branch Facilities Plan a |
|---|-----------------------------------|----------|--|
| | Existing | Proposed | |
| Alma Reaves Woods - Watts
10205 Compton Ave. | 3,542 | 12,500 | Exchange Library-owned property for CRA land on the corner of 102 and Compton. New building on CRA site. |
| West Los Angeles Regional
11360 Santa Monica Blvd. | 13,740 | 13,740 | Renovate existing building. Long Range: Obtain adjacent site for parking. |
| West Valley Regional
19036 Vanowen St. | 12,469 | 14,000 | Renovate and expand to add a multipurpose meeting room on existing site. Grand opening, Oct. 2002 |
| Westchester-Loyola Village
7114 W. Manchester Ave. | 5,918 | 12,500 | Relocate and combine with Loyola Village. Obtain site for new building. Grand opening, June 2003. |
| Westwood
1246 Glendon Ave. | None | 12,500 | Under construction, 80% complete. |
| Will & Ariel Durant
7140 W. Sunset Blvd.. | 4,155 | 12,500 | Relocate. Obtain site for new building. Grand opening, Jan 2004. |
| Wilmington
1300 North Avalon Blvd. | 10,500 | ----- | New building (1988); meets standard. |
| Wilshire
149 N. St. Andrews Pl. | 6,258 | ----- | Structurally reinforce and renovate existing historic building. |
| Woodland Hills
22200 Ventura Blvd. | 6,272 | 12,500 | New building on existing site. Grand opening, Aug. 2003. |
| Westwood | None | 12,500 | Obtain site for new building. |

Adopted by the Board of Library Commissioners August 24, 1988; Revised 1991, 1992, 1998, 1999, 2001, 2002.
LAPL, 1998 Library Bond Program Annual Report, July 2003 and July 2004.

a) Some historic building renovations will not include parking.

L. TRANSPORTATION

L.1. INTERSECTION CAPACITY

1. INITIAL STUDY SCREENING PROCESS

A. Initial Study Checklist Questions

- XV.a): Would the project cause an increase in traffic which is substantial in relation to the existing traffic load and capacity of the street system (i.e., result in a substantial increase in either the number of vehicle trips, the volume to capacity ratio on roads or congestion at intersections)?
- XV.b): Would the project exceed, either individually or cumulatively, a level of service standard established by the county congestion management agency for designated roads or highways?

B. Introduction

This issue involves the ability of an intersection to accommodate the increased vehicular traffic demands associated with a proposed project. The impact typically results from the addition of new project-generated traffic to an intersection. In situations where a project involves street vacations or other substantial street system changes, it can also result from diverted or shifted traffic caused by the project.¹ Impacts may also result from a combination of new trips and diverted traffic. The impact is measured as the effect of the project on traffic operating conditions, expressed in terms of level of service (LOS) and either volume to capacity (V/C) ratio (for signalized intersections) or average vehicle delay (for unsignalized intersections). Impacts are related to factors such as type of use, size of project, access points, capacity of the transportation system, and other characteristics of the project and surrounding area. For impacts on emergency access, see K.2. FIRE PROTECTION AND EMERGENCY MEDICAL SERVICES.

Intersection capacity impacts are evaluated when project details, such as land use and size, location of access points, etc., are known. If these features are not known, see L.2. STREET SEGMENT CAPACITY. Intersection capacity impacts are typically evaluated for permanent traffic increases after project completion, but can also be evaluated for temporary traffic increases generated during project construction. Impacts should be evaluated for a future study year usually

¹ *Impacts related to loss of capacity due to temporary lane closures associated with projects requiring construction activity within the street are discussed in L.8. IN-STREET CONSTRUCTION IMPACTS.*

set one or two years after the expected year of project completion. The following traffic scenarios should be analyzed:

- Existing Conditions;
- Cumulative (Future) Base Conditions (also termed the "No Project" alternative); and
- Cumulative (Future) Plus Project Conditions

C. Screening Criteria

- Would the proposed project generate and/or cause a diversion or shift of 500 or more daily trips or 43 or more p.m. peak hour vehicle trips on the street system?

A "yes" response to the preceding question indicates further study in an expanded Initial Study, Negative Declaration, Mitigated Negative Declaration, or EIR may be required. Refer to the Significance Threshold for Intersection Capacity, and review the associated Methodology to Determine Significance, as appropriate.

A "no" response to the preceding question indicates that there would normally be no significant Intersection Capacity impact from the proposed project.

D. Evaluation of Screening Criteria

If the project is expected to generate new or shift existing vehicular traffic, estimate the number of peak hour trips expected to result from project implementation and compare this information to the Screening Criteria.

To estimate new project trips, apply the appropriate trip generation rates to the proposed project land uses.² The following two sources of trip rates are preferred:

- Standard trip generation rates/equations contained in the latest edition of Trip Generation, published by the Institute of Transportation Engineers (ITE); and
- Trip generation rates specified in a Transportation Specific Plan (TSP) or Interim Control Ordinance (ICO) must be used if the project is located in a TSP or ICO area.

² *Note that traffic studies which are required by City of Los Angeles Department of Transportation (LADOT) (CEQA and non-CEQA) are also subject to the policies and procedures of LADOT's Traffic Study Policies and Procedures Manual as well as requirements of applicable specific plans. Contact LADOT at (213) 580-1195 for further information.*

If the above sources do not provide rates for a particular land use under study, or due to unique characteristics of the project it is believed that standard rates are not appropriate, the following alternative techniques may be considered:

- Use of alternative published rates, such as those contained in the latest edition of Trip Generators (San Diego Association of Governments (SANDAG));
- Use of rates empirically derived from trip generation studies of similar developments or facilities; and
- Explicit derivation of vehicle trips based upon estimation of person trips. For example, because little or no trip rate data exist for museum facilities, trip generation for such developments could be derived by applying mode split and vehicle occupancy data to estimated person trips for the various generators (patrons, employees, service/delivery).

If the project is expected to divert or shift traffic, estimate the amount based on the project characteristics and on ambient traffic volumes for the affected streets/intersections and compare to the Screening Criteria.

For freeway ramp intersections, use the same trip generation rates and calculate the number of trips that would occur at identified ramp intersections in the a.m. or p.m. peak hour. See the Project Impact section for a discussion of trip distribution methods.

2. DETERMINATION OF SIGNIFICANCE

A. Significance Threshold

A proposed project would normally have a significant impact on intersection capacity if the project traffic causes an increase in the V/C ratio on the intersection operating condition after the addition of project traffic of one of the following:

V/C ratio increase ≥ 0.040 if final LOS* is C

V/C ratio increase ≥ 0.020 if final LOS* is D

V/C ratio increase ≥ 0.010 if final LOS* is E or F

- * “Final LOS” is defined as projected future conditions including project, ambient, and related project growth but without project traffic mitigation.

Note that if stricter criteria are required in an applicable local TSP or ICO, those criteria will apply.

If an unsignalized intersection is projected to operate at LOS C, D, E or F, re-analyze the intersection using the signalized intersection methodology to determine the significance of impacts using the sliding scale criteria described above.

B. Methodology to Determine Significance

Environmental Setting

Describe the existing traffic conditions based on the appropriate study area, time periods, existing transportation facilities, traffic counts, and LOS.

Study Area and Time Periods for Analysis. Identify the geographic study area (i.e., intersections to be analyzed), based on project size, type, location and existing levels of traffic, in consultation with Los Angeles Department of Transportation (LADOT). Include intersections of surface streets with other surface streets and with freeway ramps, as well as the appropriate Congestion Management Program (CMP) arterial monitoring intersections.³

For most projects, analyze existing traffic for both the a.m. and p.m. weekday peak hours. For some projects, analysis of p.m., midday or weekend periods is appropriate if those are expected to be the prime periods of trip generation for the project (e.g., a recreational project).

Existing Setting. Describe existing traffic conditions, including:

- A description of the existing street system serving the defined study area (i.e., number of lanes, traffic control devices, on-street parking, etc.);
- Existing lane configurations and signal phasing at study intersections;
- Existing peak hour traffic turning movements at study intersections. Traffic counts should not be more than two years old; and
- Quantify the existing LOS at the intersections to be analyzed using the appropriate intersection capacity methodology described below:

³ See Exhibit L-3 in L. TRANSPORTATION for a map of CMP monitoring locations.

- Signalized Intersections - For the analysis of signalized intersections, determine peak hour LOS based on the Critical Movements Analysis (CMA) methodology contained in the Transportation Research Board's (TRB) Circular No. 212 - Interim Materials on Highway Capacity at the identified intersections. Summarize V/C ratio and LOS in the study; and
- Two-Way and All-Way Stop-Controlled (Unsignalized) Intersections - For two-way and all-way stop-controlled intersections, use the procedures described in Chapter 10 of TRB's Highway Capacity Manual, Special Report 209, Third Edition. Summarize average vehicle delay and LOS in the study.

LOS definitions for signalized and unsignalized intersections are listed in Exhibits L.1-1 and L.1-2. For additional details regarding intersection LOS calculation, see LADOT's Traffic Study Policies and Procedures Manual.

Project Impacts

Project impacts are typically based upon a comparison of intersection LOS for cumulative base and cumulative base plus project (final LOS) conditions. The cumulative base conditions are comprised of existing traffic levels increased by a factor to account for ambient growth, plus projected traffic levels from known related projects in the vicinity. Using the appropriate intersection capacity methodologies described above, quantify the cumulative plus project LOS at the study intersections for the projected cumulative plus project traffic volumes. The project impact is determined by comparing the projected cumulative base and cumulative plus project intersection LOS, using the defined significance threshold.

Project Trip Generation. The preferred methods of calculating trip generation rates are described above in Evaluation of Screening Criteria.

Depending upon the particular characteristics of the project, one or more of the following adjustments to the project trip generation may be appropriate (consult with LADOT for applicability):

- Central Business District (CBD) Trips - If the project is located within the CBD, defined as the area bordered by the Santa Ana Freeway to the north, Los Angeles Street to the east, the Santa Monica Freeway to the south, and the Harbor Freeway to the west, trip reduction factors may be applied to reflect prevailing CBD mode splits. (Consult with LADOT for most current rates.);

-
- Pass-by Trips – “Pass-by trips” occur when a proportion of traffic generated by a shopping center, for example, is not new to the area but is actually diverted from the flow of traffic that already existed on the adjacent street system. LADOT’s discount rates for pass-by trips are shown in Exhibit L.1-3;
 - Mode Split Adjustments - The mode split inherent in the ITE trip generation rates for most land uses reflect a relatively modest transit usage (typically less than 5 percent), and thus a low average vehicle ridership (AVR). If the project is located in an area where transit mode split or vehicle occupancy is considered to be higher than normal, identify the prevailing or projected mode split(s) for the project area to determine an appropriate adjustment to the ITE rates. Several data sources are available to perform this evaluation, including the South Coast Air Quality Management District (SCAQMD) Regulation XV data (through March 1996) which summarizes employee trips by travel mode, data from the Los Angeles County Metropolitan Transportation Authority (Metro), Southern California Association of Governments (SCAG), Southern California Rideshare office, and/or City of Los Angeles Citywide Framework regional travel demand models;
 - Captive Market (Internal) Trips - For mixed-use projects, different land uses or trip generators may capture patronage from within the project site. The following sources are available to estimate captive market reductions:
 - National Cooperative Highway Research Program (NCHRP) Report 323 - Travel Characteristics at Large-Scale Suburban Activity Centers;
 - Trip Generation; and
 - Urban Land Institute (ULI) Shared Parking.
 - Removal of Existing Land Uses - Trips from existing land uses which will be removed, but have been in place at least six months within the last two years, may be credited against the new trips generated by the project (if "existing" traffic counts reflect the existing land use). Projects within a TSP area may be subject to different regulations in regards to existing use trip credits. If driveway counts are not available, trip generation for the existing uses should be estimated using the trip generation procedures described above.

Trip Distribution. The geographic distribution of traffic generated by developments is dependent upon such factors as: the type and density of the proposed land uses; the geographic

distribution of the population, employment, and commercial centers that would attract the project-generated traffic (i.e., the "market" area); the location of site access points in relation to the surrounding street system; the level of congestion on local streets; and the physical characteristics of the street system. To identify total project trip distribution, develop individual distribution patterns for each land use associated with both the project and cumulative projects. Distribution patterns can be based upon: information from previous traffic studies; trip table data from SCAG or City of Los Angeles Framework regional travel demand forecasting models; or most recent CMP.

Cumulative Impacts

The cumulative base traffic forecasts consist of three elements: existing traffic; ambient increases due to regional growth and development; and traffic from specific known development projects in the vicinity of the project. Ambient regional growth is derived through the application of an annual growth factor to existing traffic volumes. The ambient growth factor should be no higher than the regional growth factors contained in the most recent CMP and should usually be less to avoid double counting of trips generated by cumulative projects when the cumulative projects are consistent with the long-range forecasts used to develop the ambient regional growth factor.

The list of cumulative projects (including pertinent descriptive data such as location, types and sizes of land uses, and status) should be developed from files maintained by the LADOT and supplemented with data from the City Planning Department and the Community Redevelopment Agency (CRA) of the City of Los Angeles (for adopted redevelopment areas). General criteria that should be considered for the selection of cumulative projects include:

- The sphere of influence for cumulative projects, based on their proposed size and likely influence on traffic patterns, generally within one or two miles of the proposed project;
- Very large, regionally significant projects that are located outside the typical sphere of influence (i.e., beyond two miles from the analysis area), but could impact intersections analyzed for the project; and
- Projects proposed within neighboring jurisdictions if they could impact the same analyzed intersections.

Determine the trip generation and distribution for cumulative projects using the procedures described above for the project. Add the existing traffic volumes, factored by the ambient

growth rate, to the estimated cumulative projects trips to develop cumulative base traffic projections at the study intersections.

Using the appropriate intersection capacity methodologies described in Evaluation of Screening Criteria, quantify the cumulative base LOS at the study intersections for the projected cumulative traffic volumes. Also, incorporate any approved mitigation measures associated with the cumulative projects into the cumulative base traffic assessment.

Cumulative Plus Project Impact

Using the project trip generation estimates and distribution patterns developed above, assign the project-generated trips to the street system. Then, add the estimated project-generated trips to the cumulative base traffic volumes to develop cumulative plus project traffic projections at the study intersections. Determine the final LOS⁴ and the change in the V/C ratio and compare to the Significance Threshold.

Sample Mitigation Measures

Potential mitigation measures include transportation demand management (TDM) measures, transportation system management (TSM) measures, physical roadway improvements, or a combination thereof. The following lists a variety of possible mitigation measures in priority order per LADOT guidelines. Consult with LADOT, as needed, for further information.

TDM Measures reduce single occupancy vehicle (SOV) trips and encourage ridesharing and transit use.⁵ Individual measures and actions which could be included in a TDM plan include the following:

- A commuter transportation coordinator;
- Carpool and vanpool program, including participation in a computerized matching system;
- Parking management techniques, including elimination of parking subsidies, constraining the parking supply, preferential parking for rideshare vehicles, offering a cash equivalent of parking costs as a travel allowance, etc;
- Encourage non-vehicle modes, such as bicycling, walking, or telecommuting;

⁴ "Final LOS" is defined as projected future conditions including project, ambient, and related project growth, but without project traffic mitigation.

⁵ See the most recent edition of LADOT's Traffic Study Policies and Procedures Manual for a description of the requirements for preparation and content of a TDM plan.

- Flexible or staggered work hours, potentially including compressed work weeks (i.e., 4/40 or 9/80 plans);
- Transit incentives and improvements, including subsidized transit passes, distribution of transit information and schedules, and provision of shelters or benches at bus stops and/or layover areas;
- Vehicle trip reduction incentives and services affecting visitors to the project, such as shoppers, clients, patrons, etc; and
- Site trip generation cap and/or parking cap including trip monitoring agreements.

Transit Capacity and Access Improvements:

- Implementation of a local shuttle bus service providing direct access from the project site to multimodal or rail transit stations;
- Bus benches, shelters, or other amenities;
- Concrete bus pads and bus stops; and
- Contributions toward transit stations or centers.

Traffic Signal Improvements:

- Addition of a signal to the City of Los Angeles' Automated Traffic Surveillance and Control (ATSAC) system (available only where ATSAC has not yet been constructed or a fully-funded construction contract has not been awarded);
- Upgrade of an existing ATSAC signal system to Adaptive Traffic Control System (ATCS);
- Signal modifications, including signal timing, coordination, phasing improvements, etc; and
- New signals, which requires a traffic signal warrants analysis.⁶

Physical Improvements:

- Turn restrictions;
- One-way streets;
- Conversion of mixed-flow lanes to High Occupancy Vehicle (HOV) lanes (permanently or during peak periods);
- Reversible HOV or mixed-flow lanes;
- New roadway;

⁶ See *Traffic Manual of the California Department of Transportation (Caltrans)*, *Manual on Uniform Traffic Control Devices*, by the *Federal Highway Administration (FHWA)*, and *Warrants for Traffic Signals (LADOT)* to evaluate the need for traffic signals.

- Roadway widening to add lanes;
- Extension of truncated street;
- Intersection grade separation;
- Partial intersection grade separation (i.e., left-turn flyovers);
- New freeway on- or off-ramps;
- Redesign of freeway on- and off-ramps;
- Median construction/modification to restrict access;
- Pedestrian crossing grade separation; and
- Flaring of intersections to add turn lanes.

Street Restriping and Parking Prohibitions:

- Restriping to add lanes, with or without parking removal or restrictions;
- Protected left turn pockets, or free right turn lanes; and
- Parking restrictions, daily or during peak hours.

Trip Fees/Mitigation Trust Fund:

If the project is located in a TSP area, an applicant may be required by City Ordinance to pay "trip fees" into a mitigation trust fund for implementation of larger regional projects that are specified in the TSP. If a traffic study demonstrates that the applicant is responsible for only a portion of a large and costly mitigation measure, such as a bridge or freeway ramp, a fair share contribution toward the cost of the improvement may be an acceptable mitigation.

3. DATA, RESOURCES, AND REFERENCES

LADOT, Bureau of Transportation Programs and Development Review, 100 South Main Street, 9th Floor, Los Angeles, California 90012; Telephones: (213) 972-8485 (Metro/South L.A.), (818) 374-4690 (Valley), and (213) 485-1062 (West/Coastal). For traffic study scoping, intersection/street as-built plans, traffic count files, or other assistance.

LADOT, Traffic Study Policies and Procedures Manual, March 2002 or most recent. Warrants for Traffic Signals.

City Planning Department, Community Planning Bureau, 200 North Spring Street, 6th Floor, Los Angeles, California 90012; Telephones: (213) 978-1168 (South L.A.), (213) 978-1179 (Metro/Central), (213) 978-1177 (West/Coastal). For ICOs, TSPs, Framework Regional Travel Demand Forecasting Model, Circulation Element, Proposed Transportation Element, and other planning documents.

American Association of State Highway and Transportation Officials (AASHTO), A Policy on Geometric Design of Highways and Streets, 2004.

Caltrans, Highway Design Manual, 5th Edition, July 1995.

Caltrans, Traffic Manual, September 1992.

Caltrans, 2004 Traffic Volumes on California State Highways, 2005 (or latest edition).

Federal Highway Administration (FHWA), Manual on Uniform Traffic Control Devices (MUTCD), Revision 1, 2003.

ITE, Traffic Access and Impact Studies for Site Development: A Recommended Practice, 1991.

ITE, Traffic Engineering Handbook, 5th Edition, 1999

ITE, Transportation and Land Development, 2003.

ITE, Transportation Planning Handbook, 2003.

LACMTA, CMP for Los Angeles County, adopted July 2004 (or most recent).

SANDAG, Trip Generators, October 1993 (or latest edition).

SCAG, 1991 Southern California Origin-Destination Survey, Summary Findings, February 1993. Available by calling (213) 236-1800.

TRB, Circular No. 212 - Interim Materials on Highway Capacity, 1980.

TRB, Highway Capacity Manual, Special Report 209, Third Edition, 1994.

NCHRP Report 323 - Travel Characteristics at Large-Scale Suburban Activity Centers, 1989.

ULI, Shared Parking, Second Edition, 2005.

FHWA, Manual on Uniform Traffic Control Devices, 2003.

FHWA, Technology Sharing Report 80-204, Design of Urban Streets, January 1980.

Exhibit L.1-1
LEVEL OF SERVICE (LOS) DEFINITIONS FOR SIGNALIZED INTERSECTIONS

| LOS | Volume to Capacity
(V/C) Ratio | Definition |
|------------|---|---|
| A | 0.000 - 0.600 | EXCELLENT. No vehicle waits longer than one red light and no approach phase is fully used. |
| B | 0.601 - 0.700 | VERY GOOD. An occasional approach phase is fully utilized; many drivers begin to feel somewhat restricted within groups of vehicles. |
| C | 0.701 - 0.800 | GOOD. Occasionally drivers have to wait through more than one red light; backups may develop behind turning vehicles. |
| D | 0.801 - 0.900 | FAIR. Delays may be substantial during portions of the rush hours, but enough lower volume periods occur to permit clearing of developing lines, preventing excessive backups. |
| E | 0.901 - 1.000 | POOR. Represents the most vehicles intersection approaches can accommodate; may be long lines of waiting vehicles through several signal cycles. |
| F | > 1.000 | FAILURE. Backups from nearby locations or on cross streets may restrict or prevent movement of vehicles out of the intersection approaches. Tremendous delays with continuously increasing queue lengths. |

Source: TRB, Circular No. 212, Interim Materials on Highway Capacity, 1980.

Exhibit L.1-2
LEVEL OF SERVICE (LOS) DEFINITIONS FOR
TWO-WAY AND ALL-WAY STOP-CONTROLLED INTERSECTIONS

| LOS | Average Vehicle Delay
(seconds) |
|------------|--|
| A | 0.0 - 5.0 |
| B | 5.1 - 10.0 |
| C | 10.1 - 20.0 |
| D | 20.1 - 30.0 |
| E | 30.1 - 45.0 |
| F | > 45.0 |

Source: TRB, Highway Capacity Manual, Special Report 209, Third Edition, 1994.

Exhibit L.1-3
PASS-BY TRIP DISCOUNT RATES

The pass-by trip reduction rates shown below are used for land development projects by the LADOT. However, these rates are superseded by additional guidelines provided in TSPs or ICOs. These rates are not applicable to review of impacts at project driveways and the intersection(s) immediately adjacent to the project site, and are not used in determining the need for a traffic study.

| PASS-BY
TRIP
DISCOUNT
RATE | LAND USE CATEGORY |
|-------------------------------------|--|
| 10% | Shopping Center 600,000 sf or more, Quality Restaurant, Specialty Retail, Furniture Store, Medical Office, Day Care, Theater/Cinema, Auto Sales/Repair |
| 20% | Shopping Center 300,000 to less than 600,000 sf, Bank/Savings & Loan, High Turnover Restaurant, Car Wash, Hardware/Lumber Store, Garden Center, Recreation/Health Club |
| 30% | Shopping Center 100,000 to less than 300,000 sf, Discount Club, Discount Store, Auto Parts, Music/Video Store |
| 40% | Shopping Center 50,000 to less than 100,000 sf, Supermarket, Drugstore, Bookstore |
| 50% | Shopping Center less than 50,000 sf, Fast Food Restaurant, Gasoline/Service Station, Convenience Market, Flower/Bakery/Yogurt Shop, Dry Cleaner, Liquor Store |

Note: sf = square feet

Source: LADOT.

L.2. STREET SEGMENT CAPACITY

1. INITIAL STUDY SCREENING PROCESS

A. Initial Study Checklist Question

- XV.a): Would the project cause an increase in traffic which is substantial in relation to the existing traffic load and capacity of the street system (i.e., result in a substantial increase in either the number of vehicle trips, the volume to capacity ratio on roads, or congestion at intersections)?

B. Introduction

This issue involves the ability of a street or roadway segment to accommodate increased vehicular traffic demands associated with a proposed project. The impact typically results from the addition of new traffic generated by a project to a street segment although, in situations where a project involves street vacations or other substantial street system changes, it can also result from diverted or shifted traffic caused by the project or a combination of new and diverted traffic.¹ The impact is measured as the effect of the project on traffic operating conditions, expressed in terms of level of service (LOS) and volume to capacity (V/C) ratio. Impacts are related to factors such as type of use, development densities, capacity of transportation system, and other characteristics of the project and surrounding area.

Street segment capacity impacts are generally evaluated in program-level analyses (such as specific plans or long-range development projects) for which details regarding specific land use types, sizes, project access points, etc., are not known. If such details are known, see L.1. INTERSECTION CAPACITY for applicability. As a travel demand forecasting model is generally used to develop traffic projections, the future study year will usually be the same as the horizon year used by the regional models. Depending on the project, it may not be necessary to evaluate street segment capacity impacts in addition to intersection capacity impacts. Street segment capacity impacts are evaluated for permanent traffic increases after project completion.

¹ *Impacts related to loss of capacity due to temporary lane or street closures associated with projects requiring construction activity within the street are discussed in L.8. IN-STREET CONSTRUCTION IMPACTS.*

The following traffic scenarios are to be analyzed for street segment capacity impacts:

- Existing Conditions;
- Cumulative Base Conditions (scenario assuming "No Growth" in program area); and
- Cumulative Plus Project Conditions (project can represent full buildout of a plan or a probable market scenario).

C. Screening Criteria

- Would the proposed project generate and/or cause a diversion or shift of 500 or more daily vehicle trips or 43 or more a.m. or p.m. peak hour trips?

A "yes" response to the preceding question indicates that further study in an expanded Initial Study, Negative Declaration, Mitigated Negative Declaration, or EIR may be required. Refer to the Significance Threshold for Street Segment Capacity, and review the associated Methodology to Determine Significance, as appropriate.

A "no" response to the preceding question indicates that there would normally be no significant impact on Street Segment Capacity from the proposed project.

D. Evaluation of Screening Criteria

Estimate the project trip generation using the trip generation and distribution methodologies in L.1. INTERSECTION CAPACITY. Compare the result to the Screening Criteria.

2. DETERMINATION OF SIGNIFICANCE

A. Significance Threshold

A proposed project would normally have a significant street segment capacity impact if project traffic causes an increase in the V/C ratio on the street segment operating condition after the addition of project traffic equal to or greater than the following:

- V/C ratio increase ≥ 0.080 if final LOS* is C
- V/C ratio increase ≥ 0.040 if final LOS* is D
- V/C ratio increase ≥ 0.020 if final LOS* is E or F

- * “Final LOS” is defined as projected future conditions including project, ambient, and related project growth but without project traffic mitigation.

B. Methodology to Determine Significance

Environmental Setting

Describe the existing traffic conditions based on the appropriate study area, time periods, existing transportation facilities, traffic counts, and LOS, as detailed below.

Study Area and Time Periods for Analysis. Identify the geographic study area (i.e., street segments to be analyzed), based on project size, type, location, and existing levels of traffic, in consultation with the Los Angeles Department of Transportation (LADOT). Include key major streets and secondary highways and the appropriate arterial street approaches in the Congestion Management Program (CMP). For most projects, analyze existing traffic for both the a.m. and p.m. weekday peak hours. For some projects, analysis of other time periods, such as mid-day or weekend periods, may be required if those are expected to be the prime periods of trip generation for the project (e.g., a recreational project).

Existing Setting. Inventory existing traffic conditions including, the following:

- A description of the existing street system serving the defined study area (i.e., number of lanes, traffic control devices, on-street parking, etc.); and
- Existing peak hour traffic volumes on study street segments. Traffic counts should not be older than two years.

Quantify the existing peak hour V/C ratios and LOS at the study street segments using the street capacity methodology described below.

Street Segment Capacity Methodology. Peak hour roadway (street segment) capacities are based upon several parameters including number of lanes, median type, roadway width, parking conditions, and spacing of signalized intersections. Vehicle capacities are based on the street classification. Consult with LADOT regarding roadway capacities, as needed.

For each study street segment, divide peak hour directional traffic volumes by the directional street segment capacity (determined by multiplying the number of lanes with the selected lane capacity) to calculate a V/C ratio, which is then used to determine LOS. LOS definitions for street segments are included in Exhibit L.2-1.

Project Impacts

Impacts are determined by comparing street segment LOS for the cumulative base and cumulative plus project (final LOS) traffic projections, using the defined significance threshold. The Los Angeles Department of Transportation (LADOT) should be consulted to determine the method in which to develop the traffic projections. Future base traffic volumes may be calculated using traffic growth factors or by employing a travel demand forecast model.

- **Travel Demand Forecasting Model.** Use the focused travel demand forecasting model, which is based on the Citywide Framework model, to forecast future traffic conditions. Additional street network and traffic zone detail should be added in the program study area, which requires disaggregation of the Framework model trip tables. The development of the focused area model may require other modifications and calibration. Consult with LADOT for further information.
- **Program Trip Generation.** Once the model is calibrated, replace the Framework model vehicle projections for the study area with trip ends consistent with the expected type and level of development under the project. Trips should be generated by trip type (e.g., home-work, home-other, non-work), and converted to peak hour trip tables.
- **Trip Distribution.** Using the focus area model, it is suggested that a trip table balancing process be used for each trip type to replicate the trip distribution inherent in the Framework model, prior to conversion of the daily trip tables to peak hour.

Cumulative Impacts

As described above in Project Impacts, develop the focus area model using the Citywide Framework model as the basis for the remainder of the City and the region, with additional model detail added in the program study area. The long-range regional socioeconomic growth projections inherent in the Framework model (which incorporates socioeconomic projections from the Southern California Association of Governments (SCAG) for the region outside of Los Angeles) would represent cumulative base conditions for the study. If necessary, the model trip tables can be adjusted to account for significant large cumulative developments which were not included in the original Framework model trip tables.

Cumulative Plus Project Impacts

Project impacts are usually compared against future cumulative base conditions (the "No Growth" scenario for programs). The model trip tables will likely require modification to replace future growth inherent in the regional models with "no growth" estimates for the program area. Follow the procedures described above for program trip generation to modify the trip tables. Using the street segment capacity methodology described previously, quantify cumulative base LOS at the study street segments from the travel demand focus area model and compare to cumulative plus project LOS (final LOS).²

Sample Mitigation Measures

See L.1. INTERSECTION CAPACITY.

3. DATA, RESOURCES, AND REFERENCES

See L.1. INTERSECTION CAPACITY.

² "Final LOS" is defined as projected future conditions including project, ambient, and related project growth, but without project traffic mitigation.

Exhibit L.2-1
LEVEL OF SERVICE (LOS) DEFINITIONS FOR ARTERIAL STREET SEGMENTS

| LOS | Volume to capacity (V/C) Ratio | Definition |
|------------|---------------------------------------|--|
| A | 0.000 - 0.600 | EXCELLENT. Primarily free-flow conditions at about 90 percent of free-flow speed. Vehicles are completely free to maneuver within the traffic stream. Stopped delay at signalized intersections is minimal. |
| B | 0.601 - 0.700 | VERY GOOD. Reasonably unimpeded flow at about 70 percent of free-flow speed. Ability to maneuver is only slightly restricted and delay at intersections is not bothersome. |
| C | 0.701 - 0.800 | GOOD. Stable operations at about 50 percent of free-flow speed. Ability to maneuver and change lanes may be restricted at mid-block locations. Motorists will begin to experience appreciable tension while driving. |
| D | 0.801 - 0.900 | FAIR. Small increases in flow begin to cause substantial increases in intersection approach delay. Ability to maneuver becomes more difficult, with speeds about 40 percent of free-flow speed. |
| E | 0.901 - 1.000 | POOR. Characterized by significant delays at intersection approaches and travel speeds about one-third of free-flow speed or less. Ability to maneuver is severely restricted and driver tension is high. |
| F | > 1.000 | FAILURE. Extremely low travel speeds and unstable traffic flow. Characterized by long delays at intersection approaches, severe difficulty in maneuvering between lanes, and extremely high driver tension. |

Source: Adapted from Transportation Research Board (TRB), Highway Capacity Manual, Special Report 209, Third Edition, 1994.

L.3 FREEWAY CAPACITY

1. INITIAL STUDY SCREENING PROCESS

A. Initial Study Checklist Questions

- XV.a): Would the project cause an increase in traffic which is substantial in relation to the existing traffic load and capacity of the street system (i.e., result in a substantial increase in either the number of vehicle trips, the volume to capacity ratio on roads, or congestion at intersections)?
- XV.b): Would the project exceed, either individually or cumulatively, a level of service standard established by the county congestion management agency for designated roads or highways?

B. Introduction

This issue involves the ability of a freeway segment or a freeway on- or off-ramp to accommodate increased vehicular traffic demands associated with a proposed project. The impact typically results from the addition of new traffic generated by a project. The impact is measured in terms of the project's effect on freeway operating conditions expressed as level of service (LOS) and demand to capacity (D/C) ratio. On- and off-ramps, similar to street segments, are evaluated in terms of volume to capacity (V/C) ratios and LOS.

Freeway capacity impacts can be evaluated for both short-range development projects and long-range projects for which details, such as site access points, are not yet known. Freeway capacity impacts are typically evaluated for permanent traffic increases after project completion, but can also be evaluated for temporary traffic increases generated during project construction. The future year to be analyzed should be consistent with that analyzed in the intersection capacity or street segment capacity analysis.

The California Department of Transportation (Caltrans) is responsible for the construction and operation of state highways and interstate freeways. Traffic congestion is monitored regionally by the County Transportation Commissions (Los Angeles County Metropolitan Transportation Authority (Metro)), according to state requirements.

C. Screening Criteria

- Would the proposed project add 150 or more one-way vehicle trips to a Congestion Management Program (CMP) mainline freeway monitoring segment during either the a.m. or p.m. peak hours?
- Would the proposed project add 50 or more a.m. or p.m. peak hour trips to a freeway on- or off-ramp?

A "yes" response to any of the preceding questions indicates that further study in an expanded Initial Study, Negative Declaration, Mitigated Negative Declaration, or EIR may be required. Refer to the Significance Threshold for Freeway Capacity and review the associated Methodology to Determine Significance, as appropriate.

A "no" response to all of the preceding questions indicates that there would normally be no significant impact on Freeway Capacity from the proposed project.

D. Evaluation of Screening Criteria

Estimate the number of trips to be generated by the proposed project using the trip generation and distribution methodologies in L.1. INTERSECTION CAPACITY and compare to the Screening Criteria.

2. DETERMINATION OF SIGNIFICANCE**A. Significance Threshold**

A project would normally have a significant freeway capacity impact if project traffic causes an increase in the D/C ratio on a freeway segment or freeway on- or off-ramp of 2 percent or more capacity (D/C increase ≥ 0.02), which causes or worsens LOS F conditions (D/C > 1.00).

B. Methodology to Determine Significance**Environmental Setting**

Describe the existing traffic conditions based on the appropriate study area, time periods, existing transportation facilities, traffic counts, and LOS.

Study Area and Time Periods to be Analyzed. Identify the geographic study area (i.e., freeway segments and on- or off-ramp(s) to be analyzed) based on project size, type, location, and existing levels of traffic.

For most projects, analyze existing traffic for both the a.m. and p.m. weekday peak hours. For some projects, other time periods, such as mid-day or weekend periods, may be required if those are expected to be the prime periods of trip generation (e.g., for a recreational project).

Existing Setting. Inventory existing traffic conditions, including the following:

- A description of the freeway system serving the study area (i.e., number of lanes, location of interchanges and ramps serving study area, etc.); and
- Existing peak hour traffic volumes on study freeway segments and on- and off-ramps.

Existing freeway traffic counts can be obtained from the most recent CMP or Caltrans. Traffic counts should not be older than two years.

Freeway Capacity Methodology. Quantify the existing peak hour D/C ratios and LOS at the study freeway segments by dividing peak hour directional traffic volumes by the directional freeway segment capacity (determined by multiplying the number of mainline freeway lanes with a per lane capacity value of 2,000 vehicles per hour) to calculate a D/C ratio, which is then used to determine LOS. Exhibit L.3-1 shows LOS definitions for freeway segments. This is the methodology described in the Congestion Management Program (CMP).

On- and Off-Ramp Methodology. Calculate V/C ratios and LOS for study on- and off-ramps.¹ Traffic counts may be obtained from Caltrans, Metro, Los Angeles Department of Transportation (LADOT), field counts, or other appropriate methods. Ramp capacity is a function of the number of lanes, their configuration, and road geometry. LOS definitions for on- and off-ramps are the same as arterial street segments (Exhibit L.2-1).²

¹ See *Transportation Research Board's (TRB) Highway Capacity Manual, Special Report 209. Third Edition, 1994*

² See L.2. *STREET SEGMENT CAPACITY*.

Project Impacts

Estimate the project trips to be added to freeway segments and on- and off-ramps using the trip generation and distribution methodologies in L.1. INTERSECTION CAPACITY, or L.2. STREET SEGMENT CAPACITY, as appropriate. Add to the future cumulative base levels and compare the resulting LOS and D/C ratio to the significance threshold to determine project impacts.

Cumulative Impacts

Follow the methodologies presented in L.1. INTERSECTION CAPACITY, or L.2. STREET SEGMENT CAPACITY, as appropriate. Future base traffic volumes may also be calculated by using the traffic growth factors provided in the most recent edition of the CMP, through consultation with Caltrans, or through subarea modeling.

Cumulative Plus Project Impacts

Add project traffic volumes at freeway segments and on- and off-ramps to the cumulative base levels. Compare the resulting LOS and D/C ratios to the Significance Threshold.

Sample Mitigation Measures

See L.1. INTERSECTION CAPACITY.

3. DATA, RESOURCES, AND REFERENCES

See L.1. INTERSECTION CAPACITY.

Exhibit L.3-1
LEVELS OF SERVICE (LOS) FOR FREEWAY SEGMENTS

| Level of Service (LOS) | Demand to Capacity (D/C) Ratio | Service Rating | Flow Conditions |
|-------------------------------|---------------------------------------|-----------------------|--|
| A | 0.00 – 0.35 | Good | Operating speed of 55+ mph. No delay. Highest quality of service. Free traffic flow, low volumes and densities. Little or no restriction on maneuverability or speed. |
| B | >0.35 – 0.54 | Good | Operating speed of 50 mph. Minimal delay. Stable traffic flow, speed becoming slightly restricted. Low restriction on maneuverability. |
| C | >0.54 – 0.77 | Adequate | Operating speed of 45 mph. Minimal delay. Stable traffic flow, but less freedom to select speed, change lanes, or pass. Density increasing. |
| D | >0.77 – 0.93 | Adequate | Operating speed of 40 mph. Minimal delay. Approaching unstable flow. Speed tolerable but subject to sudden and considerable variation. Less maneuverability and driver comfort. |
| E | >0.93 – 1.000 | Poor | Operating speed of 35 mph. Significant delays. Unstable traffic flow with rapidly fluctuating speeds and flow rates. Short headways, low maneuverability and low driver comfort. |
| F | >1.000 | Poor | Operating speed up to 20 mph. Considerable delays. Forced traffic flow. Speed and flow may drop to zero with high densities. |

Source: Adapted from CMP for Los Angeles County, LACMTA, 2004

L.4. NEIGHBORHOOD INTRUSION IMPACTS

1. INITIAL STUDY SCREENING PROCESS

A. Initial Study Checklist Question

- XV.a): Would the project cause an increase in traffic which is substantial in relation to the existing traffic load and capacity of the street system (i.e., result in a substantial increase in either the number of vehicle trips, the volume to capacity ratio on roads, or congestion at intersections)?

B. Introduction

This issue involves impacts of traffic generated by the project, and/or traffic diverted or shifted due to the project, on local streets in residential neighborhoods. Such impacts may result from increased traffic volumes on neighborhood streets or increased delays for vehicles exiting the neighborhood. Traffic conditions are typically expressed in terms of daily volume of traffic.

Evaluation of potential neighborhood intrusion impacts requires details regarding site access. Impacts are related to traffic volume, location of site access points in relation to neighborhood streets, traffic controls, and capacity of area streets. Neighborhood intrusion impacts are typically evaluated for permanent traffic increases after project completion, but can also be evaluated for temporary traffic increases during project construction. Analyze the same future year that is analyzed in the intersection capacity analysis. The Los Angeles Department of Transportation (LADOT) may require a Residential Neighborhood Traffic Management Program be prepared for certain projects. Contact LADOT for further information.

C. Screening Criteria

Would the proposed project:

- Generate more than 120 daily vehicle trips to a local residential street?

A "yes" response to the preceding question indicates that further study in an expanded Initial Study, Negative Declaration, Mitigated Negative Declaration, or EIR may be required. Refer to the

Significance Threshold for Neighborhood Intrusion Impacts, and review the associated Methodology to Determine Significance, as appropriate.

A "no" response to the preceding question indicates that there would normally be no significant impact on Neighborhood Intrusion from the proposed project.

D. Evaluation of Screening Criteria

The potential for neighborhood intrusion is generally based on preliminary trip generation and distribution and the location of project access points relative to local residential streets. Use the project traffic study or see L.1. INTERSECTION CAPACITY for trip generation and distribution methodologies and compare the results to the Screening Criteria. Identify the number of trips distributed to local neighborhood streets. Also, identify points at which project traffic could impact a local residential street located adjacent to, or across an arterial from, the project.

2. DETERMINATION OF SIGNIFICANCE

A. Significance Threshold

A project would normally have a significant neighborhood intrusion impact if project traffic increases the average daily traffic (ADT) volume on a local residential street in an amount equal to or greater than the following:

ADT increase $\geq 16\%$ if final ADT* $< 1,000$

ADT increase $\geq 12\%$ if final ADT* $\geq 1,000$ and $< 2,000$

ADT increase $\geq 10\%$ if final ADT* $\geq 2,000$ and $< 3,000$

ADT increase $\geq 8\%$ if final ADT* $\geq 3,000$

* "Final ADT" is defined as total projected future daily volume including project, ambient, and related project growth.

The significance of neighborhood intrusion impacts related to vehicle delay shall be determined on a case-by-case basis.

B. Methodology to Determine Significance

Environmental Setting

Describe existing traffic conditions based on the appropriate study area, time periods, existing transportation facilities, traffic counts and level of service (LOS), as detailed below.

Study Area and Time Periods to be Analyzed. Determine the residential street segments to be analyzed, based upon consideration of the potential trip generation of the project, the location of project access points, and the residential streets which are most likely to be affected. Residential neighborhood intrusion impacts are measured in terms of daily traffic volumes.

Existing Setting. Describe existing traffic conditions, including the existing residential streets to be included in the study (i.e., number of lanes, traffic control devices, on-street parking, etc.) and existing daily traffic volumes on the analyzed residential streets. Traffic counts should not be older than two years.

Project Impacts

Use the project traffic study or use the methodology in L.1. INTERSECTION CAPACITY to estimate the daily trip generation and distribute it on the street system to forecast the amount of project traffic which may travel along the analyzed residential streets. Determine the project impact by comparing the projected cumulative base and cumulative plus project ADT volumes for the analyzed residential streets and comparing the result to the Significance Threshold

Cumulative Impacts

Develop cumulative base daily traffic forecasts for the analyzed residential streets, considering both the proposed project and related projects, using the methodology in L.1. INTERSECTION CAPACITY. Determine the resulting impact.

Sample Mitigation Measures

Similar to intersection capacity impacts, potential mitigation measures for neighborhood intrusion impacts can include Transportation Demand Management (TDM) measures to reduce overall traffic levels, transportation system management (TSM) measures or physical improvements on arterial streets to encourage travel on non-residential streets (as listed in L.1. INTERSECTION CAPACITY). In addition, neighborhood traffic control measures can be implemented as mitigation measures to discourage travel on local residential streets. Specific mitigation measures are generally determined through consultation with LADOT, the appropriate City Council office, and the community. Neighborhood traffic control measures include:

- Speed humps;

- Signalized mid-block pedestrian crosswalks;
- Traffic signal timing modifications;
- Additional stop signs;
- Speed limit reductions;
- Diverters or semi-diverters;
- Cul-de-sac or street closure;
- Chokers or narrowing of street widths; and
- Turn restrictions.

In addition, LADOT may require a Residential Neighborhood Traffic Management Program be prepared. Contact LADOT for further information.

3. DATA, RESOURCES, AND REFERENCES

American Society of Civil Engineers , **Residential Streets Task Force**, Stanford P. LaHue, Sr., chmn., Residential Streets, Second Edition, 1990.

Institute of Transportation Engineers (ITE), Residential Street Design and Traffic Control, 2001.

See also L.1. INTERSECTION CAPACITY.

L.5. PROJECT ACCESS

1. INITIAL STUDY SCREENING PROCESS

A. Initial Study Checklist Questions

- XV.d): Would the project increase hazards due to a design feature (e.g. sharp curves or dangerous intersections) or incompatible uses (e.g. farm equipment)?
- XV.e): Would the project result in inadequate emergency access?
- XV.g): Would the project conflict with adopted policies, plans or programs supporting alternative transportation (e.g., bus turnouts, bicycle racks)?

B. Introduction

Project access impacts relate to the provision of access to and from the project site, and may include safety, operational, or capacity impacts. Impacts can be related to vehicular/vehicular, vehicular/bicycle or vehicle/pedestrian conflicts as well as to operational delays caused by slowing and/or queuing to access a project site. These conflicts may be created by the driveway configuration or through the placement of project driveways in areas of inadequate visibility, adjacent to bicycle or pedestrian facilities, or too close to busy or congested intersections. Evaluation of project access impacts requires details regarding land use, size, design, location of access points, etc. These impacts are typically evaluated for permanent conditions after project completion, but can also be evaluated for temporary conditions during project construction. See K.2 FIRE PROTECTION AND EMERGENCY MEDICAL SERVICES for impacts related to emergency vehicles.

Project access can be analyzed in qualitative and/or quantitative terms, in conjunction with a review of internal site circulation and access to parking areas. In addition, peak hour LOS may be quantified for primary site access points, as necessary, using the procedures discussed previously in L.1. INTERSECTION CAPACITY.

C. Screening Criteria

- Would the proposed project generate 500 or more daily trips or 43 or more vehicle trips during either the a.m. or p.m. peak hours?

If yes, would any of the following occur:

- Is a project driveway proposed on a major or secondary highway within 150 feet of an intersection with another major or secondary highway?
- Would a project driveway intersect an on-street bicycle lane or cross a sidewalk in an area of high pedestrian activity?
- Can it be readily perceived that there are access risks or deficiencies associated with the adjoining street system due to curves, slopes, walls or other barriers to adequate lines of sight?

A "yes" response to the first question and one of the other three questions indicates that further study in an expanded Initial Study, Negative Declaration, Mitigated Negative Declaration, or EIR may be required. Refer to the Significance Threshold for Project Access, and review the associated Methodology to Determine Significance, as appropriate.

A "no" response to the first question and all of the following questions indicates that there would normally be no significant Project Access impacts from the proposed project.

D. Evaluation of Screening Criteria

Identify the estimated number of daily and peak hour trips the project would generate using the project traffic study or the methodology in L.1. INTERSECTION CAPACITY. Review project site plans and the existing transportation facilities (including bicycle and pedestrian facilities) surrounding the project site. Roadway classifications are noted in the Transportation Element, or consult with Los Angeles Department of Transportation (LADOT). LADOT can also advise regarding access risks or deficiencies that may contribute to unsafe conditions. For projects in areas of potentially high pedestrian activity, consider performing a pedestrian capacity or LOS analysis. Compare the results to the Screening Criteria.

2. DETERMINATION OF SIGNIFICANCE

A. Significance Threshold

Project Access (operational)

A project would normally have a significant project access impact if the intersection(s) nearest the primary site access is/are projected to operate at LOS E or F during the a.m. or p.m. peak hour, under cumulative plus project conditions.

Bicycle, Pedestrian and Vehicular Safety

The determination of significance shall be on a case-by-case basis, considering the following factors:

- The amount of pedestrian activity at project access points.
- Design features/physical configurations that affect the visibility of pedestrians and bicyclists to drivers entering and exiting the site, and the visibility of cars to pedestrians and bicyclists.
- The type of bicycle facility the project driveway(s) crosses and the level of utilization.
- The physical conditions of the site and surrounding area, such as curves, slopes, walls, landscaping or other barriers, that could result in vehicle/pedestrian, vehicle/ bicycle or vehicle/vehicle impacts.

B. Methodology to Determine Significance**Environmental Setting**

Determine the existing LOS at the intersections nearest the project site (see the traffic study or L.1. INTERSECTION CAPACITY, as appropriate). Describe existing traffic facilities and conditions, including bicycle lanes and/or paths and sidewalks with regular pedestrian activity. Note the distance between site access points and arterial intersections and other conditions (such as curves or grade changes) that may affect traffic safety.

Project Impacts

To identify operational access impacts, use the methodology described in L.1. INTERSECTION CAPACITY and calculate the cumulative plus project volume to capacity (V/C) ratio at the intersection(s) nearest the project access by estimating project-generated trips and adding to the cumulative base projections. Determine the corresponding LOS for the a.m. and p.m. peak hours and compare to the significance threshold.

For vehicle/vehicle and bicycle and pedestrian safety impacts, review all project access points, internal circulation, and parking access from an operational and safety perspective (for example, turning radii, driveway queuing, line of sight for turns into and out of project

driveway(s)). Where project driveways would cross pedestrian facilities or bicycle facilities (bike lanes or bike paths), consider operational and safety issues related to the potential for vehicular/pedestrian and vehicular/bicycle conflicts and the severity of consequences that could result. In areas with high levels of pedestrian or bicycle activity, the collection of pedestrian or bicycle count data may be required.

Cumulative Impacts

Review the related projects or growth assumptions for projects that could impact the same street segments or intersections as the proposed project. For qualitative assessments, review project site access plans for projects that would impact the same primary intersections, bicycle routes or pedestrian facilities as the proposed project. Determine the combined impact and the project's contribution.

Sample Mitigation Measures

Potential mitigation measures include the following:

- Installation of a traffic signal or stop signs or electronic warning devices at site access points;
- Redesign and/or relocation of project access points;
- Redesign of the internal (on-site) circulation system;
- Installation of stop-signs and pavement markings internal to the site; and
- Restrict or prohibit turns at site access points.

3. DATA, RESOURCES, AND REFERENCES

Institute of Transportation Engineers (ITE), Guidelines For Driveway Location & Design, 1987.

See also L.1. INTERSECTION CAPACITY.

L.6. TRANSIT SYSTEM CAPACITY

1. INITIAL STUDY SCREENING PROCESS

A. Initial Study Checklist Question

VI.h): Would the proposal result in a substantial impact upon existing transportation systems?

B. Introduction

This issue involves the potential impacts of the proposed project on the existing transit system ridership and capacity from the increased demand by project residents, employees, patrons, etc. Where project details are known, impacts are evaluated on specific transit lines. Where specific development sizes and land use are not known, analyses can be at a more generalized level for the project area. Transit system capacity impacts are typically evaluated for permanent impacts after project completion.

C. Screening Criteria

- Will an Environmental Impact Report (EIR) be prepared for the proposed project to evaluate potential transportation impacts?

A "yes" response to the preceding question indicates that further study of this issue may be required. Refer to the Significance Threshold for Transit System Capacity, and review the associated Methodology to Determine Significance, as appropriate.

A "no" response to the preceding question indicates that no further review of Transit System Capacity would normally be required.

D. Evaluation of Screening Criteria

Review the description of the proposed project and the CEQA determination for other transportation impacts. Compare this information to the Screening Criteria.

2. DETERMINATION OF SIGNIFICANCE

A. Significance Threshold

The determination of significance shall be made on a case-by-case basis, considering the projected number of additional transit passengers expected with implementation of the proposed project and available transit capacity.

B. Methodology to Determine Significance

Environmental Setting

Describe the public transit system serving the study area, including both existing and planned bus, rail, and paratransit systems. Include all local fixed route transit services within a ¼ mile radius of the proposed project site, and express bus routes and passenger rail services within a two mile radius of the project site.

Project Impacts

Use the traffic study to identify the estimated number of daily and peak hour trips to be generated by the proposed project and the mode split analysis to determine the number of transit trips expected. If this has not been done, use the methodology in the trip generation section of L.1. INTERSECTION CAPACITY, or the most recent Congestion Management Program (CMP).

Identify the expected impacts; consult with the affected transit operators as needed. The transit operator (Los Angeles Department of Transportation (LADOT) or other) may request additional information in response to the Notice of Preparation (NOP). Note any design or program elements of the project, if any, that will encourage public transit use, including the applicable requirements of the City's Transportation Demand Management (TDM) Ordinance and any project-specific measures that will enhance capacity or support transit use (i.e., employee shuttles, van pools).

Cumulative Impacts

Identify the related projects which would use any of the same systems or transit lines as the proposed project. Assess the combined impact of the proposed and related projects and the project's proportional contribution to the cumulative demand using the methodology described above for Project Impacts.

Sample Mitigation Measures

Mitigation measures for transit impacts could occur at either the project or transit operator level. The following are some options to consider; all would require coordination with the transit operator and/or LADOT.

Measures Implemented by Project:

- Install bus stop shelters, benches, or other amenities;
- Provide new private transit service (e.g., employee shuttles, private commuter express services);
- Contribute facilities, equipment, or funds to increase the capacity of existing transit systems, add stations, upgrade traffic signals to allow for Transit Priority Systems, or expedite transit flow; and
- Provide concrete bus pads at bus stops.

Measures Implemented by Transit Operator:

- Minor re-routing of public transit line;
- Increased frequency of public transit service; and
- Provide new public transit service.

3. DATA, RESOURCES, AND REFERENCES

See L.1. INTERSECTION CAPACITY.

L.7. PARKING

1. INITIAL STUDY CHECKLIST PROCESS

A. Initial Study Checklist Question

XV.f): Would the project result in inadequate parking?

B. Introduction

Parking impacts can result from the provision of an insufficient parking supply to serve a project. Such impacts can be manifested by spillover of project parking demands to nearby on-street or off-street parking facilities. Concerns often arise if project parking demands intrude into nearby residential neighborhoods.

Parking impacts are analyzed for projects when details regarding land use, size, proposed parking supply and internal layout, etc., are known. Parking impacts are typically evaluated for permanent conditions after project completion. To evaluate temporary conditions during project construction, see L.8 IN-STREET CONSTRUCTION IMPACTS.

C. Screening Criteria

- Would the project's proposed parking supply be less than that required by City code, including Los Angeles Municipal Code (LAMC), Transportation Specific Plan (TSP) or Interim Control Ordinance (ICO) requirements, prior to applying for a variance, exemption, or amendment, if any apply to the project?
- If the project is located within the coastal zone (generally, 1000 yards inland of the mean high tide line), would the project's proposed parking supply be less than that required by California Coastal Commission requirements?

A "yes" response to any of the preceding questions indicates that further study in an expanded Initial Study, Negative Declaration, Mitigated Negative Declaration, or EIR may be required. Refer to the Significance Threshold for Parking, and review the associated Methodology to Determine Significance, as appropriate.

A "no" response to all of the preceding questions indicates that there would normally be no significant Parking impacts from the proposed project.

D. Evaluation of Screening Criteria

Review the description of the proposed project. Apply the appropriate City parking requirements (including LAMC, TSP, ICO, Specific Plan (SP) or Transit Oriented District (TOD) requirements, if any) to the proposed project land uses to determine the required amount of parking. Determine California Coastal Commission requirements if the project is located within the coastal zone. Compare these amounts to the proposed parking supply and review the Screening Criteria.

2. DETERMINATION OF SIGNIFICANCE

A. Significance Threshold

A project would normally have a significant impact on parking if the project provides less parking than needed as determined through an analysis of demand from the project.

B. Methodology to Determine Significance

Environmental Setting

Describe the existing parking supply in the vicinity of the proposed project, including both on-street and off-street parking. Also note any existing parking on the project site. Include a summary of current parking utilization within ¼ mile of the project site if the project proposes using other off-street or on-street parking spaces to meet the code requirements.

Project Impact

Demand Analysis. There are several factors which can affect the actual parking demand for a project. Depending upon individual project characteristics, one or more of the following specialized demand analyses could be performed:

- Transit Mode Split Discount - City parking requirements can be adjusted downward to reflect prevailing or projected transit ridership, to account for an existing or proposed transit/rail station in proximity to the project or if the project is located in an area with a high level of transit service. The LAMC

indicates that a reduction of up to 40 percent in parking requirements can be assumed for a project located at a rail station. (Also, see mode split discussion in trip generation section of L.1. INTERSECTION CAPACITY for relevant details.)

- Effect of Captive Market - The proximity of several land use types in a mixed-use development creates a potential for a captive market. Closeness facilitates walking between activities rather than using a vehicle, potentially reducing parking demands. The following sources are available to assist in estimating captive market reductions:
 - National Cooperative Highway Research Program (NCHRP) Report 323 - Travel Characteristics at Large-Scale Suburban Activity Centers;
 - Trip Generation; and
 - Urban Land Institute's (ULI) Shared Parking.
- Shared Parking - There is also a potential for shared use of parking spaces in mixed use or other projects. The shared use concept considers the fact that the peak parking demand does not occur simultaneously for the various land use elements. The shared parking model incorporates standardized hourly accumulation factors by land use types which represent the percentage of peak parking demand generated during each hour of the day. Use the methodology presented in the publication Shared Parking. The shared parking concept can also account for seasonal variations, using factors contained in Shared Parking.
- Parking Demand Rates - If, due to unique land uses or characteristics of the project (e.g., mixed use, senior housing), the City parking requirements are not considered appropriate for a project, other sources could be used to determine the peak parking demands for the project, including:
 - Shared Parking;
 - Institute of Transportation Engineers' (ITE) Parking Generation;

- Parking demand rates empirically derived from parking utilization/duration surveys conducted at similar facilities in similar areas; and
- Explicit derivation of parking demand based upon estimation of person trip generation and mode split.

Compare parking demand from one of the above methods to the proposed parking supply.

Cumulative Impacts

Identify the related projects which would utilize the same on-street or off-street parking facilities as the proposed project. Consider any deficiencies in the proposed parking supply. Evaluate the combined impact of the related and proposed projects.

Sample Mitigation Measures

Potential mitigation measures include the following:

- Develop and implement an aggressive transportation demand management (TDM) plan. TDM measures, which result in fewer vehicles traveling to and from a project, such as increased ridesharing and increased transit use, also reduce parking needs (see L.1. INTERSECTION CAPACITY for further discussion of TDM measures);
- Modify the project to provide additional on-site parking;
- Enter into agreements with owners of nearby parking facilities to use their facilities as project parking; and
- Provide employee parking at a remote off-site location connected to the project site with a shuttle bus service.

3. DATA, RESOURCES, AND REFERENCES

Planning and Zoning Code, (Chapter 1 of the LAMC), Parking requirements, ICOs, TSPs, Local Coastal Plans. Available from the City Planning Department's Central Publications Unit at 200 N. Spring Street, Los Angeles, California 90012; Telephone: (213) 978-1255.

ITE, Manual of Traffic Engineering Studies, 2001.

ITE, Parking Generation, 3rd Edition, 2004.

ULI and the National Parking Association, The Dimensions of Parking, Fourth Edition, 2000.

See also L.1. INTERSECTION CAPACITY.

L.8. IN-STREET CONSTRUCTION IMPACTS

1. INITIAL STUDY SCREENING PROCESS

A. Initial Study Checklist Questions

- XV.a): Would the project cause an increase in traffic which is substantial in relation to the existing traffic load and capacity of the street system (i.e., result in a substantial increase in either the number of vehicle trips, the volume to capacity ratio on roads, or congestion at intersections)?
- XV.e): Would the project result in inadequate emergency access?

B. Introduction

This impact category addresses major in-street construction activity of an extended duration that is not exempt from the CEQA process.¹ This category also includes impacts associated with projects requiring major construction activity within a street right-of-way (ROW), such as temporary loss of access to adjacent parcels, temporary loss of bus stops, and temporary loss of on-street parking. (Off-street parking is addressed in L.7. PARKING.) Impacts associated with in-street construction activity are evaluated when details, such as the location, duration, and type of construction activity within the street ROW, are known. Given that these impacts are temporary and generally occur early in the project construction phase, the analyses are based on existing or near-term conditions. The Los Angeles Department of Transportation (LADOT) may require a traffic control plan whether or not project impacts are deemed to be significant. See K.2. FIRE PROTECTION AND EMERGENCY MEDICAL SERVICES for impacts related to emergency vehicles.

C. Screening Criteria

- Would a project not exempted in Article VII of the City CEQA Guidelines require construction activities to take place within a major or secondary highway ROW which would necessitate temporary lane, alley, or street closures for more than one day (including day and evening hours, and including overnight closures if on a residential street)?

- Would a non-exempt project require construction activities to take place within a collector or local street ROW which would necessitate temporary lane, alley, or street closures for more than seven days (including day and evening hours, and including overnight closures if on a residential street)?
- Would in-street construction activities result in the loss of regular vehicular or pedestrian access to an existing land use for more than one day, including day and evening hours and overnight closures if access is lost to residential units?
- Would in-street construction activities result in the temporary loss for more than one day of an existing bus stop or rerouting of a bus route that serves the project site?

A "yes" response to any of the preceding questions indicates that further study in an expanded Initial Study, Negative Declaration, Mitigated Negative Declaration, or EIR may be required. Refer to the Significance Threshold for In-Street Construction Impacts, and review the associated Methodology to Determine Significance, as appropriate.

A "no" response to all of the preceding questions indicates that there would normally be no significant impact from In-Street Construction of the proposed project.

D. Evaluation of Screening Criteria

Review project construction plans to determine whether construction activities would result in street closures, blocked access or the loss or rerouting of transit stops. Determine the classification of street affected based upon width and average daily traffic, or contact LADOT for assistance. Identify bus stops and bus routes that serve the project construction area. Compare this information to the Screening Criteria.

2. DETERMINATION OF SIGNIFICANCE

A. Significance Threshold

The determination of significance shall be made on a case-by-case basis, considering the following factors:

¹ See *City of Los Angeles CEQA Guidelines, Article VII, Categorical Exemptions*.

Temporary Traffic Impacts:

- The length of time of temporary street closures or closures of two or more traffic lanes;
- The classification of the street (major arterial, state highway) affected;
- The existing traffic levels and level of service (LOS) on the affected street segments and intersections;
- Whether the affected street directly leads to a freeway on- or off-ramp or other state highway;
- Potential safety issues involved with street or lane closures; and
- The presence of emergency services (fire, hospital, etc.) located nearby that regularly use the affected street.

Temporary Loss of Access:

- The length of time of any loss of vehicular or pedestrian access to a parcel fronting the construction area;
- The availability of alternative vehicular or pedestrian access within ¼ mile of the lost access; and
- The type of land uses affected, and related safety, convenience, and/or economic issues.

Temporary Loss of Bus Stops or Rerouting of Bus Lines:

- The length of time that an existing bus stop would be unavailable or that existing service would be interrupted;
- The availability of a nearby location (within ¼ mile) to which the bus stop or route can be temporarily relocated;

- The existence of other bus stops or routes with similar routes/destinations within a ¼ mile radius of the affected stops or routes; and
- Whether the interruption would occur on a weekday, weekend or holiday, and whether the existing bus route typically provides service that/those day(s).

Temporary Loss of On-Street Parking:

- The current utilization of existing on-street parking;
- The availability of alternative parking locations or public transit options (e.g. bus, train) within ¼ mile of the project site; and
- The length of time that existing parking spaces would be unavailable.

B. Methodology to Determine Significance

Environmental Setting

Describe the physical setting, including the classification of adjacent streets, on-street parking conditions in the immediate vicinity of the construction project, a description of the land uses affected by construction, and an inventory of existing bus stops and transit lines within a ¼ mile radius of the construction site. See L.1. INTERSECTION CAPACITY if construction impacts on intersection operating conditions are to be evaluated. See L.2. STREET SEGMENT CAPACITY if construction impacts on street segment operating conditions are to be evaluated.

Project Impacts

Review proposed construction procedures/plans to determine whether construction activity within the street ROW would require any of the following:

- Street or lane closures;
- Block existing vehicle or pedestrian access to parcels fronting the street;
- Closure or movement of an existing bus stop or rerouting an existing bus line;

- Removal of existing, heavily used, on-street parking spaces; or
- Creation of traffic hazards.

Compare the results to the significance factors to determine the level of impact. Consider safety and economic concerns, existing traffic levels, as well as congestion impacts.

Intersection and/or street segment capacity analyses may be used to determine whether street construction would result in significant impacts on the LOS. Project impacts would be determined by comparing the intersection or street segment LOS for pre-construction and construction conditions, which could incorporate expected traffic shifts.

Cumulative Impacts

Review the related projects list for those proposals with concurrent construction schedules. Identify those projects that would impact the same streets, bus stops, bus routes, parking spaces and/or access points. Determine the impact of the related projects in combination with that of the proposed project.

Sample Mitigation Measures

Potential mitigation measures include the following:

- Traffic management plan;
- Detour plan;
- Modification of construction procedures (e.g., cut-and-cover techniques rather than open cut techniques);
- Limit major road traffic obstructions to off-peak hours;
- Coordinate with emergency service and public transit provider agencies;
- Provide alternative vehicular and/or pedestrian access to affected parcels;
- Coordinate access with adjacent property owners and tenants;

- Provide advance notification of temporary bus stop loss and/or bus line relocation;
- Provide and sign temporary bus stops within a reasonable walking distance of closed bus stops;
- Identify temporary alternative bus route(s), and provide and sign bus stops along that route;
- Provide advance notice of temporary parking loss; and
- Identify temporary parking replacement or alternative adjacent parking within a reasonable walking distance.

3. DATA, RESOURCES, AND REFERENCES

Public Works Standards Inc., Work Area Traffic Control Handbook, Ninth Edition, 2003

California Department of Transportation (Caltrans), State of California Manual of Traffic Controls for Construction and Maintenance Work Zones, 1990.

Federal Highway Administration (FHWA), Manual on Uniform Traffic Control Devices (MUTCD), Revision 1, 2003.

FHWA, National Highway Institute, Design and Operation of Work Zone Traffic Control, Participant Notebook, 1987.

See also L.1. INTERSECTION CAPACITY.

M. PUBLIC UTILITIES

M.1. WATER

1. INITIAL STUDY SCREENING PROCESS

A. Initial Study Checklist Questions

- XVI.b): Would the project require or result in the construction of new water or wastewater treatment facilities or expansion of existing facilities, the construction of which could cause significant environmental effects?
- XVI.d): Would the project have sufficient water supplies available to serve the project from existing entitlements and resources, or are new or expanded entitlements needed?

B. Introduction

Potable water is provided in the City by the Los Angeles Department of Water and Power (LADWP). The City receives a significant portion of its supply from the Metropolitan Water District of Southern California (MWD). Additional information on the City's water supply and distribution infrastructure is provided in 3. Data, Resources, and References.

The quantity of water consumed by a project is determined by several factors, including the size, type and characteristics of a project. The need for construction of new or replacement water facilities (e.g., reservoirs, storage tanks, water mains, filtration plants, pumps, wells, and other connections or distribution facilities) would depend on the existing capacity and anticipated demand for the project area.

The Federal government has mandated low-flush toilets via the Energy/Policy act of 1992. The City of Los Angeles Ordinance Nos. 163,532 and 164,093, adopted in 1988, require new buildings to utilize low-flush toilets and urinals (1.5 gallons per flush) in order to obtain building permits. In addition, Title 20 of the California Administrative Code (CAC) Section 1604 establishes efficiency standards (i.e., maximum flow rates) for all new showerheads, lavatory faucets, and sink faucets and prohibits the sale of fixtures that do not comply with the regulations. City Ordinance No. 163,532 also contains provisions requiring xeriphytic (low-water consumption) landscaping.

Under Senate Bill 901, (Public Resources Code (PRC) and California Water Code (CWC) 10910), effective January 1, 1996, when a lead agency prepares a notice of preparation (NOP) for an

EIR for projects of a certain size, the water agency must assess whether the water demand anticipated for the project is covered by the water agency's master water management plan. If the water agency concludes that supplies are insufficient, it must provide the lead agency with: its plans for additional water supplies, including estimated total costs and financing methods associated with acquiring additional water supplies; all federal, state, and local permits, approvals, or other entitlements necessary to acquire or develop the additional water supplies; and estimated timeframes for acquiring the additional water supplies. This information is then incorporated into the project's environmental documentation.

LADWP updates its Urban Water Management Plan every five years to account for changing conditions. This Plan projects water supply and distribution needs based on anticipated growth in population, housing, and employment and identifies water supply strategies to meet this demand. LADWP currently expects to have adequate water supplies for all anticipated development in the City.

C. Screening Criteria

- Would implementation of the proposed project cause the Community Plan area to exceed the projected growth in population, housing, or employment for the year of project occupancy/buildout?
- Would the project's water consumption require the construction of additional off-site water infrastructure?

A "yes" response to any of the preceding questions indicates further study in an expanded Initial Study, Negative Declaration, Mitigated Negative Declaration or EIR may be required. Refer to the Significance Threshold for Water, and review the associated Methodology to Determine Significance, as appropriate.

A "no" response to all of the preceding questions indicates that there would normally be no significant impact on Water from the proposed project.

D. Evaluation of Screening Criteria

Review the description of the proposed project, project site, and adjacent or surrounding area, including water infrastructure serving the area. Determine whether new off-site water infrastructure would be required to meet project needs. Consult with LADWP as necessary. Infrastructure could include water mains, storage tanks, reservoirs, filtration plants, pumps, wells, and other connections

or distribution facilities. Based on the project land use types, determine the population, housing units, and employment to be generated by the project. Add this to existing levels and compare to the totals projected in the Community Plan for the year of project occupancy. Consult with the City Planning Department as needed. Compare this information to the Screening Criteria.

2. DETERMINATION OF SIGNIFICANCE

A. Significance Threshold

The determination of significance shall be made on a case-by-case basis, considering the following factors:

- The total estimated water demand for the project;
- Whether sufficient capacity exists in the water infrastructure that would serve the project, taking into account the anticipated conditions at project buildout;
- The amount by which the project would cause the projected growth in population, housing or employment for the Community Plan area to be exceeded in the year of the project completion; and
- The degree to which scheduled water infrastructure improvements or project design features would reduce or offset service impacts.

B. Methodology to Determine Significance

Environmental Setting

In a description of the environmental setting, include the following information:

- Description of major water infrastructure serving the project site, including the type of facilities, location and sizes, and any planned improvements;
- Description of the water conditions for the project area and known improvement plans; and

- The existing population, housing, and employment for the Community Plan area in which the project site is located.

Project Impacts

Review the project description and the information from the Environmental Setting and Evaluation of Screening Criteria. Determine what improvements would be needed, if any, to adequately serve the project. Describe the degree to which presently scheduled off-site improvements offset impacts. As necessary, consult with LADWP or the latest Urban Water Management Plan.

Consider the water conditions for the project area, known improvement plans, and the project's water demand. The project's water demand can be calculated on the basis of estimated population and per capita demands (for residential land uses), unit demand factors by acre (for residential and non-residential land uses), or from a direct analysis of facilities and fixtures (for non-residential land uses). For planning purposes, LADWP generally forecasts demand based upon population trends and average per capita factors. LADWP does not maintain any standard unit demand factors for specific types of land uses. Residential demands can be approximated based upon LADWP per capita data. The average FY 2001-2002 residential water demand was estimated at 101 gallons per capita per day (gpcd), derived by dividing total residential water use by total estimated population within LADWP's service area.¹ This is based upon the combined Citywide mix of multiple family and single family dwelling units. In general, demand from single-family units tends to be higher, primarily because of a higher rate of outside water use for landscaping. Water demand from multi-family units tends to be lower than this average. MWD may also be consulted for typical water demand factors.

Any water conservation measures included in the proposed project, particularly those that are beyond requirements of present regulations, should be described and their impact on water use factored into the project demand, to the extent possible. These would include such measures as water reuse, drip irrigation systems, and/or computerized (moisture-sensitive) irrigation systems.

If not done under Evaluation of Screening Criteria, determine the change in population, housing units, and employment generated by the project. Compare these figures to the totals projected in the Community Plan for the year of project occupancy. Consult with the City

¹ LADWP, *Urban Water Management Plan, Fiscal Year 2001-2002 Update*.

Planning Department as needed. Determine the impact from growth which exceeds the projections.

Cumulative Impacts

Review the list of related projects. Identify those that would utilize the same water infrastructure. Using the methodology described above in Project Impacts, determine the combined effect of the related projects and the proposed project on water infrastructure and the growth in population, housing and employment projected in the Community Plan.

Sample Mitigation Measures

Potential mitigation measures include the following:

- Incorporate a recirculating hot water system to reduce waste in long piping systems where water must be run for considerable periods before hot water is received at the outlet. Use tankless water heaters;
- Retrofit other buildings within the City to offset the net water consumption induced by the proposed project;
- Use reclaimed water as a source for project irrigation systems;
- Set automatic irrigation systems to irrigate during early morning or evening hours to minimize water loss due to evaporation and reset to water less in cooler months and during rainfall season;
- Use drip irrigation and soak hoses in lieu of sprinklers to lower the amount of water lost to evaporation and overspray;
- Practice xeriscaping that exceeds City requirements;
- Recycle all water used in cooling systems to the maximum extent possible;
- If a fleet will be maintained, incorporate a water recycling system in on-site facilities for washing vehicles; and
- Perform regular preventive maintenance on all pumps, valves, and piping, in the project's water system to minimize water waste.

3. DATA, RESOURCES, AND REFERENCES

LADWP, Water Supply Division, Water Resources Unit, 111 North Hope Street, Los Angeles, California 90012; Telephone: (213) 367-2661. Current information on annual Citywide water consumption can be obtained from annual reports prepared by LADWP, or by contacting the Water Supply Division directly.

City of Los Angeles Landscape Ordinance (No. 170,978) establishes consistent landscape standards for projects, including water management, conservation and xeriscape.

The Urban Water Management Plan (UWMP) for the City of Los Angeles is prepared every five years and contains data regarding future water demand projections, water supply sources, and other water system planning information. (Available through LADWP.)

Fiscal Year 2001-2002 Annual UWMP update for questions call (213) 367-0800.

Environmental and Public Facilities Maps (1996):

- Potable Water Distribution System; and
- Potable Water Delivery System Service Areas.

Water Supply and Distribution Background Information

LADWP is responsible for supplying water within the City limits, and for ensuring that the delivered water quality meets applicable California health standards for drinking water. Total Citywide 2002 potable water demand was estimated at 670,099 acre feet (AF), and is projected to be about 749,900 AF by the year 2015.²

LADWP's water supply comes from these sources: local groundwater, reclaimed water, Owens Valley water, Colorado River Water, and California Aqueduct Water. Local groundwater is produced primarily from wells in the San Fernando Valley, and provides approximately 11 percent of the total supply during fiscal year 2001-2002. Two Owens Valley aqueducts owned by the City bring water from the eastern slopes of the High Sierras. Historically, the Owens Valley supplied a large majority of the City's water supply, but the amount of this source that the City can divert has been significantly reduced as a result of the settlement of environmental litigation. Most of the

² LADWP, *Urban Water Management Plan*, June 1995.

remainder of the water supply is purchased from MWD and delivered either from the Colorado River or from the Sacramento-San Joaquin Delta via the California Aqueduct.

LADWP has instituted significant water conservation measures that were particularly successful in reducing demands during drought. In 1995, reclaimed water supplied about 3,000-4,000 AF of water (about six percent of total demand), and the City expects to supply up to 12 percent (90,000 AF) of its total water demand with reclaimed water by the year 2015.

LADWP supplies water that meets or exceeds all health-related state and federal standards, accomplished in part in the following ways: (1) filtration of the Los Angeles Aqueduct supply at a state-of-the-art treatment plant; (2) control of access to water supply and storage areas; (3) control of algae growth and/or covering of reservoirs; (4) continuous disinfection of water entering mains; and (5) water quality testing, inspection, cross-control prevention, and older main replacement.

Water supply infrastructure includes water storage facilities, transmission and distribution pipelines, booster pumping stations, pressure reducing stations, and other related facilities. Water storage is essential for the conservation of water to supply daily peaks, meet high demand conditions, and provide for firefighting and emergencies. The City water system has 110 tanks and reservoirs ranging in size from 10 thousand to 60 billion gallons with a total capacity of 109 billion gallons. Water is distributed through a network of over 7,200 miles of water mains ranging from 4 inches to 120 inches in diameter. Because of the size and range in elevation (0 to 2,400 feet) the system has been divided into 102 pressure zones, with almost 90 booster pumping stations to provide water service at higher elevations.

Selected Legislation

State

California Administrative Code, Title 20, Section 1604 (efficiency standards)

Water Conservation in Landscaping Act, California Government Code, Division 1, Chapter 3, Article 10.8, Section 65591-65600. This Act calls for Department of Water Resources (DWR) to promote and prepare model ordinance. Provides for water efficient landscape ordinance to be adopted by local agencies.

M.2. WASTEWATER

1. INITIAL STUDY SCREENING PROCESS

A. Initial Study Checklist Question

- XVI.a): Would the project exceed wastewater treatment requirements of the applicable Regional Water Quality Control Board?
- XVI.b): Would the project require or result in the construction of new water or wastewater treatment facilities or expansion of existing facilities, the construction of which could cause significant environmental effects?
- XVI.c): Would the project require or result in the construction of new storm water drainage facilities or expansion of existing facilities, the construction of which could cause significant environmental effects?
- XVI.d): Would the project result in a determination by the wastewater treatment provider which serves or may serve the project that it has adequate capacity to serve the project's projected demand in addition to the provider's existing commitments?

B. Introduction

The City of Los Angeles operates wastewater treatment and reclamation facilities which serve most of its incorporated areas and several other cities and unincorporated areas in the Los Angeles basin and San Fernando Valley. The elements of the existing system are two treatment plants, two water reclamation plants, a collection system consisting of over 6,500 miles of local, trunk, mainline and major interceptor sewers, five major outfall sewers, and 46 pumping plants. (See Exhibit M.2-1).

Wastewater service and planning areas are determined by natural drainage patterns and do not generally conform to City boundaries. Cities that have contractual rights to discharge specific quantities of wastewater into the City's system are Beverly Hills, Burbank, Culver City, El Segundo, Glendale, San Fernando, Santa Monica, and Universal City. The City serves Marina Del Rey and the Naval Yard in San Pedro. In addition, County Sanitation Districts 4, 5, 9, 11, 16 and 27 serve parts or all of Hollywood, Inglewood, Windsor Hills, Baldwin Hills, Alhambra, Pasadena, and South Pasadena, which also have contractual rights to discharge specific quantities of wastewater into the City's system. The Los Angeles County Sanitation Districts serve the Harbor Gateway as well as several small "islands" north of Inglewood.

The sanitary sewer system serving the City of Los Angeles and its contract agencies is operated under the jurisdiction of the Department of Public Works. The Bureau of Sanitation provides advance planning and financial management, and maintains and operates the wastewater collection and treatment system. The Bureau of Engineering provides design and construction engineering. More detailed information on the City's wastewater collection and treatment system is included in 3. Data, Resources, and References.

Wastewater service requirements are related to the size and type of projects and geographic area served. New projects (e.g., residential, commercial, industrial) may increase wastewater generation and affect wastewater collection and treatment systems. The City's Wastewater Capital Improvement Program (CIP) includes planned improvements to the City's major sewers, pumping plants, and treatment/reclamation plants which are intended to provide capacity in the larger components for planned patterns of development. City Ordinance No. 166,060 (Sewer Allocation) limits the annual increase in wastewater flows discharged into the Hyperion Treatment System to 5 million gallons per day (mgd).

C. Screening Criteria

- Would the project produce wastewater flows greater than existing flows in an area shaded on Exhibits M.2-2 through M.2-11
- Would the project produce a new or increased average daily wastewater flow of 4,000 gallons per day (gpd) or more, regardless of location?
- Does the proposed project include a change in land use limitations (such as a zone change, variance or General Plan amendment), which could allow greater average daily flows than could be produced following the current land use limitations?

A "yes" response to any of the preceding questions indicates further study in an expanded Initial Study, Negative Declaration, Mitigated Negative Declaration, or EIR may be required. Refer to the Significance Threshold for Wastewater, and review the associated Methodology to Determine Significance, as appropriate.

A "no" response to all of the preceding questions indicates that there would normally be no significant Wastewater impact from the proposed project.

D. Evaluation of Screening Criteria

Review the description of the proposed project and project site and determine the wastewater generation that would be expected with full implementation of the project. If the proposed project would generate wastewater flows larger than existing flows, locate the project and appropriate point of connection to the wastewater collection system on the sewer capacity threshold study area maps, Exhibits M.2-2 through M.2-11, prepared by the Department of Public Works. If the project would change the land use limitations, compare the maximum average daily flows produced by the current land use and zoning designations with the amount that could be produced under the proposed project. The sewage generation factors contained in Exhibit M.2-12 may be used to calculate average daily wastewater flows for a variety of land uses. If needed, consult with the sewer permit counter staff (see 3. DATA, RESOURCES, AND REFERENCES).

Compare this information to the Screening Criteria.

2. DETERMINATION OF SIGNIFICANCE

A. Significance Threshold

A project would normally have a significant wastewater impact if:

- The project would cause a measurable increase in wastewater flows at a point where, and a time when, a sewer's capacity is already constrained or that would cause a sewer's capacity to become constrained; or
- The project's additional wastewater flows would substantially or incrementally exceed the future scheduled capacity of any one treatment plant by generating flows greater than those anticipated in the Wastewater Facilities Plan or General Plan and its elements.

B. Methodology to Determine Significance

Environmental Setting

In a description of the environmental setting, include the following information:

- Location of the proposed development and appropriate point of connection to the wastewater collection system on the pertinent Sewer Wye Map;

- Description of the existing wastewater system which would serve the project, including its capacity and current flows. Include plans for additions or expansions of the existing system, and the population projected for the planning subregion; and
- Summary of adopted wastewater-related plans and policies that are relevant to the project area.

Project Impacts

Using the information from the Evaluation of Screening Criteria and the description of the proposed project, project site and existing wastewater infrastructure; evaluate the project's wastewater system needs. Pertinent information includes the size, type of use, and location of the proposed project, the point of connection to the wastewater collection system, and the anticipated average daily wastewater flow, taking into consideration design or operational features that would reduce or offset service impacts. If applicable, compare the maximum average daily flows anticipated with the proposed project to the maximum flows that could be produced under the existing land use designation and zoning.

Compare the project's wastewater system needs to the appropriate sewer's capacity and/or the wastewater flows anticipated in the Wastewater Facilities Plan or General Plan (including specific plans, Community Plans, etc.). A sewer's capacity is considered constrained if the depth of flow is equal to or greater than three-quarters of the sewer's diameter; "measurable" means any change greater than ½ inch (0.013 meters). Consult with the Department of Public Works sewer permit counter staff, if necessary, to gauge the anticipated capacity and demand conditions at project buildout and/or to prepare a sewer availability assessment.

Wastewater flow in gpd may be calculated by applying wastewater generation flow factors (see Exhibit M.2-12) for each of the land uses/facility types for the project. The flows for all applicable land uses may then be added in order to obtain total projected wastewater flow.

Example:

To calculate the wastewater flow from a mixed-use development with 20 one-bedroom condominiums, 20 two-bedroom condominiums, and 4,000 gross square feet (gsf) of general commercial/retail, use the wastewater generation flow factors from Exhibit M.2-12 as follows:

Residential Uses:

| | | | |
|------------------------------|----------|---|-----------|
| One bedroom condos: 20 x 120 | gpd/unit | = | 2,400 gpd |
| Two bedroom condos: 20 x 160 | gpd/unit | = | 3,200 gpd |

Commercial Uses:

| | | | |
|---------|------------------------------|---|----------------|
| Retail: | 4,000 gsf x 80 gpd/1,000 gsf | = | <u>320 gpd</u> |
|---------|------------------------------|---|----------------|

TOTAL PROJECT: 5,920 gpd

Cumulative Impacts

Review the list of related projects. Identify those that would be served by the same wastewater facilities as the proposed project. In the same manner as for Project Impacts, evaluate the cumulative impact on wastewater infrastructure. To the extent known, consider design or operational features of the related projects that would reduce or offset service impacts typically expected. Identify any wastewater capital improvement projects that would reduce or offset the expected service impacts. Determine the combined effect of the proposed project and the related projects on the wastewater infrastructure.

Sample Mitigation Measures

Potential mitigation measures include the following:

- Retrofit other buildings with low-flow plumbing fixtures to offset wastewater generation associated with the project;
- Install a holding tank large enough to hold three times the project daily wastewater flow so that the tank would hold all project wastewater during peak wastewater flow periods for discharge into the wastewater collection system during off-peak periods;
- Include a grey water system to reuse wastewater from the project;
- Offset excess wastewater generation by restricting the wastewater generation of other land uses within the same service area (e.g., by dedicating open space); and

- Construct new wastewater treatment or conveyance infrastructure, or capacity enhancing alterations to existing systems.

3. DATA, RESOURCES, AND REFERENCES

For the most recent data and information regarding wastewater treatment and conveyance, contact the Bureau of Sanitation, Wastewater Engineering Services Division.

Wastewater Engineering Services Division
2714 Media Center
Los Angeles, CA 90065
Telephone: (323) 342-6256

Detailed information about the location, size and slope of existing sewers is available on line at <http://navigatela.lacity.org/> and at the Bureau of Engineering's public counters:

| | |
|---------------------------------|--|
| Central District..... | 201 North Figueroa Street, 3 rd Floor, Counter C
Los Angeles, California. 90012
Telephone: (213) 977-7030 |
| Valley District..... | 6262 Van Nuys Boulevard, Suite 251
Van Nuys, California 91401
Telephone: (818) 374-5090 |
| West Loas Angeles District..... | 1828 Sawtelle Blvd., 3 rd Floor
West Los Angeles, California 90025
Telephone: (310) 575-8384 |
| Harbor District..... | 638 South Beacon Street, Suite 402
San Pedro, California 90731
Telephone: (310) 732-4677 |

Information about the land uses anticipated in the general plan is available on line at <http://navigatela.lacity.org/> and at the City Planning Department's Community Planning Bureau public counters. See Chapter H for contact information.

Ordinance No. 166,060 (Sewer Allocation) limits the annual increase in the wastewater quantity discharged into the HTP system to five mgd. Bureau of Engineering Special Order No. SO06-0691 changed the design peak dry weather flow for sanitary sewers from three-quarter depth to one-half the sewer diameter to implement the City-adopted goal of no overflows or diversions

from the wastewater collection system. Since these two criteria impact the sewer capacity availability assessment and approval, they should be considered in the evaluation of project impacts. Engineering personnel at the sewer permit counters implement the ordinance.

City of Los Angeles, City Planning Department. General Plan Framework Element, 1996 readopted, August 8, 2001.

The current Wastewater Facilities Plan, which addresses the City's wastewater treatment and collection needs over a 2010 planning horizon, was adopted by the City Council on January 22, 1991. The Plan is currently being revised through an integrated resource planning effort to address demand and capacity through 2020 with new construction and expansion of facilities and operations; water reclamation; and conservation. (Integrated Plan for the Wastewater Program.)

Bureau of Engineering, Wastewater Program Management Division. Wastewater Capital Improvement Program Management Plan. Part D. General Procedural Memorandum No. 16. Sewer Availability Assessment for Proposed Developments.

Wastewater Facilities Background Information

Hyperion Treatment Plant

The Hyperion Treatment Plant (HTP) is located on a 144-acre (58.3 ha) site adjacent to Santa Monica Bay, southwest of the Los Angeles International (LAX) Airport. The drainage area served by the plant is approximately 328,000 acres (133,000 ha) of the greater metropolitan area. The largest wastewater treatment facility in the City, HTP provides full secondary treatment for an average dry weather flow of 413 mgd (1.56 million m³/d). Solids handling facilities are provided for 468 dry tons per day.

A small portion of the HTP's effluent is reused, principally for recharging barrier wells, but most of the effluent is discharged into Santa Monica Bay. The five-mile outfall consists of a 12-foot (3.66m) diameter reinforced concrete pipe, a wye structure, and two diffuser legs that discharge primary and secondary treated effluent at a depth of 187 feet (57 m). The city also maintains a one-mile outfall, which is a 12-foot (3.66m) diameter reinforced concrete pipeline terminating at a depth of 50 feet (15.2), in standby condition in case of emergency.

Raw sludge removed from the primary sedimentation system and excess waste activated sludge from the activated sludge system, are pumped into anaerobic sludge digesters for stabilization. The resulting biosolids are either reused in agriculture, or used by landfills as daily cover. No biosolids are discharged into the ocean.

The HTP receives sewage from five major interceptor sewer systems:

- **Central Outfall Sewer (COS)**, serving South Central Los Angeles, El Segundo, and portions of Culver City;
- **North Central Outfall Sewer-North Outfall Sewer (NCOS-NOS)**, serving the southern portions of the cities of Burbank and Glendale, eastern portions of the San Fernando Valley, sections of eastern, central, and south-central Los Angeles, and portions of Culver City;
- **North Outfall Sewer-La Cienega, San Fernando Valley Relief (NOS-LCSFVRS)**, serving the central, northeastern, and western areas of the San Fernando Valley, the western portion of the City, and Beverly Hills, Hollywood, and Playa Del Rey;
- **Coastal Interceptor Sewer System (CIS)**, serving Pacific Palisades, Venice, Mar Vista, the City of Santa Monica and adjacent areas of Los Angeles County; and
- **North Outfall Replacement Sewer (NORS)**, designed to take the pressure off of the North Outfall Sewer.

Within the HTP Service Area, the City operates and maintains pumping plants at those locations where, because of inadequate hydraulic head, sewage flow must be pumped in order to reach the approximate treatment facility. These pumping plants vary in size from capacities of about 30 to 100 gallons per minute (gpm) (114-379 l/min) to capacities of up to 35,000 gpm (132,000 l/min).

Tillman Water Reclamation Plant

The Donald C. Tillman Water Reclamation Plant (TWRP) is located in the West San Fernando Valley at the intersection of Victory Boulevard and Woodley Avenue on the edge of the Sepulveda Flood Control Basin. TWRP has a current design capacity of 80 mgd (0.302 million m³/d).

The TWRP is an upstream plant that treats constant flows, since it has the ability to bypass flow to the HTP for treatment. The TWRP receives its influent wastewater from the Additional Valley

Outfall Relief Sewer (AVORS) as well as the East Valley Interceptor Sewer (LCSFVRS) tunnel and the downstream system. This hydraulic relief eliminates dry weather overflows from the North Outfall Treatment Facility (NOTG) into Ballona Creek in Culver City.

The tertiary effluent from TWRP is used by the City for irrigating nearby parks, golf courses, greenbelt areas, and for filling the manmade Balboa Lake, or is discharged to the Los Angeles River. All waste solids are returned to AVORS for transport to HTP.

Los Angeles-Glendale Water Reclamation Plant

The Los Angeles-Glendale Water Reclamation Plant (LAGWRP) is located at the southwest junction of the Los Angeles River Flood Control Channel and Colorado Boulevard between Griffith Park and Glendale.

The LAGWRP is a full tertiary treatment facility with capacity to provide tertiary treatment for an average dry weather flow of 20 mgd (0.76 million m³/d). The plant receives its influent wastewater from the North Outfall Sewer (NOS), thus providing hydraulic relief for the downstream interceptor conveyance facilities and the HTP, while producing recycled water. The plant effluent is pumped to the recycled water distribution system or flows by gravity to the Los Angeles River. All Solids removed from the treatment process are returned untreated to the North Outfall Sewer for conveyance to and treatment at the Hyperion Treatment Plant.

There are two other wastewater treatment facilities in the LAGWRP service area: the Burbank Water Reclamation Plant and the Los Angeles Zoo Treatment Facility.

The Burbank Water Reclamation Plant located in and owned and operated by the City of Burbank. It treats an average flow of 8.5 mgd and its effluent is used for industrial purposes or discharged to the Burbank Western Flood control Channel, a tributary channel to the Los Angeles River. Solids from the Burbank Water Reclamation Plant are conveyed to and treated at the Hyperion Treatment Plant.

The Los Angeles Zoo Treatment Facility is adjacent to the west side of the Golden State Freeway just south of the Ventura Freeway. It provides primary treatment, chlorination and dechlorination of 2.5 mgd of runoff and wash-down water from animal enclosures. The effluent is discharged to the Los Angeles River and the solids are discharged to the North Outfall Sever for conveyance to and treatment at the Hyperion Treatment Plant.

Terminal Island Treatment Plant

The Terminal Island Treatment Plant (TITP) is located on Terminal Island in the Los Angeles Harbor area and covers approximately 20 acres (8 ha). The existing facility provides tertiary treatment for an average dry weather flow of 30 mgd (0.114 million m³/d). In addition to tertiary treatment, advanced treatment (microfiltration with reverse osmosis) can be provided for 5 mgd. The tertiary effluent flows to the Los Angeles Outer Harbor to a point approximately 3,000 feet (914 m) off-shore via a 60-inch (1,520 mm) diameter outfall. Advanced treated water is used for recharging barrier wells, landscape irrigation, boiler water and cooling water. Solids from the TITP (up to about 19 dry tons per day) are thickened, anaerobically digested, dewatered and hauled to Kern, San Diego, Los Angeles, and Riverside Counties for land application and reuse as a soil amendment.

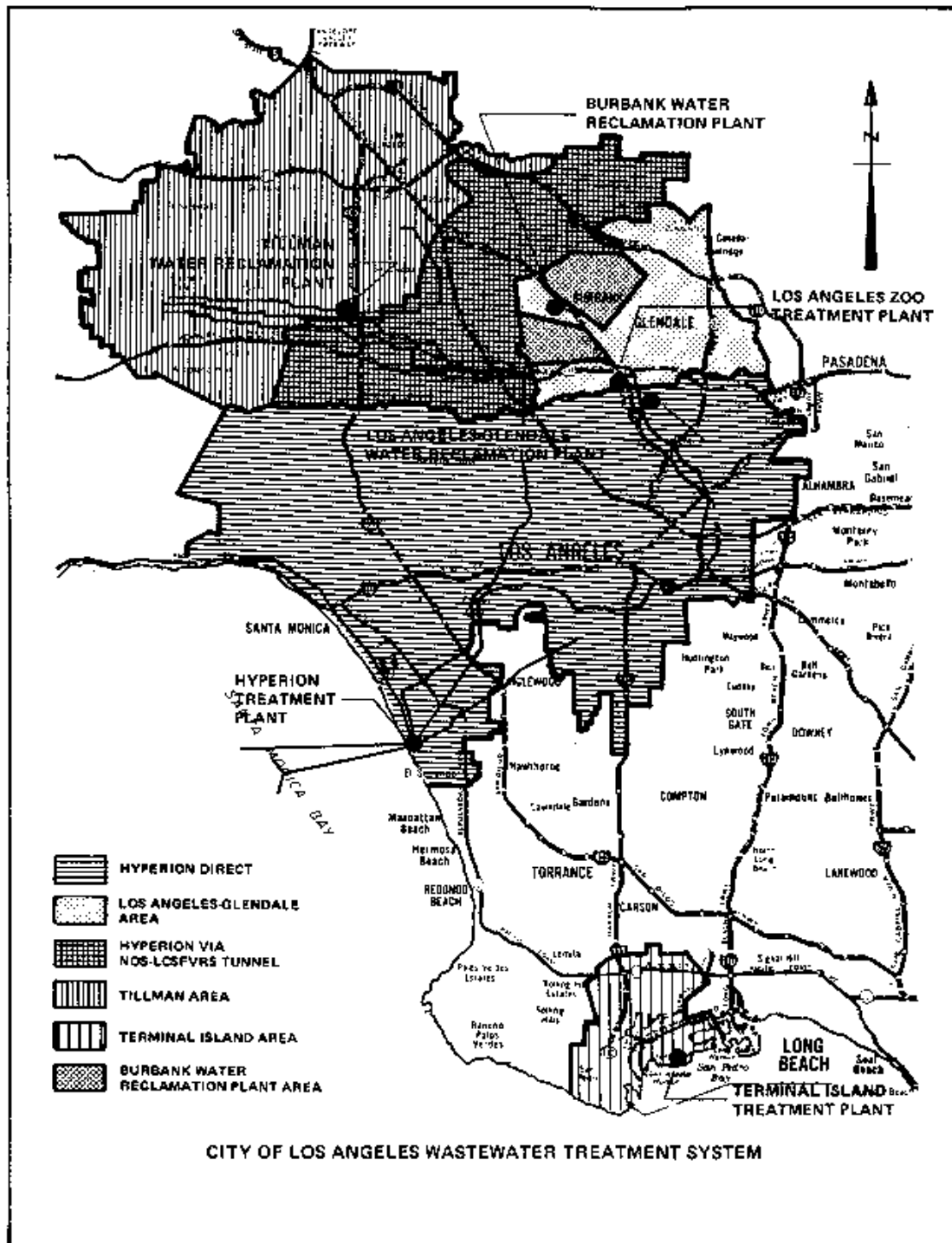


Exhibit M.2-1

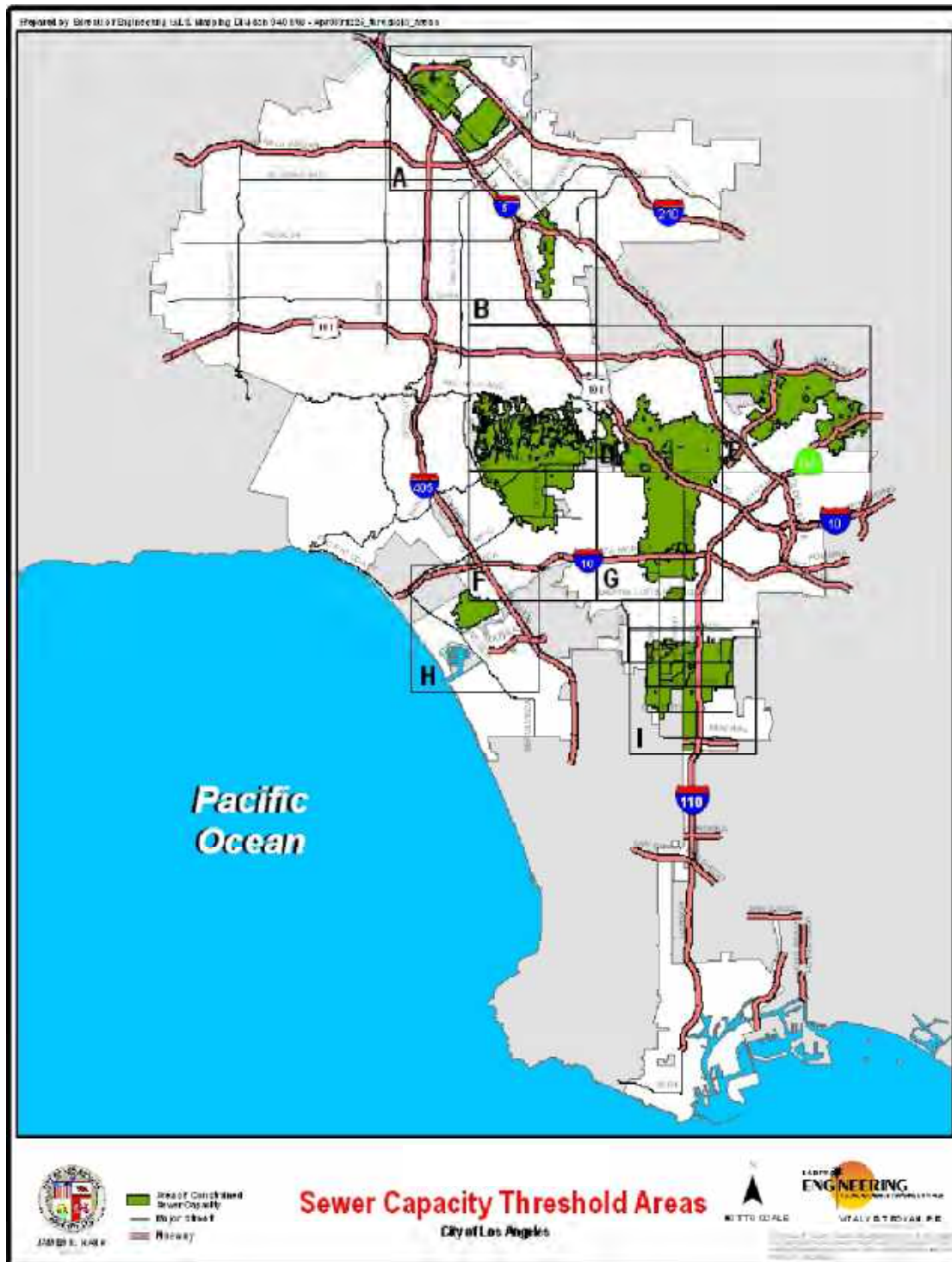


Exhibit M. 2-2

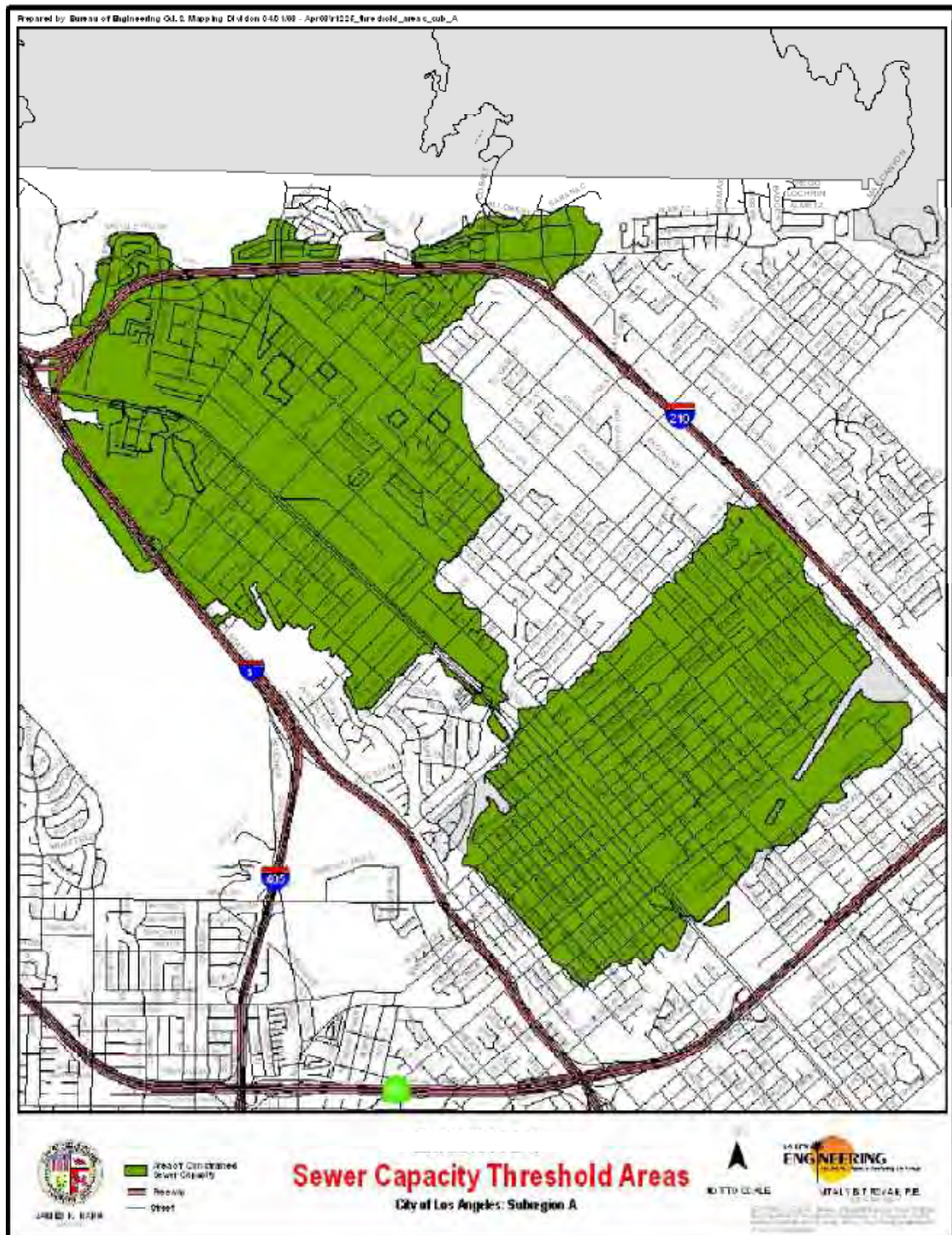


Exhibit M. 2-3

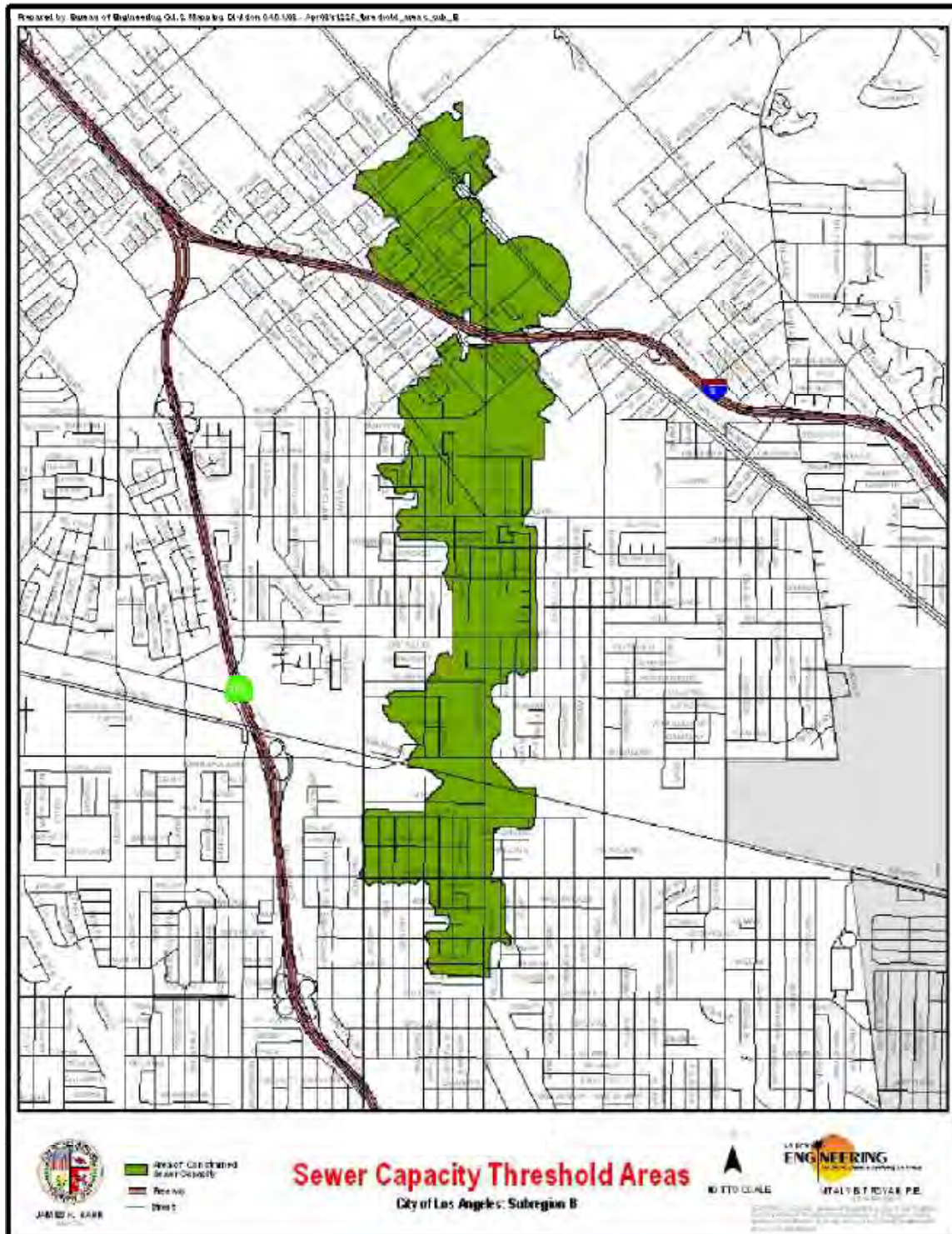


Exhibit M.2-4

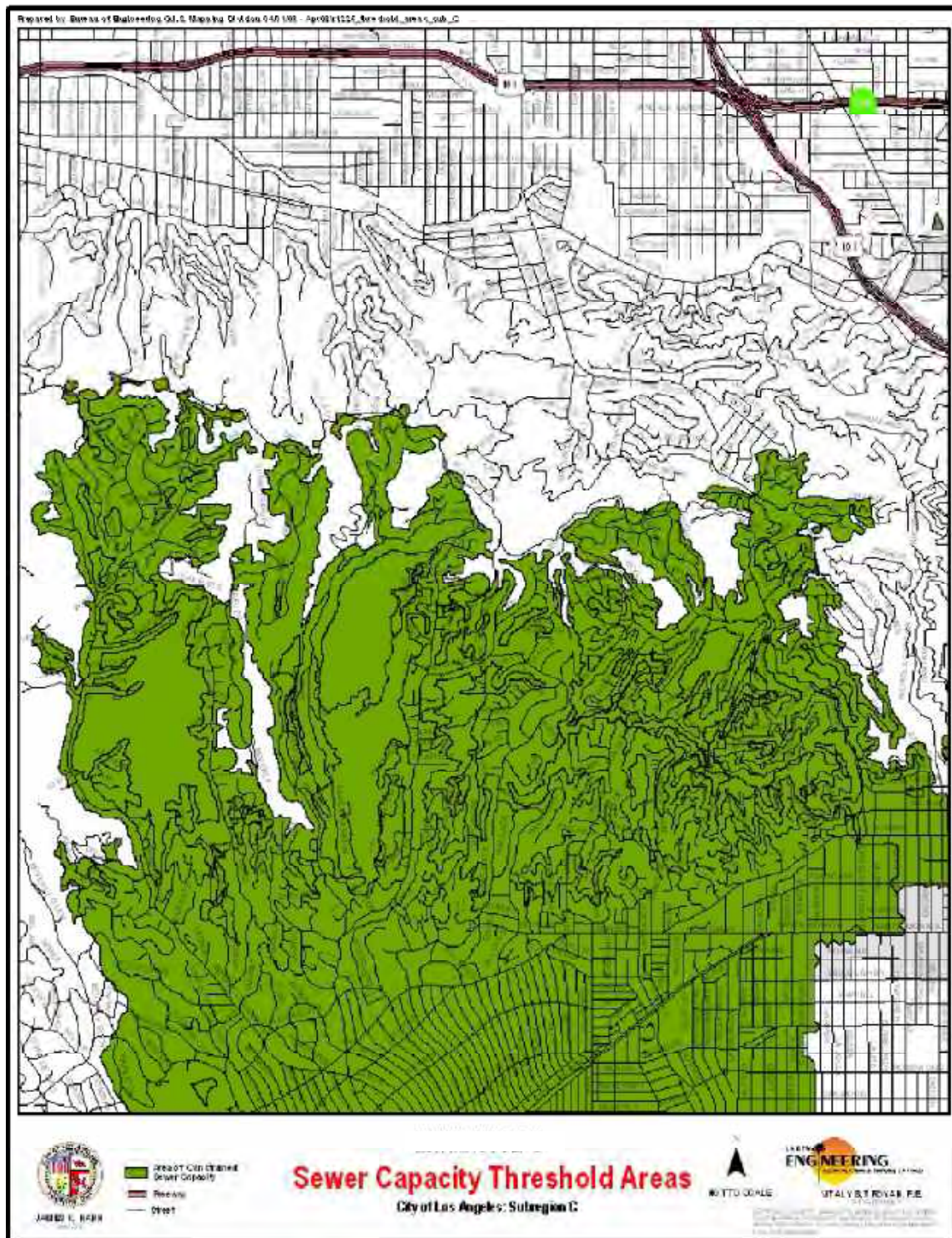


Exhibit M. 2.5

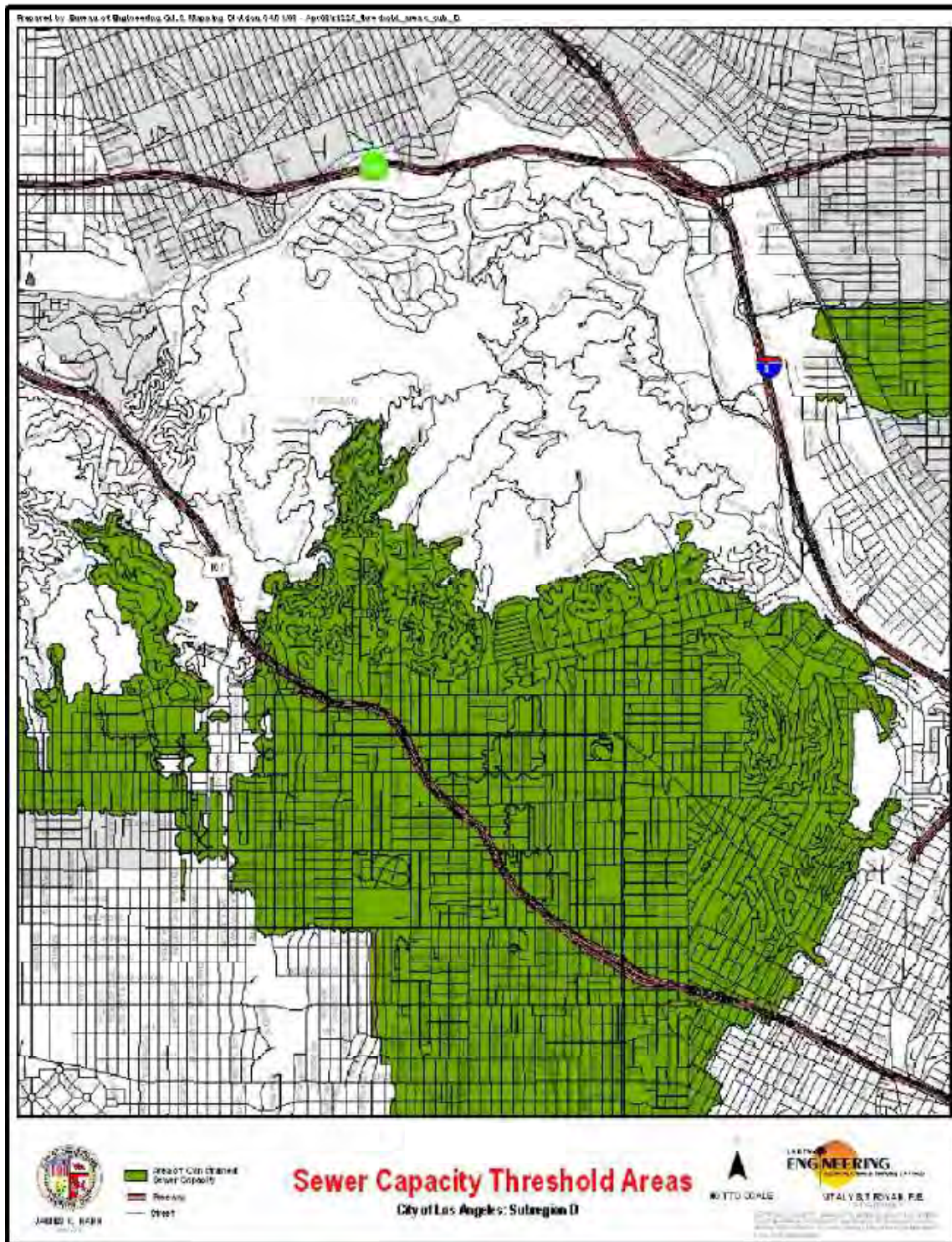


Exhibit M.2-6

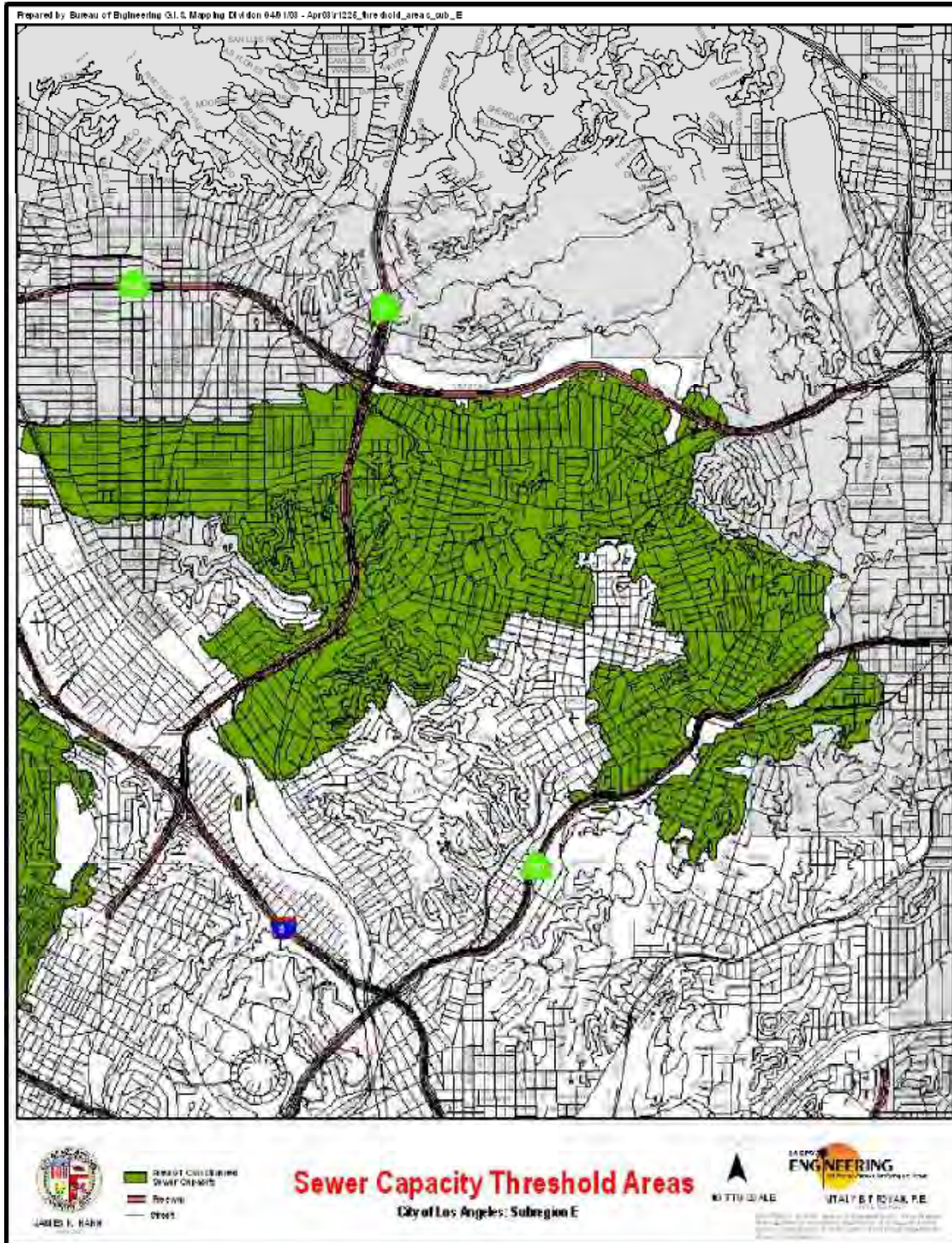


Exhibit M.2-7

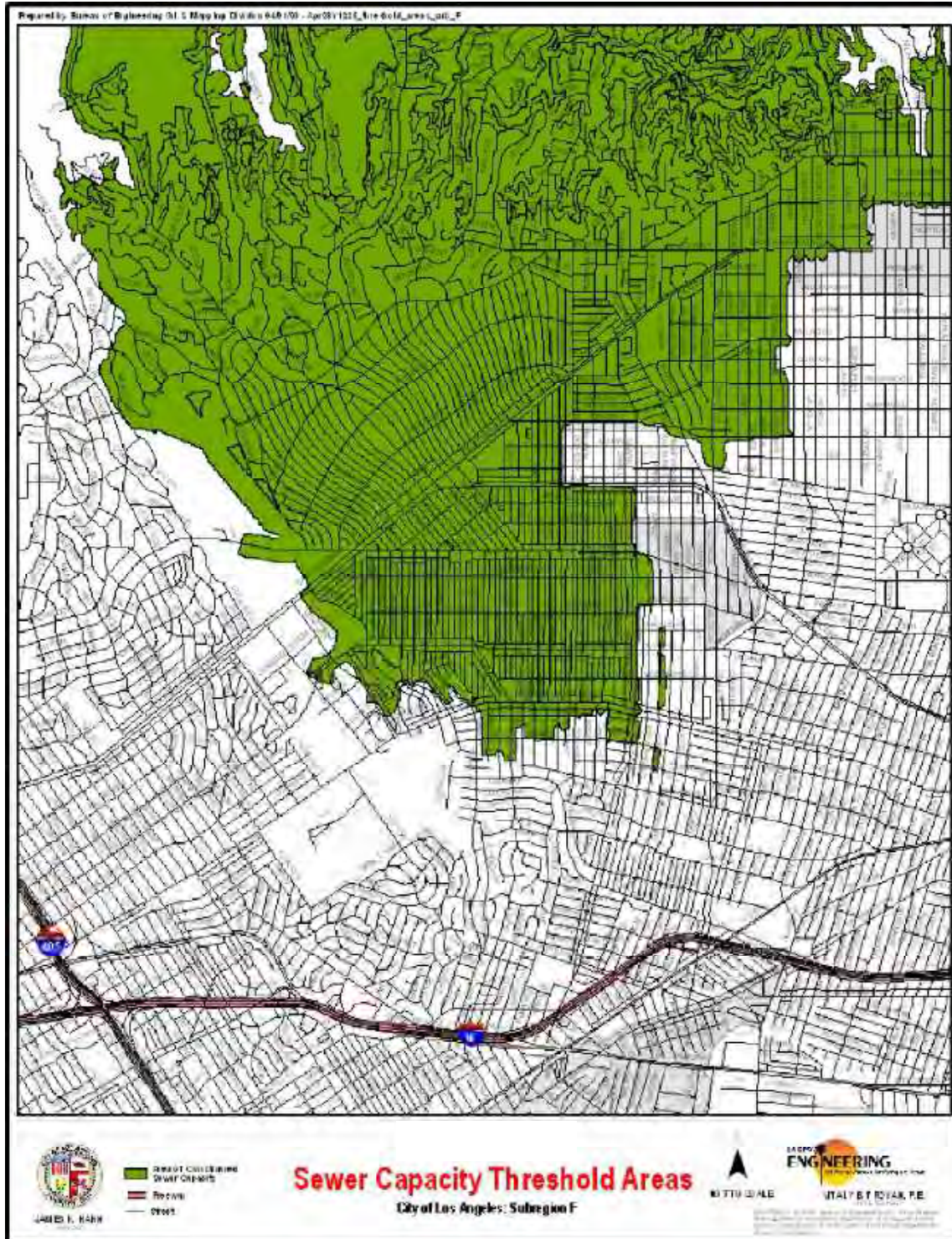


Exhibit M.2-8

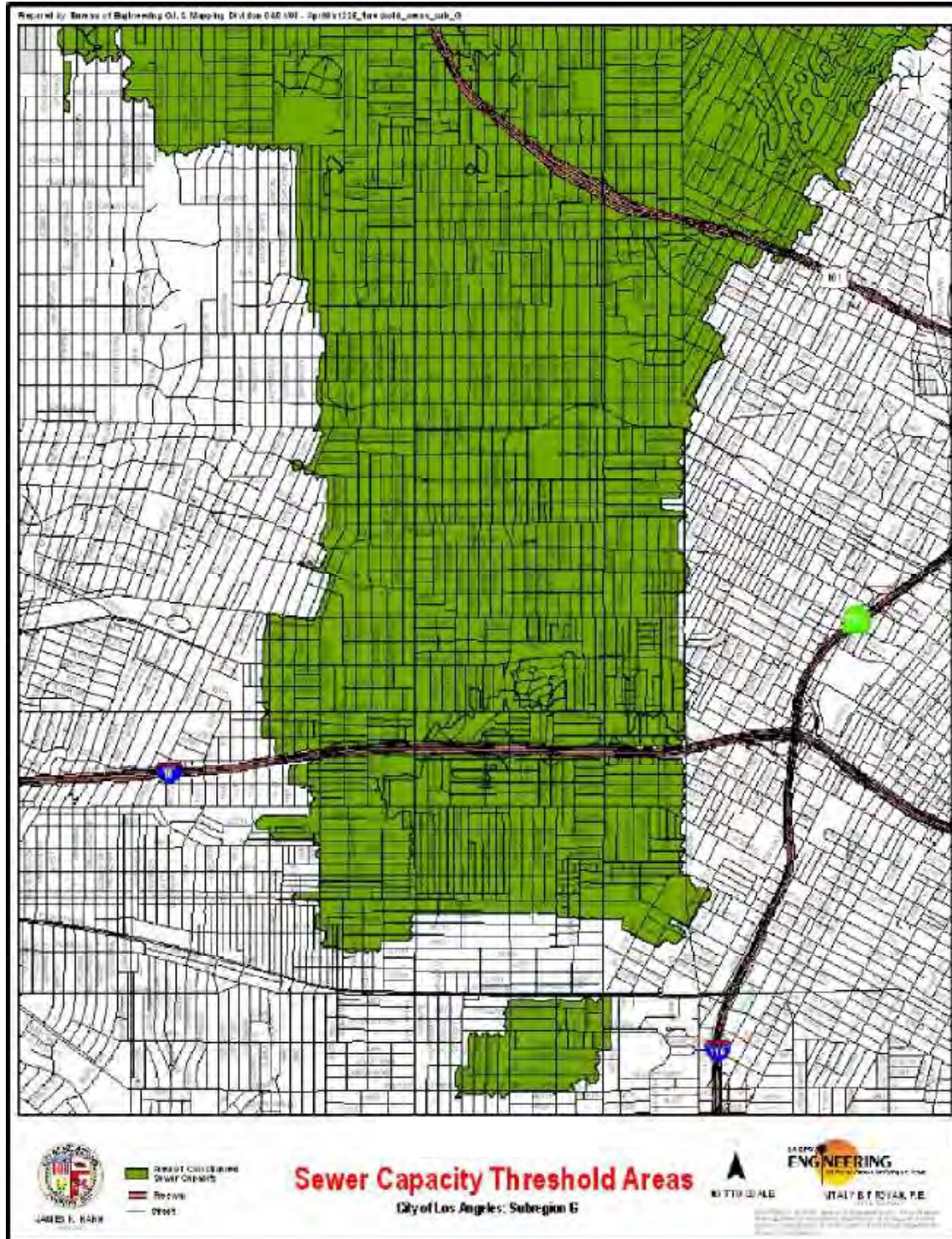


Exhibit M.2-9

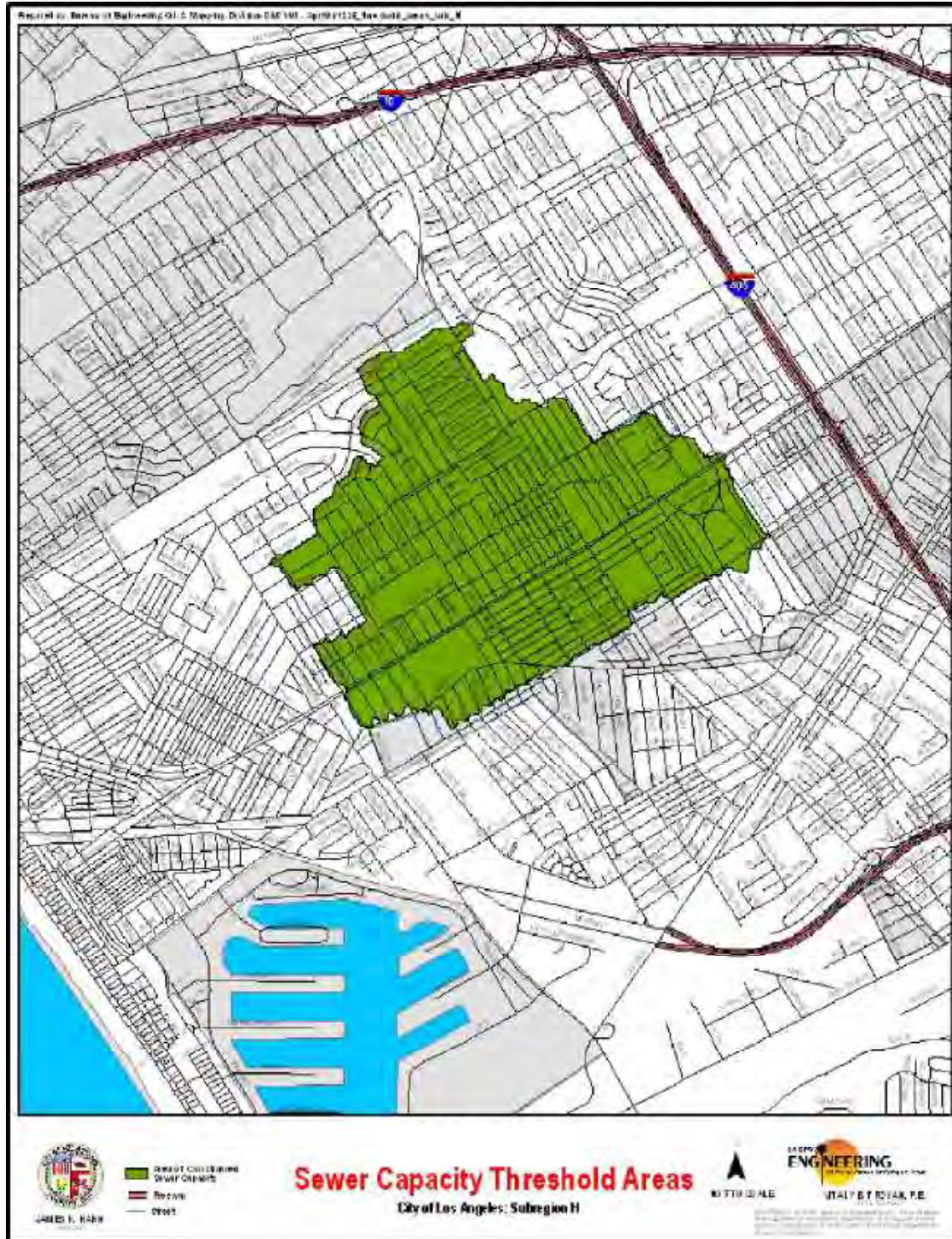


Exhibit M.2-10

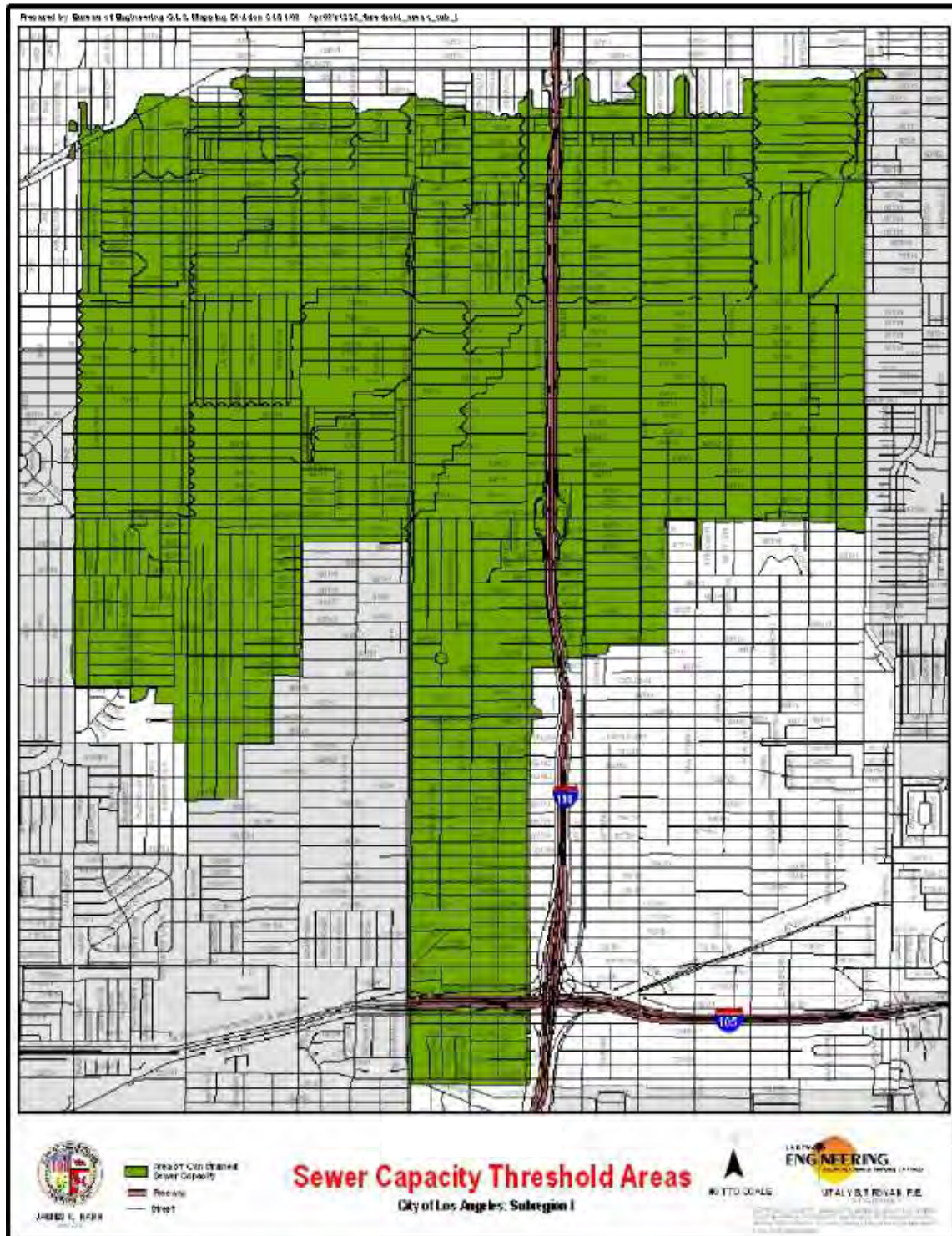


Exhibit M. 2-11

Exhibit M.2-12

SEWAGE GENERATION FACTORS

| Type Description | Average Daily Flow (Gpd/unit) |
|--|--|
| Acupuncture Office/Clinic | 150/1000 Gr.sq.ft. |
| Arcade - Video Games | 80/1000 Gr.sq.ft. |
| Auditorium | 4/seat |
| Auto Parking | 20/1000 Gr.sq.ft. |
| Auto Body/Mech Repair Shop | 800/1000 Gr.sq.ft. + Process Flow |
| Bakery | 280/1000 Gr.sq.ft. |
| Bank: Headquarters | 150/1000 Gr.sq.ft. |
| Bank: Branch | 80/1000 Gr.sq.ft. |
| Banquet Room/ Ballroom | 800/1000 Gr.sq.ft. |
| Bar: Cocktail, Fixed Seat | 18/seat |
| Bar: Juice (No Baking Facilities) | 120/1000 Gr.sq.ft. |
| Bar: Juice (With Baking Facilities) | 280/1000 Gr.sq.ft. |
| Bar: Cocktail Public Table Area | 500/1000 Gr.sq.ft. |
| Barber Shop | 100/1000 Gr.sq.ft. |
| Beauty Parlor | 280/1000 Gr.sq.ft. |
| Building Construction Field Office | 150/office |
| Bowling Alley: Alley, Lanes & Lobby Area | 80/1000 Gr.sq.ft. |
| Bowling Facility: Arcade/ Bar/ Restaurant/ Dancing | See Individual Categories |
| Cafeteria: Fixed Seat | 30/seat |
| Car Wash: Automatic | Process Flow |
| Car Wash: Coin Operated Bays | Process Flow |
| Car Wash: Hand Wash | Process Flow |
| Car Wash: Counter & Sale Area | 80/1000 Gr.sq.ft. |
| Chapel: Fixed Seat | 4/seat |
| Chiropractic Office | 150/1000 Gr.sq.ft. |
| Church: Fixed Seat | 4/seat |
| Church School: Day Care/elem | 8/occupant |
| Church School: One Day Use/week | 200/1000 Gr.sq.ft. |
| Cocktail Lounge: Fixed Seat | 18/seat |
| Coffee House: No Pastry Baking & No Food Prep. | 120/1000 Gr.sq.ft. |
| Coffee House: Pastry Baking Only | 280/1000 Gr.sq.ft. |
| Coffee House: Serves Prepared Food | 30/seat |
| Cold Storage: No Sales | 20/1000 Gr.sq.ft. |
| Cold Storage: Retail Sales | 80/1000 Gr.sq.ft. |
| Comfort Station: Public | 100/fixture |
| Commercial Use | 80/1000 Gr.sq.ft. |
| Community Center | 4/occupant |
| Conference Room of Office Bldg. | Same as other areas in an office bldg. |
| Counseling Center ¹ | 150/1000 Gr.sq.ft. |
| Credit Union | 150/1000 Gr.sq.ft. |
| Dairy | Process Flow |
| Dairy: Barn | Process Flow |
| Dairy: Retail Area | 80/1000 Gr.sq.ft. |

¹ *Counseling center include marriage counseling centers, alcohol/drug rehabilitation/dependency centers, nutrition center, diet centers, etc.*

Exhibit M.2-12, continued
SEWAGE GENERATION FACTORS

| <u>Type Description</u> | <u>Average Daily Flow (Gpd/unit)</u> |
|---|--------------------------------------|
| Dancing Area of Bar or Nightclub | 600/1000 Gr.sq.ft. |
| Dance Studio | 80/1000 Gr.sq.ft. |
| Dental Office/Clinic | 250/1000 Gr.sq.ft. |
| Doughnut Shop | 280/1000 Gr.sq.ft. |
| Drug Rehabilitation Center | 150/1000 Gr.sq.ft. |
| Equipment Booth | 20/1000 Gr.sq.ft. |
| Film Processing – 1-Hour Photo, etc. | 100/1000 Gr.sq.ft. |
| Film Processing – Industrial | 80/1000 Gr.sq.ft. + Process Flow |
| Food Processing Plant | 80/1000 Gr.sq.ft. + Process Flow |
| Gas Station: Self Service | 100/w.c. |
| Gas Station: Four Bays Maximum | 430/station |
| Golf Course: 18-hole/ 9-hole Green Area | 0 |
| Golf Course: Driving Range | 0 |
| Golf Course Facility: Lobby/Office/Restaurant/Bar | See Individual Categories |
| Gymnasium – Basketball, Volleyball | 250/1000 Gr.sq.ft. |
| Hanger (Aircraft) | 80/1000 Gr.sq.ft. |
| Health Club/ Spa ² | 800/1000 Gr.sq.ft. |
| Homeless Shelter | 75/bed |
| Hospital | 75/bed |
| Hospital: Convalescent | 75/bed |
| Hospital: Animal | 280/1000 Gr.sq.ft. |
| Hospital: Psychiatric | 75/bed |
| Hospital: Surgical | 450/bed |
| Hotel: Use Guest Rooms Only | 130/room |
| Jail | 85/inmate |
| Kennel: Dog Kennel/Open Run | 100/1000 Gr.sq.ft. |
| Laboratory: Commercial | 250/1000 Gr.sq.ft. |
| Laboratory: Industrial | Process Flow |
| Laundromat | 170/machine |
| Library: Public Area | 80/1000 Gr.sq.ft. |
| Library: Stacks, Storage | 25/1000 Gr.sq.ft. |
| Lobby of Retail Area ³ | 80/1000 Gr.sq.ft. |
| Lodge Hall | 4/seat |
| Lounge | See Lobby of Retail Area |
| Machine Shop | 80/1000 Gr.sq.ft. + Process Flow |
| Manufact or Indust Facility | 80/1000 Gr.sq.ft. + Process Flow |
| Massage Parlor | 275/1000 Gr.sq.ft. |
| Medical Building | 250/1000 Gr.sq.ft. |
| Medical Lab in Hospital | 250/1000 Gr.sq.ft. |

² Health club/spa includes lobby area, workout floors, aerobic rooms, swimming pools, Jacuzzi, sauna, locker rooms, showers, and restrooms. If a health club/spa has a gymnasium facility, use the gymnasium rate for that portion. Gymnasiums include basketball courts, volleyball courts, and any other large open space with low occupancy density.

³ Lobby of retail includes lounges, holding rooms, waiting areas, etc.

Exhibit M.2-12, continued
SEWAGE GENERATION FACTORS

| <u>Type Description</u> | <u>Average Daily Flow (Gpd/unit)</u> |
|--|--------------------------------------|
| Medical Office/ Clinic | 250/1000 Gr.sq.ft. |
| Mini-mall | 80/1000 Gr.sq.ft. |
| Mortuary: Embalming | 5/7 Gr.sq.ft. |
| Mortuary: Chapel | 4/seat |
| Mortuary: Living Area | 80/1000 Gr.sq.ft. |
| Motel: Use Guest Rooms Only | 130/room |
| Museum: All Areas | 20/1000 Gr.sq.ft. |
| Museum: Office over 15% | 150/1000 Gr.sq.ft. |
| Museum: Sales Area | 80/1000 Gr.sq.ft. |
| Office Building | 150/1000 Gr.sq.ft. |
| Office Building with Cooling Tower | 180/1000 Gr.sq.ft. |
| Plating Plant | 80/1000 Gr.sq.ft. + Process Flow |
| Pool Hall (No Alcohol) | 80/1000 Gr.sq.ft. |
| Post Office: Full Service ⁴ | 150/1000 Gr.sq.ft. |
| Prisons | 175/inmate |
| Residential Dorm: College or Residential | 75/student |
| Residential: Apt. -Bachelor/single | 80/dwelling Unit |
| Residential: Apt. - 1 Bedroom | 120/dwelling Unit |
| Residential: Apt. - 2 Bedroom | 160/dwelling Unit |
| Residential: Apt. - 3 Bedroom | 200/dwelling Unit |
| Residential: Apt. - >3 Bedroom | 40/additional bedroom |
| Residential: Boarding House | 75/bed |
| Residential: Condo - 1 Bedroom | 120/dwelling Unit |
| Residential: Condo - 2 Bedroom | 160/dwelling Unit |
| Residential: Condo - 3 Bedroom | 200/dwelling Unit |
| Residential: Condo - >3 Bedroom | 40/additional bedroom |
| Residential: Duplex/ Townhouse/ SFD - 1 Bd. | 130/dwelling Unit |
| Residential: Duplex/ Townhouse/ SFD - 2 Bd. | 180/dwelling Unit |
| Residential: Duplex/ Townhouse/ SFD - 3 Bd. | 230/dwelling Unit |
| Residential: Duplex/ Townhouse/ SFD - >3 Bd | 50/additional bedroom |
| Residential: Room Addition – Bedroom | 50/additional bedroom |
| Residential: Room Addition Other Than Bedroom | 0 |
| Residential: Room Conversion into Bedroom | 50/additional bedroom |
| Residential: Room Conversion into Other Than Bedroom | 0 |
| Residential: Mobile Home | 160/dwelling Unit |
| Residential: Artist 2/3 of Area | 250/dwelling Unit |
| Residential: Artist Residence | 80/dwelling Unit |
| Residential: Guest Home With Kitchen | See Residential: Apartment |
| Residential: Guest Home without Kitchen | 50/bedroom |
| Rest Home | 75/bed |
| Restaurant: Drive-in | 40/stall |
| Restaurant: Drive-in | 20/seat |

⁴ Full service post offices include U.S. Postal Service, UPS, Federal Express, and other private express mail services.

Exhibit M.2-12, continued
SEWAGE GENERATION FACTORS

| <u>Type Description</u> | <u>Average Daily Flow (Gpd/unit)</u> |
|--|--------------------------------------|
| Restaurant: Fast Food - Indoor Seat | 20/seat |
| Restaurant: Fast Food - Outdoor Seat | 12/seat |
| Restaurant: Full Service - Indoor Seat | 30/seat |
| Restaurant: Full Service - Outdoor Seat | 18/seat |
| Restaurant: Take-out | 300/1000 Gr.sq.ft. |
| Retail Area | 80/1000 Gr.sq.ft. |
| Rifle Range: Shooting Stalls, Shooting Lanes, Lobby | 80/1000 Gr.sq.ft. |
| Rifle Range Facility: Bar, Restaurant | See Individual Categories |
| School: Arts/Dancing/Music (Part Time) | 80/1000 Gr.sq.ft. |
| School: Arts/Dancing/Music (Full Time) | See type of school below |
| School: Day Care Center | 8/child |
| School: Elementary or Junior High ⁵ | 8/student |
| School: High School ⁵ | 12/student |
| School: Kindergarten | 200/1000 Gr.sq.ft. |
| School: Martial Arts (Part Time) | 80/1000 Gr.sq.ft. |
| School: Martial Arts (Full Time) ⁵ | See type of school below |
| School: Nursery - Day Care | 8/child |
| School: Special Class | 8/student |
| School: Trade or Vocational ⁵ | 12/student |
| School: Training ⁵ | 12/student |
| School: University or College ⁵ | 18/student |
| School: Dormitory ⁶ | 75/student |
| School: Stadium, Pavilion | 4/seat |
| Spa/ Jacuzzi: Commercial - with backwash | Process Flow |
| Spa/ Jacuzzi: Residential, replaceable filter crtrdg | 0 |
| Storage: Building/Warehouse | 20/1000 Gr.sq.ft. |
| Storage: Self Storage Bldg. | 20/1000 Gr.sq.ft. |
| Store: Ice Cream/Yogurt | 80/1000 Gr.sq.ft. |
| Store: Retail | 80/1000 Gr.sq.ft. |
| Studio: Film/ TV – Audience Viewing Room | 4/seat |
| Studio: Film/ TV – Regular Use Indoor Filming Area | 80/1000 Gr.sq.ft. |
| Studio: Film/ TV – Indust. Use Film Proc, Machine Shop | 80/1000 Gr.sq.ft. + Process Flow |
| Studio: Recording | 80/1000 Gr.sq.ft. |
| Swimming Pool: Commercial with backwash | Process Flow |
| Swimming Pool: Residential replaceable filter crtrdg | 0 |
| Tanning Salon: Independent, No Shower | 80/1000 Gr.sq.ft. |
| Tanning Salon: Within a Health Spa/Club | 800/1000 Gr.sq.ft. |

⁵ The sewage generation factor for schools based on student capacity covers the following facilities: classrooms and lecture halls, professors' offices, administration offices, laboratories for classes or research, libraries, bookstores, student/professor lounges, school cafeterias, warehouses and storage areas, auditoriums and gymnasiums. For any facility not listed under "schools" (e.g., stadium), see the generation factor listed for that land use type.

⁶ The sewage generation factor for a college dormitory based on student capacity also includes the sewage generation factor for the dormitory cafeterias.

Exhibit M.2-12, continued
SEWAGE GENERATION FACTORS

| <u>Type Description</u> | <u>Average Daily Flow (Gpd/unit)</u> |
|------------------------------------|---------------------------------------|
| | |
| Theatre: Drive-in | 10/vehicle |
| Theatre: Live/Music/Opera | 4/seat |
| Theatre: Cinema | 4/seat |
| Tract: Commercial/ residential | 1/acre |
| Trailer: Construction/Field Office | 150/office |
| Veterinary Clinic/Office | 280/1000 Gr.sq.ft. |
| Warehouse | 20/1000 Gr.sq.ft. |
| Warehouse with Office | Use Factor for Each Separate Category |
| Waste Dump: Recreational | 430/station |
| Wine Tasting Room: Kitchen | 215/1000 Gr.sq.ft. |
| Wine Tasting Room: All Areas | 80/1000 Gr.sq.ft. |

Notes:

Gpd/unit = Gallons per day (gpd) per unit as indicated.

Gr.sq.ft. = Gross Square Feet: area included within the exterior or the surrounding walls of a building excluding courts.

GPM Peak = Peak Flow in gallons per minute. There is an assumption that the peak to average flow ratio is 3.5. Therefore, 1.0 gpm x 1440 minutes/day divided by 3.5 = 412 gpd which is the unit flow factor in the table.

See next page for metric equivalents.

Source: Bureau of Sanitation. Sewerage Facilities Charge, Sewage Generation Factors for Residential and Commercial Categories. Effective June 6, 1996.

METRIC CONVERSION

The President's Executive Order 12770, Metric Usage in Federal Government Programs, was signed on July 25, 1991. Federal regulations recently enacted require that all government affairs be conducted in metrics. The City of Los Angeles must comply with the resultant federal regulations in order to obtain federal funding and permit approvals. For example, federally funded street improvement projects must be designed, advertised and contracted in metric units.

In response to the federal government's actions, the City Engineer has issued a Metric Conversion Manual and a Special Order for metric conversion within the Bureau of Engineering intended to keep the Bureau current with the situation and allow time to analyze the full impact of the conversion while protecting potential federal funding. Review of private development standards and requirements is currently under way and will be the subject of a separate Special Order. That study will determine whether land developers should submit documents and plans in metrics or if they may continue to use Imperial units. Meanwhile, the following is intended for use only with Table 1 and the foregoing thresholds.

| GALLONS | EQUIVALENT
LITERS
(1 qt = .9463 l) | gpd/1000 Gr.sq.ft.
converted to
l per day / 100 m2 | GALLONS | EQUIVALENT
LITERS
(1 qt = .9463 l) | gpd/1000 Gr.sq.ft.
converted to
l per day / 100 m2 |
|---------|--|--|---------|--|--|
| 800 | 3,028 | 3,260 | 130 | 492 | 530 |
| 600 | 2,271 | 2,445 | 120 | 454 | 489 |
| 500 | 1,893 | 2,037 | 100 | 379 | 407 |
| 450 | 1,703 | 1,834 | 85 | 322 | 346 |
| 430 | 1,628 | 1,752 | 80 | 303 | 326 |
| 412 | 1,560 | 1,679 | 75 | 284 | 306 |
| 300 | 1,136 | 1,222 | 50 | 189 | 204 |
| 280 | 1,060 | 1,141 | 40 | 151 | 163 |
| 275 | 1,041 | 1,120 | 30 | 114 | 122 |
| 250 | 946 | 1,019 | 25 | 95 | 102 |
| 230 | 871 | 937 | 20 | 76 | 81 |
| 215 | 814 | 876 | 18 | 68 | 73 |
| 200 | 757 | 815 | 12 | 45 | 49 |
| 180 | 681 | 733 | 10 | 38 | 41 |
| 175 | 662 | 713 | 8 | 30 | 33 |
| 170 | 643 | 693 | 5 | 19 | 20 |
| 160 | 606 | 652 | 4 | 15 | 16 |
| 150 | 568 | 611 | 1 | 4 | 4 |

1 gpd/acre = 9 liters per day per hectare

M.3. SOLID WASTE

1. INITIAL STUDY SCREENING PROCESS

A. Initial Study Checklist Questions

XVI.f): Would the project be served by a landfill with sufficient permitted capacity to accommodate the project's solid waste disposal needs?

XVI.g): Would the project comply with federal, state, and local statutes and regulations related to solid waste?

B. Introduction

The management of solid waste in the City of Los Angeles involves public and private refuse collection services as well as public and private operation of solid waste transfer, resource recovery, and disposal facilities. The Bureau of Sanitation provides collection services primarily to single family residences and some of the smaller multi-family residences. The City is also responsible for collecting waste from the City Hall complex, some public buildings, parks and fire stations. Multi-family residences, such as apartment complexes and condominiums, and commercial and industrial buildings, contract with a private company to collect and transport their materials for disposal or recycling.

The solid waste management hierarchy encompasses the system of solid waste source reduction, composting, transformation and disposal. The demolition, construction, and operation of projects results in the generation of solid waste. Project impacts are related to: the amount of waste generated and diverted; the need for additional solid waste collection routes or disposal facilities; and compliance with adopted policies and objectives.

In September 1989, the California Integrated Solid Waste Management (ISWM) Act (also known as AB 939) was passed. It required each city in the state to divert at least 25 percent of its solid waste from landfill disposal through source reduction, recycling, and composting, by the end of 1995. Cities must now divert at least 50 percent of their waste stream. AB 939 further requires each city to conduct a Solid Waste Generation Study and to prepare annually a Source Reduction and Recycling Element (SRRE) to describe how it will reach its goals.

The City of Los Angeles has also prepared a Solid Waste Management Policy Plan

(CiSWMPP), which was adopted by the City Council in November 1994. The CiSWMPP is a long-term planning document containing goals, objectives and policies for solid waste management for the City. It specifies citywide diversion goals and disposal capacity needs.

C. Screening Criteria

- Would implementation of the proposed project result in solid waste generation of five tons or more per week?

A "yes" response to the preceding question indicates further study in an expanded Initial Study, Negative Declaration, Mitigated Negative Declaration, or EIR may be required. Refer to the Significance Threshold for Solid Waste, and review the associated Methodology to Determine Significance, as appropriate.

A "no" response to the preceding question indicates that there would normally be no significant impact on Solid Waste from the proposed project.

D. Evaluation of Screening Criteria

Review the description of the proposed project. Estimate typical project waste generation. The following solid waste generation factors may be used*:

- Residential 12.23 pounds per household per day
- Commercial 10.53 pounds per employee per day
- Industrial 8.93 pounds per employee per day

* These factors are estimates prior to recycling, composting or other waste diversion programs. Factors do not include generation of construction debris.

Compare this information to the Screening Criteria.

2. DETERMINATION OF SIGNIFICANCE

A. Significance Threshold

The determination of significance shall be made on a case-by-case basis, considering the following factors:

- Amount of projected waste generation, diversion, and disposal during demolition, construction, and operation of the project, considering proposed design and operational features that could reduce typical waste generation rates;
- Need for an additional solid waste collection route, or recycling or disposal facility to adequately handle project-generated waste; and
- Whether the project conflicts with solid waste policies and objectives in the SRRE or its updates, CiSWMPP, Framework Element or the Curbside Recycling Program, including consideration of the land use-specific waste diversion goals contained in Volume 4 of the SRRE.¹

B. Methodology to Determine Significance

Environmental Setting

In a description of the environmental setting, include a description of the solid waste collection services (both diversion and disposal), and facilities which would serve the project. Include the name, location, and other relevant characteristics of the services or facilities, such as the remaining capacity of nearby landfills, daily capacity at recycling centers, the availability of disposal and recycling services, the materials accepted, etc.

Project Impacts

Based on the proposed land uses and their sizes, calculate the amount of anticipated solid waste that would result from implementation of the proposed project. Include both demolition and construction waste and waste generated by project operations. Identify any design measures, such as recycling programs and other waste diversion features, that would reduce the amount typically expected. Consider whether the project's waste would require the addition of a new solid waste collection route or other major improvements.

Compare the project's anticipated waste generation with the land use-specific waste diversion goals in the SRRE, if applicable, and with the overall waste reduction goals in the

¹ *Waste diversion goals have been identified for a limited number of targeted waste generators and materials. Future updates of the SRRE may expand the land uses and materials covered, or modify the current waste diversion goals.*

CiSWMPP, the Framework Element, and Curbside Recycling Program. Note whether the project would support the City's waste reduction goals and/or whether the project would meet specific waste diversion targets, if applicable. A project need not guarantee that it would meet the land use specific waste diversion goals in the SRRE; however, project proponents should identify measures to incorporate into the project to work toward meeting the goals.

Cumulative Impacts

Review the description of the related projects. Identify those that affect the same solid waste collection, disposal, and recycling facilities as the proposed project. Determine the amount of waste generation and diversion from these related projects and then consider the combined impact of the proposed related projects, in the same manner as described above for Project Impacts.

Sample Mitigation Measures

Potential mitigation measures include the following:

- Incorporate recycled content materials in building products, furnishings and building maintenance;
- Recycle construction and demolition debris and California Redemption Value (CRV) generated during construction;
- Use mulching, composting, and grass-cycling on landscaped areas. Use xeriscaping or other low maintenance methods in landscape design;
- Develop a project recycling plan that includes the design and allocation of recycling collection and storage space in the project. As a result of the City's space allocation ordinance, the Los Angeles Municipal Code (LAMC) includes provisions for recycling areas or rooms in all new development projects and certain expansions;
- Incorporate a statement or brochure instructing occupants about source reduction, recycling and procurement of recycled content materials into the ownership agreement, property management agreements and tenant agreements;
- Institute an employee participation recycling program whereby employees are given individual containers/bins to separate newspaper, white and/or colored paper for

regular collection by recyclers;

- Educate residents about proper household hazardous waste collection programs;
- Institute employee education which would, through a series of brief educational sessions, outline various methods whereby employees can further contribute to methods of recycling/conservation in the office and home (e.g., contracting with firms for the purchase of recycled paper, use of two-sided reports, replacement of styrofoam cups with coffee mugs); and
- Conduct an annual waste audit review to measure the effectiveness of the tenant education program and recycling collection activities. Use the results to improve the project recycling plan. Include:
 - A review of purchasing patterns to eliminate materials not compatible with the established waste diversion program;
 - A review of operating procedures which generate either large amounts of waste or non-recyclable materials;
 - A review of occupancy uses and activities;
 - The evaluation and expansion of recyclable materials to be included in a recycling program; and
 - A review of employee awareness of recycling program goals, procedures, and accomplishments, as well as evaluations and implementation of training for all project occupants.

3. DATA, RESOURCES, AND REFERENCES

The Bureau of Sanitation provides information regarding citywide generation, disposal and diversion rates, disposal facilities, commercial, industrial, and residential programs, and collection contracts and agencies. Solid Resources Citywide Recycling Division is located at 433 S. Spring Street, Suite 500, Los Angeles, California 90013; Telephone: (213) 473-8228. For information on commercial, industrial, institutional, and multi-family diversion programs and resources, contact the Integrated Waste Management Office at 433 S. Spring Street, 5th Floor, Los Angeles, California 90013; Telephone: (213) 473-8150.

ISWM Act of 1989 (Public Resources Code 40050 et. seq.) requires specific waste diversion rates in cities and counties by the target years of 1995 (at least 25 percent) and 2000 (at least 50 percent) and mandates, through the California Integrated Waste Management Board (CIWMB) preparation of the SRRE.

CiSWMPP is a long-term planning document containing goals, objectives and policies for solid waste management and specifies citywide diversion goals and disposal capacity at 62 percent by the year 2005.

SRRE contains programs and policies for fulfillment of the goals of the ISWM Act and is updated annually. An executive summary of the 1995 annual update is available from the IWMO free of charge.

The Space Allocation Ordinance (No. 171687) was adopted by the City Council on August 6, 1997, and includes requirements for recycling centers and facilities as well as for areas for collecting and loading recyclable materials. All new construction development projects, multiple family residential development projects of four or more units where the addition of floor area is 25 percent or more, and other development projects where the addition of floor area is 30 percent or more shall provide an adequate Recycling Area or Room for collecting and loading recyclable materials. The ordinance specifies the size, location, conditions of operations, and restrictions on Recycling Areas or Rooms. See Subdivision 19 of Section A of Section 12.21 of the LAMC. Additional information is available from the IWMO.

M.4. ENERGY

1. INITIAL STUDY SCREENING PROCESS

A. Initial Study Checklist Questions

- VIII.a): Would the project conflict with adopted energy conservation plans?
- VIII.b): Would the project use non-renewable resources in a wasteful and inefficient manner?
- XII.a): Would the proposal result in a need for new systems, or substantial alterations to power or natural gas?

B. Introduction

Within the City of Los Angeles, electricity is provided by the Los Angeles Department of Water and Power (LADWP), and natural gas is provided by the Southern California Gas Company (The Gas Company). Energy service requirements are related to the size and type of projects, and the geographic area served. New projects (e.g., residential, commercial, industrial) may increase energy consumption and affect the energy distribution infrastructure.

Customers in the City consume electricity at a rate of approximately 22 million megawatt hours per year. Of LADWP's nearly 1.4 million customers, the largest number of customers are residential. Business and industry customers, however, consume about 70 percent of the electricity. A portion of the electrical consumption is also dedicated to street lighting and water supply distribution.¹ Additional background on electric infrastructure is found in 3. Data, Resources, and References.

The Gas Company serves about 19 million people in more than 530 cities in Southern and Central California, throughout 23,000 square miles. Of the approximately 5.4 million customers, nearly 4.5 million are residential. The average natural gas consumption for residential uses is 50

¹ LADWP, *Statistics, Fiscal Year 1993-94*.
LADWP, 2003.

therms per year.² The Gas Company has about 48,000 miles of gas mains, of which 44,000 miles are for distribution and 3,319 miles are for transmission and/or storage.

Title 24 of the California Code of Regulations establishes energy conservation standards for new construction. These standards relate to insulation requirements, glazing, lighting, shading, and water and space heating systems. Also, the California Subdivision Map Act requires that new subdivision designs provide for future passive or natural heating and cooling opportunities, to the maximum extent feasible. The Los Angeles Municipal Code (LAMC) incorporates these state requirements.

C. Screening Criteria

- Would the project design or operation conflict with adopted energy conservation plans or policies of the City, or exceed the growth anticipated in the applicable Community Plan?
- Would the project, result in the need for new (off-site) energy supply facilities, or major capacity enhancing alterations to existing facilities?

A "yes" response to any of the preceding questions indicates further study in an expanded Initial Study, Negative Declaration, Mitigated Negative Declaration or EIR may be required. Refer to the Significance Threshold for Energy, and review the associated Methodology to Determine Significance, as appropriate.

A "no" response to all of the preceding questions indicates that there would normally be no significant impact on Energy from the proposed project.

D. Evaluation of Screening Criteria

Review the description of the proposed project, project site, and energy distribution infrastructure. Determine the energy supply and distribution systems required to serve the project. New off-site energy supply facilities or capacity enhancing alterations to existing facilities include installation, replacement of, or upgrades to, power plants, receiving stations, distribution stations, natural gas mains, or storage or connecting systems. If necessary, consult with the LADWP or The Gas Company.

² *The Gas Company, Fact Sheet, Spring 1993, and telephone communication, Mr. Don Dockray, The Gas Company, June 17, 1994 and interview, 2004.*

Also, consider conflicts with the energy conservation and infrastructure programs and policies of applicable utility plans, specific plans, the General Plan and its elements, or the Community Plan.

To evaluate the potential increase in growth, and the corresponding demand for energy from a proposed General Plan amendment, compare the projected population of the applicable planning subregion before and after the General Plan amendment. The Framework Element identifies future population goals for the City. If assistance in determining population projections for a planning subregion is needed, contact the City Planning Department, Community Planning Bureau.

Compare this information to the Screening Criteria.

2. DETERMINATION OF SIGNIFICANCE

A. Significance Threshold

The determination of significance shall be made on a case-by-case basis, considering the following factors:

- The extent to which the project would require new (off-site) energy supply facilities and distribution infrastructure, or capacity enhancing alterations to existing facilities;
- Whether and when the needed infrastructure was anticipated by adopted plans; and
- The degree to which the project design and/or operations incorporate energy conservation measures, particularly those that go beyond City requirements.

B. Methodology to Determine Significance

Environmental Setting

In a description of the environmental setting, include the following information:

- Description of the electricity and natural gas supply and distribution infrastructure serving the project site. Include plans for new transmission facilities or expansion of existing facilities; and
- Summary of adopted energy conservation plans and policies relevant to the project.

Project Impacts

Using the information from the Evaluation of Screening Criteria and the description of the proposed project, project site and the existing energy distribution infrastructure, evaluate the new energy supply and distribution systems which the project would require. Describe the energy conservation features that would be incorporated into project design and/or operation that go beyond City requirements, or that would reduce the energy demand typically expected for the type of project proposed. Consult with the DWP or The Gas Company, if necessary to gauge the anticipated supply and demand conditions at project buildout.

If project demand would require new infrastructure, determine whether the infrastructure was anticipated by adopted plans, such as applicable utility plans, specific plans, the General Plan and its elements, or the Community Plan. If the new energy supply or distribution system was anticipated at a later time by adopted plans, consider the impact of accelerating additions or alterations.

Cumulative Impacts

Review the list of related projects. Identify those that would be served by the same energy distribution infrastructure as the proposed project. In the same manner as for Project Impacts, evaluate the cumulative impact on energy supply and distribution infrastructure. To the extent known, consider energy conservation features that would be incorporated into the related projects and the impact of these features on the need for new energy supply and distribution infrastructure systems typically expected with the type of projects proposed. Determine whether new energy supply and distribution infrastructure systems would be required as a results of the combined effect of the proposed project and the related projects.

Sample Mitigation Measures

Potential mitigation measures include the following:

- Use tinted and solar reflective glass on appropriate exposures, such as the exterior-facing and/or most solar-exposed sides of the building, to reduce cooling loads;
- Use natural lighting and/or lighting types that are more efficient than incandescent lighting;
- Incorporate light sensors which automatically shut off the lights when occupants have left the room;

- Use lighting switches and thermostats equipped with multi-switch provisions for control by occupants and building personnel;
- Time control public area lighting, both interior and exterior;
- Install a variable air volume system which reduces energy consumption for air cooling and heating or water heating;
- Design the project with air conditioning which will have a 100 percent outdoor air economizer cycle to obtain free cooling during dry outdoor climatic periods;
- Do not allow office lighting loads to exceed an average 2.3 watts per square foot of conditioned floor area;
- Control mechanical systems (heating, ventilation, and air conditioning (HVAC)) and lighting) with computer time clocks;
- Recycle lighting system heat for space heating during cool weather. Exhaust lighting system heat via ceiling plenums, to reduce cooling loads in warm weather;
- Cascade ventilation air from high-priority areas to low-priority areas before being exhausted, thereby decreasing the volume of ventilation air required. For example, cascade air from occupied space to corridors to mechanical spaces before being exhausted;
- Distribute electricity within the project at 480/277 volts, three-phase, and stepped down where necessary for 110-volt outlets using dry transformers. Operate installed lighting systems at 227 volts;
- Design buildings to be well-sealed and include vestibules to prevent outside air from infiltrating and increasing interior space conditioning loads;
- Finish exterior walls and roofs with light-colored materials with high emissivity characteristics to reduce cooling loads. Use light-colored materials for interior walls to reflect more light and thus increase lighting efficiency;
- Use solar water heating for swimming pools.

3. DATA, RESOURCES, AND REFERENCES

LADWP, 111 North Hope Street, Los Angeles, California 90012; Power System Telephone: (213) 367-0285.

City Planning Department, Community Planning Bureau, 200 N. Spring St., City Hall, Los Angeles, California 90012; Telephone: (Eastside) (213)-978-1183, (Metro/Central) (213)-978-1179, (South LA) (213)-978-1168, (West/Coastal) (213)-978-1177, (Valley - 6262 Van Nuys Blvd., Van Nuys, California 91401) (818) 347-5055.

The Gas Company, (213) 244-2518, for information regarding natural gas consumption and infrastructure.

LAMC Sections 12.95.2 and 12.95.3 require projects, which include conversion of residential, commercial, or industrial uses, to submit a report concerning compliance with the Title 24 energy conservation standards.

LADWP, Power for the 21st Century (brochure).

LADWP, The Power System and Los Angeles (brochure).

LADWP, Los Angeles Department of Water and Power (brochure).

Electrical Consumption

The largest single source of power supply for the LADWP is coal, which provides 55 percent of the City's energy. Oil and natural gas provide about 20 percent of the City's energy; hydroelectricity accounts for about four percent; nuclear, 10 percent; and the remainder (11 percent) comes from purchased power.³ The sources of coal-fired power production are three coal-fired power plants located outside California, in which the LADWP owns shares. The greatest amount of coal-fired power is received from the Intermountain Generating Station near Delta, Utah. About one-fifth of the LADWP's power production is received from the Mohave Power Plant in southern Nevada and the Navajo Power Project near Page, Arizona. Of the four power plants producing energy from natural gas located within the Los Angeles Basin, the largest of these is the Haynes Generating Station in Long Beach. The other plants are the Valley, Harbor, and Scattergood generating stations.

³ LADWP, *Statistics, Fiscal Year 1991-1992*"

The two main hydroelectric power plants serving the City include Hoover Dam, on the Colorado River, and Castaic Power Plant, on the California State Aqueduct, about 22 miles north of the City. In addition, hydroelectric power is derived from several smaller Los Angeles Aqueduct stations, as well as purchased from other producers, mainly the Columbia River Power System. Nuclear power has been a source of electricity for the City since 1986, from the Palo Verde Nuclear Generating Station near Phoenix.

The LADWP has 21 receiving stations, designed to handle large quantities of bulk power from the major transmission lines connected to the power generating plants in California and neighboring states. The receiving stations lower the voltage of electricity to subtransmission levels, sending the power on to 120 distributing stations in the City. The distribution stations either serve a large manufacturing or commercial center directly or, as in most cases, they each supply a five- to ten-square mile area for residential and business consumers. The distribution stations reduce the voltage from 34,500 to 4,800 volts for efficient distribution of electricity to local transformers. The local distribution system consists of 6,100 miles of overhead pole-lines and 2,200 miles of underground cable.⁴

To accommodate future needs, the LADWP prepares 10-year and 20-year plans. The 10-year plan, updated annually, forecasts demand, distribution, and transmission needs to maintain system integrity. The 20-year plan, also updated annually, forecasts resource needs based on demand projections. The power system is designed to accommodate the maximum peak load of the City, which far exceeds the needs of any one project. In addition, the Electrical Infrastructure Systems Element of the General Plan indicates where major transmission facilities are anticipated.

⁴ LADWP, *The Power System and Los Angeles*, December 1990.

Channel Law Group, LLP

8383 Wilshire Blvd.
Suite 750
Beverly Hills, CA 90211

Phone: (310) 347-0050
Fax: (323) 723-3960
www.channellawgroup.com

JULIAN K. QUATTLEBAUM, III
JAMIE T. HALL *
CHARLES J. McLURKIN

Writer's Direct Line: (310) 982-1760
jamie.hall@channellawgroup.com

*ALSO Admitted in Texas

December 7, 2021

VIA ELECTRONIC MAIL

Planning and Land Use Management Committee
Los Angeles City Council
c/o City Clerk
200 North Spring Street
Los Angeles, CA 90012
clerk.plumcommittee@lacity.org
armando.bencomo@lacity.org

Re: Item No. 11 Agenda for December 7, 2021; ZA-2020-2164-ELD-SPR-1A; ENV-2020-2165-CE-1A; Council File No. 21-0593-S1

Dear Members of the Planning and Land Use Management Committee ("Committee"):

This firm represents Holt Partners ("Association") with regard to the proposed development project located at 825-837 Holt Avenue ("Project"). This letter supplements the correspondence that was submitted earlier today objecting to the Project on CEQA grounds. It has come to my attention that a revised Class 32 Memorandum ("Memorandum") prepared by the City and/or Real Party in Interest. This Memorandum recast the mitigation measure pertaining to noise (temporary noise barriers) as a component of the project in order to avoid the legal maxim that you cannot utilize a mitigation measure to reach a conclusion that a project is exempt from CEQA. See *Salmon Protection & Watershed Network v. County of Marin* (2004) 125 Cal.App.4th 1098.

However, this component is clearly a mitigation measure intended to reduce project impacts. The City cannot now recast it as something else.

In *Lotus v. Department of Transportation* (2014) 223 Cal. App. 4th 645 ("*Lotus*"), Caltrans was found to have certified an insufficient EIR based on its failure to properly evaluate the potential impacts of a highway project. The *Lotus* court found that Caltrans erred by:

. . . incorporating the proposed mitigation measures into its description of the project and then concluding that any potential impacts from the project will be less than significant. As the trial court held, the “avoidance, minimization and/or mitigation measures,” as they are characterized in the EIR, are not “part of the project.” They are mitigation measures designed to reduce or eliminate the damage to the redwoods anticipated from disturbing the structural root zone of the trees by excavation and placement of impermeable materials over the root zones. ***By compressing the analysis of impacts and mitigation measures into a single issue, the EIR disregards the requirements of CEQA.***

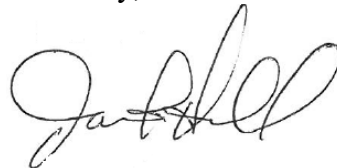
(*Id.* at 655–656, *emph. added.*) The court ordered Caltrans’ certification of the EIR be set aside, finding:

. . . this shortcutting of CEQA requirements subverts the purposes of CEQA by omitting material necessary to informed decisionmaking and informed public participation. It precludes both identification of potential environmental consequences arising from the project and also thoughtful analysis of the sufficiency of measures to mitigate those consequences. The deficiency cannot be considered harmless.

The City is poised to make the same mistake as Caltrans in *Lotus v. Department of Transportation*. In any event, Petitioner’s expert has concluded that the mitigation measure proposed by the City is inadequate to reduce the project’s impacts to a less than significant level.

I may be contacted at 310-982-1760 or at jamie.hall@channellawgroup.com if you have any questions, comments or concerns.

Sincerely,

A handwritten signature in black ink, appearing to read "Jamie T. Hall", with a stylized, cursive script.

Jamie T. Hall

Channel Law Group, LLP

8383 Wilshire Blvd.
Suite 750
Beverly Hills, CA 90211

Phone: (310) 347-0050
Fax: (323) 723-3960
www.channellawgroup.com

JULIAN K. QUATTLEBAUM, III
JAMIE T. HALL *
CHARLES J. McLURKIN

Writer's Direct Line: (310) 982-1760
jamie.hall@channellawgroup.com

*ALSO Admitted in Texas

December 7, 2021

VIA ELECTRONIC MAIL

Planning and Land Use Management Committee
Los Angeles City Council
c/o City Clerk
200 North Spring Street
Los Angeles, CA 90012
clerk.plumcommittee@lacity.org
armando.bencomo@lacity.org

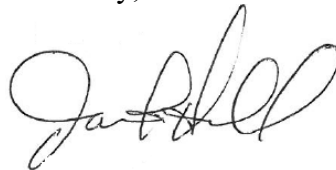
Re: Item No. 11 Agenda for December 7, 2021; ZA-2020-2164-ELD-SPR-1A; ENV-2020-2165-CE-1A; Council File No. 21-0593-S1

Dear Members of the Planning and Land Use Management Committee ("Committee"):

This firm represents Holt Partners ("Association") with regard to the proposed development project located at 825-837 Holt Avenue ("Project"). This letter supplements the correspondence that was submitted earlier today objecting to the Project on CEQA grounds. Petitioner's expert, RK Engineering Group, Inc., has prepared the attached supplemental expert report. See **Exhibit A**. RK Engineering Group has reviewed the November 2021 Noise Study and continues to conclude that the Project will have significant effects on noise. As a result, the Project is ineligible for a Class 32 exemption from CEQA.

I may be contacted at 310-982-1760 or at jamie.hall@channellawgroup.com if you have any questions, comments or concerns.

Sincerely,



Jamie T. Hall

Exhibit A

December 7, 2021

Mr. Jamie Hall
CHANNEL LAW GROUP, LLP
8383 Wilshire Boulevard, Suite 750
Beverly Hills, CA 90211

**Subject: 825-837 South Holt Avenue Noise Impact Review, City of Los Angeles
(Supplemental Review Letter 12/07/2021)**

Dear Mr. Hall:

Introduction

RK ENGINEERING GROUP, INC. (RK) previously prepared the 825-837 South Holt Avenue Noise Impact Review, City of Los Angeles, dated December 6, 2021. The information provided in this review letter was based on the 825 South Holt Avenue Project Noise and Vibration Analysis, dated April 2020 (Noise Study). It has come to our attention that a newer version of the Noise Study, dated November 2021, is now available for review.

The purpose of this supplemental letter is to review November 2021 Noise Study and identify any changes to the analysis that may affect the findings of our original comment letter.

Findings

As described in RK's December 6th letter, a significant construction noise impact is expected to occur at all surrounding residential properties located within 50 feet of the project site. This impact was, to some extent, previously identified in the April 2020 Noise Study and a mitigation measure requiring the installation a 14-foot high temporary construction noise barrier around the site was provide to attempt to reduce the impact.

The November 2021 Noise Study no longer identifies any significant construction noise impact to occur from the project, and has subsequently removed the mitigation measure. It still appears, however, that the analysis has taken credit for the noise barrier as part of the noise reduction calculations, yet no mention of it was found in the report.

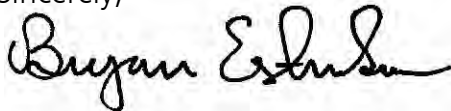
This latest omission in the November Noise Study further conceals the full impact of the project, and there is now an additional concern that the Noise Study has taken more unsubstantiated noise reduction credits without adequate justification. It needs to be clearly stated that the 14-foot high temporary barrier will be installed if it is being assumed as part of the calculation.

Conclusions

Based upon this supplemental review, in conjunction with our previously identified comments and analysis, RK still finds that the Noise Study has not adequately addressed all of the potential noise impacts from the 825-837 South Holt Avenue project in accordance with the LA CEQA Guide and Municipal Code requirements. Given the close proximity to adjacent homes and sensitive receptors, construction activities and mechanical HVAC equipment will cause significant noise impacts. Therefore, the proposed Project does not qualify for a Class 32 Exemption under the California Environmental Quality Act ("CEQA") and 14 Cal. Code of Regs. 1500 et seq. ("CEQA Guidelines"). A full CEQA analysis must be prepared to adequately assess and mitigate the potential noise impacts that the project may have on the surrounding environment. The project should provide additional CEQA review and mitigation to reduce impacts to the maximum extent feasible.

RK appreciates the opportunity to work with the CHANNEL LAW GROUP, LLP. If you have any questions please give call at (949) 474-0809.

Sincerely,

A handwritten signature in black ink, appearing to read "Bryan Estrada".

Bryan Estrada, AICP, PTP
Principal