

U.S. Department of Transportation

Federal Highway Administration

FHWA Roadway Construction Noise Model User's Guide

FHWA-HEP-05-054 DOT-VNTSC-FHWA-05-01 **Final Report** January 2006





Prepared for

U.S. Department of Transportation Federal Highway Administration Office of Natural and Human Environment Washington, DC 20590 Prepared by U.S. Department of Transportation Research and Innovative Technology Administration John A. Volpe National Transportation Systems Center Acoustics Facility Cambridge, MA 02142

NOTICE

This document is disseminated under the sponsorship of the Department of Transportation in the interest of information exchange. The United States Government assumes no liability for its contents or use thereof. This report does not constitute a standard, specification, or regulation.

The United States Government does not endorse products or manufacturers. Trade or manufacturers' names appear herein solely because they are considered essential to the object of this document.

REPORT D	OCUMENTATION PA	GE	Form Approved OMB No. 0704-0188		
Public reporting burden for t including the time for review the data needed, and completi this burden estimate or any c reducing this burden, to Wash Reports, 1215 Jefferson Davis Management and Budget, Paperw	this collection of informatic ring instructions, searching and reviewing the collect ther aspect of this collect ington Headquarters Services Highway, Suite 1204, Arling ork Reduction Project (0704-	on is estimated to avera existing data sources, ion of information. Se on of information, inc. 5, Directorate for Info gton, VA 22202-4302, and -0188), Washington, DC 2	age 1 hour per response, gathering and maintaining end comments regarding luding suggestions for rmation Operations and d to the Office of 20503.		
1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE January 2006		3. REPORT TYPE AND DATES COVERED Final Report January 2004-January 2006		
 4. TITLE AND SUBTITLE FHWA Roadway Construction Noi 6. AUTHOR(S) Reherman, Clay N.⁽³⁾, Rochat, Michael C.⁽³⁾, Fleming, Gregg Christopher⁽¹⁾ 	se Model, Version 1.0 User's Judith L. ⁽³⁾ , Thalheimer, Eric G. ⁽³⁾ , Ferroni, Mark ⁽¹⁾ , Corbis	s Guide ch S. ⁽²⁾ , Lau, ier,	5. FUNDING NUMBERS HW-66/CS036		
7. PERFORMING ORGANIZATION NAME(S) AND U.S. Department of Transporta Research and Innovative Techr John A. Volpe National Transp Environmental Measurement and Cambridge, MA 02142	ADDRESS(ES) Ition Iology Administration Iortation Systems Center I Modeling Division, DTS-34		8. PERFORMING ORGANIZATION REPORT NUMBER DOT-VNTSC-FHWA-05-01		
9. SPONSORING/MONITORING AGENCY NAME(S U.S. Department of Transporta Federal Highway Administratic Office of Natural and Human E Washington, DC 20590) AND ADDRESS(ES) ution n nvironment		10. SPONSORING/MONITORING AGENCY REPORT NUMBER FHWA-HEP-05-054		
 SUPPLEMENTARY NOTES U.S. Department of Transportation Federal Highway Administration Office of Natural and Human Environmen Washington, DC 20590 	(2) Parsons Brinckerhoff Quade & Do 75 Arlington St. t Boston, MA 02116	ouglas Inc. (3) U.S. Departmen Research and Innov John A. Volpe Nati Environmental Meas Cambridge, MA 021	at of Transportation vative Technology Administration conal Transportation Systems Center surement and Modeling Division 42		
12a. DISTRIBUTION/AVAILABILITY STATEME This document is available to Information Service, Springfi	NT) the public through the Nati eld, VA 22161	onal Technical	12b. DISTRIBUTION CODE		
13. ABSTRACT (Maximum 200 words)					
The Roadway Construction Noise for the prediction of construc proximity to residences and bus on surrounding communities. I projects' progress. Each pro contractor's need to progress t	e Model (RCNM) is the Federa ction noise. Due to the fa sinesses, construction noise in addition to community iss oject needs to balance the che work.	al Highway Administrati act that construction i must be controlled and sues, excessive noise o community's need for	ion's (FHWA) national model is often conducted in close d monitored to avoid impacts can threaten a construction peace and quiet with the		
During the Central Artery/Tur program developed the Constr specification ever developed i construction noise prediction s state and local governments, calculations and equipment d construction noise screening t noise limits for a variety of c	mel (CA/T) project in Bos action Noise Control Speci n the United States. As p spreadsheet was developed. If the FHWA developed the atabase used in the CA/T col to easily predict constr construction noise projects of	ton, Massachusetts, th fication 721.560, the art of the CA/T projec Because the CA/T predic RCNM, which is based prediction spreadshee ruction noise levels an of varying complexity.	he project's noise control e most comprehensive noise ct noise control program, a tion tool can benefit other d on the noise prediction et. The RCNM provides a d determine compliance with		
14. SUBJECT TERMS			15. NUMBER OF PAGES		
construction noise, noise lev Highway Administration	eis, dBA, noise models, comm	unity impact, Federal	16. PRICE CODE		
17. SECURITY CLASSIFICATION OF REPORT	 SECURITY CLASSIFICATION OF THIS PAGE 	19. SECURITY CLASSIFICATIO OF ABSTRACT	DN 20. LIMITATION OF ABSTRACT		
Unclassified	Unclassified	Unclassified	Unlimited		

Standard Form 298(Rev. 2-89) Prescribed by ANSI Std. 239-18 298-102

METRIC/ENGLISH CO	INVERSION FACTORS							
ENGLISH TO METRIC	METRIC TO ENGLISH							
LENGTH (APPROXIMATE)	LENGTH (APPROXIMATE)							
1 inch (in) = 2.5 centimeters (cm)	1 millimeter (mm) = 0.04 inch (in)							
1 foot (ft) = 30 centimeters (cm)	1 centimeter (cm) = 0.4 inch (in)							
1 yard (yd) = 0.9 meter (m)	1 meter (m) = 3.3 feet (ft)							
1 mile (mi) = 1.6 kilometers (km)	1 meter (m) = 1.1 yards (yd)							
	1 kilometer (km) = 0.6 mile (mi)							
AREA (APPROXIMATE)	AREA (APPROXIMATE)							
1 square inch (sq in, in ²) = 6.5 square centimeters (cm ²)	1 square centimeter (cm ²) = 0.16 square inch (sq in, in ²)							
1 square foot (sq ft, ft^2) = 0.09 square meter (m ²)	1 square meter (m ²) = 1.2 square yards (sq yd, yd ²)							
1 square yard (sq yd, yd ²) = 0.8 square meter (m ²)	1 square kilometer (km ²) = 0.4 square mile (sq mi, mi ²)							
1 square mile (sq mi, mi ²) = 2.6 square kilometers (km ²)	10,000 square meters $(m^2) = 1$ hectare (ha) = 2.5 acres							
1 acre = 0.4 hectare (he) = 4,000 square meters (m^2)								
MASS – WEIGHT (APPROXIMATE)	MASS – WEIGHT (APPROXIMATE)							
1 ounce (oz) = 28 grams (gm)	1 gram (gm) = 0.036 ounce (oz)							
1 pound (lb) = 0.45 kilogram (kg)	1 kilogram (kg) = 2.2 pounds (lb)							
1 short ton = 2,000 = 0.9 tonne (t) pounds (lb)	1 tonne (t) = 1,000 kilograms (kg) = 1.1 short tons							
1 teaspoon (tsp) = 5 milliliters (ml)	1 milliliter (ml) = 0.03 fluid ounce (fl oz)							
1 tablespoon (tbsp) = 15 milliliters (ml)	1 liter (I) = 2.1 pints (pt)							
1 fluid ounce (fl oz) = 30 milliliters (ml)	1 liter (I) = 1.06 guarts (gt)							
1 cup © = 0.24 liter (I)	1 liter (I) = 0.26 gallon (gal)							
1 pint (pt) = 0.47 liter (l)								
1 quart (qt) = 0.96 liter (l)								
1 gallon (gal) = 3.8 liters (l)								
1 cubic foot (cu ft, ft ³) = 0.03 cubic meter (m ³)	1 cubic meter (m ³) = 36 cubic feet (cu ft. ft ³)							
1 cubic yard (cu yd, yd ³) = 0.76 cubic meter (m ³)	1 cubic meter (m^3) = 1.3 cubic yards (cu yd, yd ³)							
TEMPERATURE (EXACT)	TEMPERATURE (EXACT)							
[(x-32)(5/9)] °F = y °C	[(9/5) y + 32] °C = x °F							
QUICK INCH - CENTIMET	ER LENGTH CONVERSION							
0 1 2	3 4 5							
Inches								
Centimeters $\begin{array}{c c} & & & \\ 0 & 1 & 2 & 3 & 4 & 5 \end{array}$	6 7 8 9 10 11 12 13							
QUICK FAHRENHEIT - CELSIUS TEMP	PERATURE CONVERSION							
°F -40°22° -4° 14° 32° 50° 68°	° 86° 104° 122° 140 158 176194212°							
C-40-30° -20° -10° 0° 10° 20° For more exact and or other conversion factors, see NIST Mice	30° 40° 50° 60° /0° 80° 90°100°							
Price \$2.50 SD Catalog No. C13 10286.	Updated 6/17/98							

Table of Contents

Section	Page
Table of Contents	i
List of Figures	ii
List of Tables	iii
1 Introduction	1
2 Background	2
3 The RCNM	4
3.1 RCNM Main Page	4
3.1.1 File Menu	5
3.1.2 Edit Menu	5
3.1.3 View Menu	6
3.1.4 Options Menu	6
3.1.5 Help Menu	
3.2 Input Data	
3.2.1 Receptors	
3.2.2 Equipment	9
3.2.3 Noise Metric and Noise Limit Criteria	10
4 Results	18
5 Calculations in the RCNM	20
5.1 Metric Calculation	20
5.2 Exceedance Calculation	20
5.3 Totals Calculation	
6 References	22
Appendix A: Best Practices for Calculating	
Estimated Shielding for Use in the RCNM.	A-1

List of Figures

<u>Fig</u>	ure	Page
1	The PCNM main page	1
1. 2	-Files Menu	
2. 3	<pre></pre>	
З. Л	-Viaw- Manu	
4. 5	< View > Menu	0
5. 6	Equipment list modification dialogue box	0 7
0. 7	Units modification pull-down menu	
8	Equipment dialogue box with pull-down menu shown	9
9.	Noise Metric pull-down menu	
10.	Noise Limit Criteria pop-up dialogue box	
11.	The Noise Limit Criteria "Clear" command button	
12.	Noise Limit Criteria pull-down menu	
13.	Noise Limit Criteria "Value" dialogue box	
14.	Noise Limit Criteria "Maximum" dialogue box	
15.	Noise Limit Criteria "Baseline +" dialogue box	
16.	Noise Limit Criteria "Conditional" dialogue box	
17.	L10 Adjustment dialogue box	
18.	Noise Limits display window	
19.	The RCNM main-page Results display	

List of Tables

Table	Page
1. CA/T equipment noise emissions and acoustical usage factors database	3
2. Default Noise Limit Criteria	11

1 Introduction

The Roadway Construction Noise Model (RCNM) is the Federal Highway Administration's (FHWA) national model for the prediction of construction noise. Due to the fact that construction is often conducted in close proximity to residences and businesses, construction noise must be controlled and monitored to avoid impacts on surrounding communities. In addition to community issues, excessive noise can threaten a construction project's progress. Each project needs to balance the community's need for peace and quiet with the contractor's need to progress the work.

The Central Artery/Tunnel (CA/T) project in Boston, Massachusetts, which began in the early 1990s, is the largest urban construction project ever conducted in the United States. Its noise control program developed the Construction Noise Control Specification 721.560, the most comprehensive noise specification ever developed in the United States [1]. As part of the CA/T project noise control program, a construction noise prediction spreadsheet was developed [2]. Because the CA/T prediction tool can benefit other state and local governments, the FHWA developed the RCNM, which is based on the noise prediction calculations and the equipment database used in the CA/T prediction spreadsheet. The RCNM provides a construction noise screening tool to easily predict construction noise levels and to determine compliance with noise limits for a variety of construction noise projects of varying complexity.

2 Background

The RCNM is a national model based on the noise calculations and extensive construction noise data compiled for the CA/T Project. The basis for the national model is a spreadsheet tool developed in support of the CA/T project [2]. The CA/T predictions originated from Environmental Protection Agency (EPA) noise level work [3] and an Empire State Electric Energy Research Corp. Guide [4] which utilizes an "acoustical usage factor" to estimate the fraction of time each piece of construction equipment is operating at full power (i.e., its loudest condition) during a construction operation. Table 1 presents a construction equipment noise database compiled through the CA/T project [2]. This database is used to predict construction noise within the RCNM. The noise levels listed represent the A-weighted maximum sound level (Lmax), measured at a distance of 50 feet from the construction equipment.

filename: EQUIPLST.xls			•		
revised: 7/26/05		Acoustical	Spec 721.560	Actual Measured	No. of Actual
	Impact	Use Factor	Lmax @ 50ft	Lmax @ 50ft	Data Samples
Equipment Description	Device ?	<u>(%)</u>	(dBA, slow)	(dBA, slow)	(Count)
All Other Equipments FLID	No	50	05	(samples averaged)	0
All Other Equipment > 5 HP	NO	50	80	IN/A	0
Backboe	No	40	80	04 78	372
Bar Bender	No	20	80	N/Δ	0
Blasting	Yes	N/A	94	N/A	0
Boring Jack Power Unit	No	50	80	83	1
Chain Saw	No	20	85	84	46
Clam Shovel (dropping)	Yes	20	93	87	4
Compactor (ground)	No	20	80	83	57
Compressor (air)	No	40	80	78	18
Concrete Batch Plant	No	15	83	N/A	0
Concrete Mixer Truck	No	40	85	79	40
Concrete Pump Truck	No	20	82	81	30
Concrete Saw	No	20	90	90	55
Crane	No	16	85	81	405
Dozer	No	40	85	82	55
Drill Rig Truck	No	20	84	79	22
Drum Mixer	No	50	80	80	1
Dump Truck	No	40	84	76	31
Excavator	No	40	85	81	170
Flat Bed Truck	No	40	84	74	4
Front End Loader	No	40	80	79	96
Generator	No	50	82	81	19
Generator (<25KVA, VMS signs)	No	50	70	73	74
Gradall	No	40	85	83	70
Grader	No	40	85	N/A	0
Grappie (on backnoe)	NO	40	85	87	1
Horizontal Boring Hydr. Jack	NO	25	80	82	6
Hydra Break Ram	Yes	10	90	N/A	0
	Yes	20	90	101	122
Man Lift	No	20	85	75	22
Mounted Impact Hammer (hoe ram)	Ves	20	90	90	23
Pavement Scarafier	No	20	85	90	212
Paver	No	50	85	77	9
Pickup Truck	No	40	55	75	1
Pneumatic Tools	No	50	85	85	90
Pumps	No	50	77	81	17
Refrigerator Unit	No	100	82	73	3
Rivit Buster/chipping gun	Yes	20	85	79	19
Rock Drill	No	20	85	81	3
Roller	No	20	85	80	16
Sand Blasting (Single Nozzle)	No	20	85	96	9
Scraper	No	40	85	84	12
Shears (on backhoe)	No	40	85	96	5
Slurry Plant	No	100	78	78	1
Slurry Trenching Machine	No	50	82	80	75
Soil Mix Drill Rig	No	50	80	N/A	0
Tractor	No	40	84	N/A	0
Vacuum Excavator (Vac-truck)	No	40	85	85	149
Vacuum Street Sweeper	No	10	80	82	19
Ventilation Fan	No	100	85	79	13
Vibrating Hopper	No	50	85	87	1
Vibratory Concrete Mixer	No	20	80	80	1
Vibratory Pile Driver	No	20	95	101	44
Warning Horn	No	5	85	83	12
vveider / Torch	No	40	/3	/4	5

Table 1. CA/T equipment noise emissions and acoustical usage factors database.

3 The RCNM

The RCNM is a computer program used to assess construction noise impacts. The computer on which it is installed should be equipped with the Microsoft Windows 98 or newer operating system (OS) and 192 MB or more of random access memory (RAM). The display should be set to 1024×768 pixels or greater, and the computer should carry the Adobe Acrobat 4.0 or newer software.

The RCNM allows the estimation of three key metrics of interest: Lmax, Leq, and L10 at receptor locations for a construction operation that can include up to 20 pieces of equipment. RCNM allows for user-defined construction equipment and user-defined noise limit criteria. The two main uses of the RCNM are to allow typical computer users to: 1. easily predict noise emissions from construction equipment, and 2. determine a construction work plan's compliance with noise criteria limits. A variety of construction work scenarios can be created quickly, allowing the user to determine the impact of changing construction equipment and adding/removing the effects of shielding due to noise mitigation devices such as barriers.

3.1 RCNM Main Page

The RCNM consists of one main display page with Input Data and Results sections, shown in Figure 1.

	nu		- 10 K														
n		Case Do	escription														
Hece	eptor					D		Function	MG.	de Minera	•		Noise	Metric:	L10	•	
		Description		Land	Use	B	aseline (dBA)	Baseline (dBA)	Ba	iseline BA)	-			loise Lin	nit Criter	ia)	
1	N-231 i	n C17A6	Residen	ntial		-	78.0	75.	0	71.0	0			L10 Ca	lculatio	n	
2						-			_		_		-				
3	-					-					-				Recep	tor #1	
4	w/						-		- 20						Noise	Limite	10
Equi	pment	Receptor	#1: N-231 i	in C17A	6												
	Active	Desc	ription		Impact Device	Usage(%)	Spec Lmax (dBA)			Actua Lmax (dBA)	4	Distance to Receptor (feet)	Estima Shieldi (dBA	ted 📥		
1	V	Compactor (ground)		-	1	20	1% 🗐		80.0	V	1	83.2	50.0	1	0.0		
2		Concrete Saw		-		20)% 🗐		90.0	V		89.6	50.0)	0.0		
3	V	Dozer		-		40)% 🗐		85.0	V		81.7	50.0)	0.0		
4	V	Flat Bed Truck		-	-	40)% 📃		84.0			74.3	50.0)	0.0		
5	V	Excavator		-		40)% 🔳		85.0	V		80.7	50.0	0	0.0		
6	101			-	-		10			-					•		
lts						Rece	eptor #1:	N-231 in	C17A	6							
			Calculated	- (dBA)			Noise Lin	nits (dBA)					Noise	Limit Exce	edance ((ABB	J.
			Curoundled	a (april	D	av	Eve	ninq		Night		D	ay	Even	ing	Nig	ht
		Equipment	Lmax*	L10	Lmax	L10	Lmax	L10	Lmax	L	10	Lmax	L10	Lmax	L10	Lmax	L10
C	ompactor	rotal	03.0	79.2	95.0	03.0	00.U	90.0	00	0	74.0	4.b	0.3 None	4.0	0.3	3.6	14.3 5.2
	ompactul oncrete 9	(ground) Saw	89.6	85.6	85.0	83.0	85.0	80.0	20	0	74.0	1000	26	4.6	56	9.6	11.6
	07er		81.7	80.7	85.0	83.0	85.0	80.0	80	0	74.0	None	None	None	0.7	1.7	6.7
	LID IT	ruck	74.3	73.3	85.0	83.0	85.0	80.0	80	.0	74.0	None	None	None	None	None	None
D	аг кел т			. 0.0	05.0	00.0	05.0	00.0	00	0	74.0	Mana	None	Mone	None	0.7	E 7 .
D	at Bed 1 xcavator		80.7	79.7	85.0	83.0	85.0	80.0	00	.0.	74.01	NUME	NONE	NONE	1400161	0.71	3.7

Figure 1. The RCNM main page

Several command buttons and pull-down menus allow the user to modify the input data before results are calculated by the model.

3.1.1 File Menu

The <File> menu, shown in Figure 2, contains items that allow the user to create, open, and save a case, export the results of a case, and exit the program.



Figure 2. <File> Menu

- <New> creates a new case. If a case is currently open, the user is prompted to save it before closing.
- <Open...> allows the user to open an existing case file ([name].cas).
- <Save> saves the case with the current filename. If this is a new case, the user is asked for a new filename ([name].cas).
- <Save As...> The user is asked for a filename for a new case ([name].cas) and saves the case with that filename.
- <Export Results> prompts the user to save the case results for the current or all receptors to a comma separated value (CSV) file with the following naming convention: [name].csv. This type of file is easily read into a spreadsheet program. The user can also save the case results to a text file (TXT), which saves the results to a space-separated text format with the following naming convention: [name].txt.
- <Exit> closes the application. If changes have been made to the open case, the user is asked if he/she would like to save the case.

3.1.2 Edit Menu

The <Edit> menu, shown in Figure 3, allows the user to copy and paste data, delete data, and undo changes.



Figure 3. <Edit> Menu

- <Copy> lets the user copy into a clipboard the contents of a single cell or an entire line from an RCNM dialogue box.
- <Paste> lets the user copy the contents of the clipboard into a single cell or an entire line of an RCNM dialogue box.
- <Delete> lets the user delete from the case a receptor or piece of equipment selected in the receptor or equipment dialogue box.
- <Undo> lets the user revert the RCNM one step to where it was before the latest change was made.

3.1.3 View Menu

The <View> menu, shown in Figure 4, allows the user to focus in <Zoom +> on either the Input Data or Results section of the RCNM's main page. To activate Zoom +, click on Zoom + and guide the spyglass + icon to either Input Data or Results and single-click.



Figure 4. <View> Menu

To deactivate Zoom + and go back to the full RCNM screen, click on <math>Zoom - and guide the spyglass - icon to the Input Data or Results section that has been maximized on the screen.

3.1.4 Options Menu

The <Options> menu, shown in Figure 5, allows the user to modify the equipment list and change the case's units of measure from feet to meters.

Þ	Noadway Construction Noise Model (RCNM)										
File	Edit	View	Options	Help							
	Inp	ut Da	Modify	/ the Equipment List							
	•		Units		۲	iption:					
		Rec	eptor		_						
				Description		Land					

Figure 5. <Options> menu

The <Options> menu allows the user to add new types of equipment to the equipment list. The equipment list modification dialogue box, shown in Figure 6, allows the user to specify a user-defined piece of equipment and add it. The user can specify the following

data: whether the equipment is an impact device, the equipment's usage factor¹, and the equipment's Lmax level (spec and/or actual²). The user can also delete equipment that's been added by selecting it and clicking the delete button. The default equipment cannot be modified, but it may be deleted entirely from the case by selecting it and clicking the delete button. Selecting the default button restores the default equipment list (from the CA/T Project) and eliminates any user-defined equipment.

ſ		Add this it			1	
	Description	Impact Device	Usage(%)	Spec Lmax (dBA)	Actual Lmax (dBA)	
- 33			0% N	/A N	¶/A	
1	All Other Equipment > 5 HP		50%	(dBA) 85.0	(dBA) N/A	۲ ۲
1	All Other Equipment > 5 HP		50%	85.0	N//	Ā
2	Auger Drill Rig	121	20%	85.0	84.4	4
3	Backhoe		40%	80.0	77.6	5
4	Bar Bender Plasting		20%	80.0	N/A	4 -
		Delete				

Figure 6. Equipment list modification dialogue box

Data for user-defined pieces of equipment may be saved to an equipment file ([name].equ), along with all other equipment in the current list, including default equipment. This file may be opened in other cases to incorporate these pieces of equipment.

The <Options> menu, as shown in Figure 7, also allows the user to change the case's units of measure from feet to meters or from meters to feet. The only input data affected by this tool are the Distance to Receptor values.

¹ Usage factor is the percentage of time during a construction noise operation that a piece of construction equipment is operating at full power. In the case of construction blasting, the equipment gives a very short duration blast, and can be quantified by using a 1% usage factor in the RCNM to allow for some prediction. Never use a usage factor of zero because the log of zero causes a mathematical impossibility. The usage factor term only affects the computation of Leq and L10. The usage factor does not enter into the equation when calculating the more important term for blasting, that being the Lmax.

² "Spec" refers to noise levels stated in noise specifications, and "Actual" refers to Lmax values measured at 50 ft from the equipment.



Figure 7. Units modification pull-down menu

3.1.5 Help Menu

The <Help> Menu loads for the user the RCNM User's Guide in Portable Document Format (PDF). This PDF is searchable by key word using the Adobe Acrobat Edit / Find search tool.

3.2 Input Data

The user is required to input receptor data and equipment data before a case can be processed. The user is advised to type in some summary comments about the case in the Case Description dialogue box before inputting data. Also, in order to determine noise limit exceedance values, the user can input noise limit criteria.

3.2.1 Receptors

Multiple receptors may be input for a case, but only one receptor may be processed at a time. The name of the highlighted receptor chosen for processing appears in blue type above the Equipment input dialogue box and the Noise Limits command button (see Figure 1). The user specifies the receptors for a study by entering information into the Receptors input box in the main window of the RCNM. The user is required to enter the receptor name, land use, daytime baseline L10 or Leq, evening baseline L10 or Leq, and nighttime baseline L10 or Leq. The baseline levels indicate the sound level at a receptor before any construction noise contributions. Baseline levels are only necessary if the desired noise criteria limits are based on *relative* increases in noise level. If the desired noise criteria limits are based on the user should insert a placeholder number other than zero.

When entering information for more than one receptor, it may be desirable to copy information already entered. An entire receptor row may be highlighted and copied to another row, where copying multiple rows requires the selection of the same number of rows when pasting (this same functionality also applies to editable cells). Note: Entire rows may be selected by clicking on the row number.

Again, the RCNM will only calculate results for the receptor displayed in blue type in the Input Data portion of the main page. The results for other receptors may be displayed by selecting the desired receptor in the Receptor window; to select a receptor, click in any cell in the row. Up to 100 receptors may be included in any case. Information for receptors is saved in the case file ([name].cas).

3.2.2 Equipment

Core equipment noise data are stored in the RCNM and are accessible by a pull-down menu in the main page, as in Figure 8.

	Active	Description	Impact Device	Usage(%)	Sj Lr (d	pec max BA)	Ac Ln (df	tual nax BA)	Distance to Receptor (feet)	Estimated . Shielding (dBA)
1 🗹		Compactor (ground) 🗸 🗸		20%		80.0	1	83.2	50.0	0.0
2	V	Concrete Saw 👻		20%		90.0	V	89.6	50.0	0.0
3	V	Dozer 👻		40%		85.0	V	81.7	50.0	0.0
4	V	Flat Bed Truck 👻		40%		84.0	V	74.3	50.0	0.0
5	V	Excavator 👻		40%		85.0	V	80.7	50.0	0.0
6		Crane Dozer Drill Rig Truck Drum Mixer Dump Truck Eveawalor								

Figure 8. Equipment dialogue box, with pull-down menu shown

As discussed in Section 3.1.4, new pieces of equipment may be added to a case and saved in an equipment file ([name].equ). When the user-defined equipment file is opened through the <Options> / <Modify the Equipment List> menu, user-defined equipment will appear in the equipment pull-down menu. The user activates and inactivates chosen equipment types by ticking and unticking the "Active" checkbox. The user is required to specify:

- 1. The type of reference emission levels to use ("Spec", if applicable, or "Actual", [the default is "Actual"]);
- 2. Distance to Receptor that is, the distance between each type of equipment and the receptor being analyzed (the default distance is 50 feet); and
- 3. Estimated Shielding (in dBA) associated with each type of equipment (can leave the default value of 0.0 when not considering shielding). NOTE: A Best Practices document is presented in Appendix A showing how to determine Estimated Shielding using several Rules of Thumb developed from experience at the CA/T project.

When entering information for more than one piece of equipment, it may be desirable to copy information already entered. An entire equipment row may be highlighted and copied to another row, where copying multiple rows requires the selection of the same number of rows when pasting (this same functionality also applies to editable cells). Note: Entire rows may be selected by clicking on the row number.

The user may analyze up to 20 pieces of equipment at one time, and they may be included in any combination of different or identical equipment types.

3.2.3 Noise Metric and Noise Limit Criteria

While a case is open, the user can choose a noise metric (for baseline levels, noise limits, and calculated results) and enter the noise limit criteria for a local area. The user may edit the Lmax and L10 or Leq day, evening, and night noise limit criteria for a residential, commercial, or industrial area. Daytime, evening, and nightime may represent any time periods the user wishes, but they are typically defined as 7 AM to 6 PM, 6 PM to 10 PM, and 10 PM to 7 AM, respectively. The criteria, used together with the baseline sound levels, define the noise limits for each receptor. CA/T Noise Limit Criteria are used as a default [1], but users may input their own criteria. The RCNM offers a metric pull-down menu and two or three command buttons to the right of the Receptor input dialogue box.

• Metric Pull-Down Menu

A pull-down menu allows the user to choose between the L10 or Leq metric, as in Figure 9. The chosen metric represents that used for the baseline levels, noise limits, and calculated results. For the noise limits and calculated results, Lmax values are also included.



Figure 9. Noise Metric pull-down menu

• Noise Limit Criteria Pop-up Dialogue Box

A pop-up dialogue box allows the user to specify Noise Limit Criteria information for an area being studied in a case, as in Figure 10. The flexibility of the Noise Limit Criteria allows RCNM users to incorporate criteria based on local noise ordinances and baseline levels measured for each receptor.

scription		Land Use		Daytime Baseline (dBA)	Evening Baseline (dBA)	Nighttime Baseline (dBA)		N	oise Limit Cı	iteria
	Comm	ercial	-	78.0	77.0	75.0			L10 Calcula	tion
pise Limit C Lmax (dBA)	riteria								Noi	MIC7 se Limits
	n	au	Eve	enina	Nic	aht				
i i i	Impact	Non-Impact	Impact	Non-Impact	Impact	Non-Impact	_		Ē.	-
Residential	Value	Value	Value	Value	Value	Value	ctu	ıal	Distance to	Estimate
Commercial	N/A	N/A	N/A	N/A	N/A	N/A	Lma HBA	.× 4)	(feet)	(dRA)
1	N1.74	NI/A	N/A	N/A	N/A	N/A	-	9	(1001)	(3011)
L10 (dBA)	NZA	176								
L10 (dBA)	117A	Day	Ev	ening	N	iqht				
L10 (dBA)	IN/A	Day Non-Impact	Ev Impact	ening Non-Impact	N Impact	ight Non-Impact			· · · · · · · · · · · · · · · · · · ·	
L10 (dBA)	Impact Exempt	Day Non-Impact Maximum	Ev Impact Baseline+	ening Non-Impact Baseline+	N Impact Conditional	ight Non-Impact Conditional				
L10 (dBA) Residential Commercial	Impact Exempt Exempt	Day Non-Impact Maximum Maximum	Ev Impact Baseline+ N/A	ening Non-Impact Baseline+ N/A	N Impact Conditional N/A	ight Non-Impact Conditional N/A				
L10 (dBA) Residential Commercial Industrial	Impact Exempt Exempt Exempt	Day Non-Impact Maximum Maximum Maximum	Ev Impact Baseline+ N/A N/A	ening Non-Impact Baseline+ N/A N/A	N Impact Conditional N/A N/A	ight Non-Impact Conditional N/A N/A				
L10 (dBA) Residential Commercial Industrial	Impact Exempt Exempt	Day Non-Impact Maximum Maximum Open S	Ev Impact Baseline+ N/A N/A	ening Non-Impact Baseline+ N/A N/A ar Default	N Impact Conditional N/A N/A	ight Non-Impact Conditional N/A N/A		D	Noise Li ay L10 L	nit Excee Evenin max
L10 (dBA) Residential Commercial Industrial	Impact Exempt Exempt	Day Non-Impact Maximum Maximum Open S	Ev Impact Baseline+ N/A N/A ave Clea	ening Non-Impact Baseline+ N/A N/A ar Default	N Impact Conditional N/A N/A	ight Non-Impact Conditional N/A N/A		D	Noise Li ay L10 L	nit Exceec Eveninc max I

Figure 10. Noise Limit Criteria pop-up dialogue box

The user may populate this dialogue box with Noise Limit Criteria information derived from CA/T Construction Noise Control Spec. 721.560 [1] by clicking on the "Default" command button and clicking "Yes" when asked to load information from the default file, which is stored in the RCNM (see Table 2).

	Daytime (7	AM to 6 PM)	Evening (6 PM	M to 10 PM)	Nighttime (10	PM to 7 AM)
Land Use	L10 Limit (dBA)	Lmax Limit (dBA)	L10 Limit (dBA)	Lmax Limit (dBA)	L10 Limit (dBA)	Lmax Limit (dBA)
Residential	maximum of 75 and baseline + 5 for non- impact [*] and exempt for impact ^{**}	85 for non- impact and 90 for impact	baseline + 5	85	if baseline <70 then baseline +5; if baseline ≥70 then baseline + 3	80
Commercial	maximum of 80 and baseline + 5 for non- impact and exempt for impact	N/A	N/A	N/A	N/A	N/A
Industrial	maximum of 85 and baseline+5 for non-impact and exempt for impact	N/A	N/A	N/A	N/A	N/A

 Table 2. Default Noise Limit Criteria

Non-impact equipment is equipment that generates a constant noise level while in operation.

^{**} Impact Equipment is equipment that generates impulsive noise. Impulse Noise is defined as noise produced by the periodic impact of a mass on a surface, of short duration (generally less than one second), high intensity, abrupt onset and rapid decay, and often rapidly changing spectral composition.

Otherwise, the user may clear any information present in the dialogue box and specify new data in each cell. Clicking on the "Clear" command button will prompt the user to set all the cells in the dialogue box to Not Applicable (N/A), as in Figure 11. By clicking "Yes," the user will populate all cells with N/A; by clicking "No," the dialogue box will return to the data present before the user clicked "Clear."



Figure 11. The Noise Limit Criteria "Clear" command button

Clicking on any cell in the Noise Limit Criteria dialogue box reveals a Noise Limit Criteria pull-down menu. Click on this pull-down menu to access the six options, as in Figure 12.

Rece		Case Description						-							
	otor				-	~ .					Noise	e Metric:	L10	•	
0	Noise Limit Cr	iteria						- 🗆 🖻	3 🗌			Noise Lin	nit Criter	ia	
1	I may (dBA)											L10 Ca	lculatio	n	
3		Dav	- îl	Evenir	10		Viaht	1							
4		Impact Non-Im	pact In	npact N	Ion-Impact	Impact	Non-li	mpact	_				necep		1
	Residential	Value Valu	ie V	alue	Value	Value	Va	ue					Noise	Limits	
Fai	Commercial	N/A N//	4	N/A	20								\mathbf{X}		
	Industrial	Exempt Maxi	num	N/A Clear	Default]			Ok	Cance					
ults			OK	Cance	el 🛛						Noise	Limit Exce	edance (d	(BA)	
ults				_						Day	1	Even	ing	Nig	nt 📃
	_				110	Lmax	L10	Lmax 80.0	L10 74.0	Lmax 4.6	L10	Lmax 4.6	L10 8.3	Lmax	L10
	Equipment	Lmax*	L10	Lmax 85.0	83.0	85.0	8111	00.0	74.0	None	None	None	None	3.2	5.2
ults 1 Co	Equipment Total mpactor (ground)	Lmax* 89.6 83.2	L10 88.3 79.2	Lmax 85.0 85.0	83.0 83.0	85.0 85.0	80.0	80.0	74.0						
1 Co 2 Co	Equipment Total mpactor (ground) ncrete Saw	Lmax* 89.6 83.2 89.6	L10 88.3 79.2 85.6	Lmax 85.0 85.0 85.0	83.0 83.0 83.0	85.0 85.0 85.0	80.0 80.0 80.0	80.0 80.0	74.0	4.6	2.6	4.6	5.6	9.6	11.6
1 Co 2 Co 3 Do	Equipment Total mpactor (ground) ncrete Saw zer	Lmax* 89.6 83.2 89.6 81.7	L10 88.3 79.2 85.6 80.7	Lmax 85.0 85.0 85.0 85.0	83.0 83.0 83.0 83.0	85.0 85.0 85.0 85.0	80.0 80.0 80.0 80.0	80.0 80.0 80.0	74.0	4.6 None	2.6 None	4.6 None	5.6 0.7	9.6	6.7
1 Co 2 Co 3 Do 4 Fia	Equipment Total mpactor (ground) ncrete Saw zer zer t Bed Truck	Lmax* 89.6 83.2 89.6 81.7 74.3 90.7	L10 88.3 79.2 85.6 80.7 73.3 79.7	Lmax 85.0 85.0 85.0 85.0 85.0	83.0 83.0 83.0 83.0 83.0 83.0	85.0 85.0 85.0 85.0 85.0	80.0 80.0 80.0 80.0 80.0	80.0 80.0 80.0 80.0	74.0 74.0 74.0 74.0 74.0	4.6 None None	2.6 None None	4.6 None None	5.6 0.7 None	9.6 1.7 None	11.6 6.7 None

Figure 12. Noise Limit Criteria pull-down menu

Through these six options, the user specifies what Noise Limit Criteria changes, if any, are desirable in each cell. The six cell options are:

- i. Exempt (for the specified metric and land use, the equipment is exempt from noise limits)
- ii. N/A (for the specified metric and land use, the equipment does not have applicable noise limits)
- iii. Value (user is prompted to enter a value for which the noise level should not exceed), as in Figure 13:

					No	iise Limit Cr L10 Calcula	iteria tion
rimpact	Ev Impact	ening Non-Impact	Nic Impact	aht Non-Impact		Noi	MIC7 se Limits
	alue 💽	Value	= 85 .	IBA		Distance to Receptor (feet)	Estimate Shielding (dBA)
a a pen	Save Cle	ar Default	Ok	Cancel		<u> </u>	

Figure 13. Noise Limit Criteria "Value" dialogue box

iv. Maximum (set value for which a noise level should not exceed to the maximum of two possible levels: A user-defined level or the Baseline level plus some user-defined increment), as in Figure 14:

						L10 Calcula	tion
Impact	Evenin Impact N	q polypact	Night	there			MIC7
	impoce int	on impact	impact norm		Ð	3 Noi	se Limits
Max - h	ximum 💌	Valu	e = Maximumum o c	of dBA or Baseline +	dBA	Distance to Receptor (feet)	Estimate Shieldin (dBA)
a a			Ok	Cancel			

Figure 14. Noise Limit Criteria "Maximum" dialogue box

v. Baseline + (set value for which a noise level should not exceed to the Baseline level plus some user-defined increment), as in Figure 15:

				_ D >		No L	ise Limit Cri .10 Calcula	iteria tion
	Ev	ening	N	light			2	MIC7
	Impact	Non-Impact	Impact	Non-Impact		X	Noi	se Limits
	aseline+	v	alue = Ba:	seline +	dBA		Distance to Receptor (feet)	Estimate Shieldin (dBA)
n- la la			0	k Cancel				
pen 9	ave Cle	ar Default]					

Figure 15. Noise Limit Criteria "Baseline +" dialogue box

vi. Conditional (set conditional value for which a noise level should not exceed; the user is prompted to enter the following information: 1. a comparison value, i.e., "If Baseline < [value], then ..."; 2. an increment value to add to the baseline level if the baseline level is *less than* the comparison value; 3. an increment value to add to the baseline level if the baseline level is *greater than or equal to* the comparison value), as in Figure 16:

				oise Limit Cri L10 Calcula	iteria Ition
w Non-Impact	Evening Impact Non-Impa	Night ict Impact Non-Impact		Noi	MIC7 se Limits
av No	Jitional 💌 If El	Baseline < dBA Then Value = Baseline + Value = Baseline +	dBA dBA	Distance to Receptor (feet)	Estimate Shieldin (dBA)
Open S	ave Clear Defa	Ok Cancel			

Figure 16. Noise Limit Criteria "Conditional" dialogue box

To see the current value of a cell, simply hold the mouse pointer over the cell. Once the user has specified values for all the cells in the Noise Limit Criteria dialogue box, these criteria can be saved in a criteria file ([name].cri) by clicking on the "Save" command button. The user will be prompted to give the criteria file a name. These criteria can thereafter be loaded into any case by clicking on the "Open" command button.

The user returns to the Noise Limit Criteria dialogue box by clicking "Ok", and returns to the case by clicking "Ok" again.

• L10 Calculation (this button is present if the L10 metric is chosen)

By clicking on the "L10 Calculation" command button, the user can specify the adjustment factor used to calculate L10, as in Figure 17. By clicking the "Default" command button, the user automatically calls for an adjustment factor of 3 dBA, a value empirically derived from extensive CA/T Project data [2].

Bece		Case De	scription						_							
	eptor											Nois	Metric:	L10	-	
		Description		Land Use	e	B	aytime aseline (dBA)	Evening Baseline (dBA)	Nighttir Baselir (dBA)				Noise Lin	nit Criteri	ia	
1	N-231 i	n C17A6	Residential			-	78.0	75.	0 3	71.0			L10 Ca	lculation	1	
2						-										
3	-					-								Recept	tor #1	
4						-	9							Maira	1	1
Equij	pment	Receptor ‡	11: N-231 in C	17A6			L10 Ad	justmen	đ					HOISE I	Lunico	
	Active	Descr	iption	lm De	npact evice	Usag		L10 =	Leq +	3.0 dBA			Estima Shieldi (dBA	ted ng		
1		Compactor (ground)		-	1									0.0		
2	1	Concrete Saw		-				-	-					0.0		
3	V	Dozer		-	1			OK	Cance	a De	fault			0.0		
4	¥	Flat Bed Truck		-				L						0.0		
5	V	Excavator		-		L	//6		00.0		00.1			0.0		
6				-				1	1	1	-			-		
lts				_		Rece	eptor #1:	N-231 in	C17A6							
lts			Calculated (df	3A)		Rece	eptor #1: Noise Lim	N-231 in its (dBA)	C17A6			Noise	Limit Exce	edance (c	IBA)	
Its		Frainces	Calculated (dt	3A)	Day	Rece	e ptor #1: Noise Lim Ever	N-231 in its (dBA)	C17A6 Niał	it	Day	Noise	Limit Exce Even	edance (c	IBA) Nigł	110
lts		Equipment	Calculated (df	3A)	Das max	Rece , L10 830	eptor #1: Noise Lim Ever Lmax	N-231 in its (dBA) inq L10	C17A6 Nigh Lmax	it L10 74.0	Day Lmax	Noise	Limit Exce Even Lmax	edance (c inq L10 83	IBA) Nigł Lmax	t L10 14.3
Its	ompactor	Equipment Total (ground)	Calculated (df Lmax* L1 89.6 83.2	3A) 10 L 88.3 79.2	Das max 85.0 85.0	Rece , L10 83.0 83.0	eptor #1: Noise Lim Ever Lmax 85.0 85.0	N-231 in its (dBA) ing L10 80.0 80.0	C17A6 Nigh Lmax 80.0 80.0	t L10 74.0 74.0	Dav Lmax 4.6 None	Noise L10 5.3 None	Limit Exce Even Lmax 4.6 None	edance (c ing L10 8.3 None	IBA) Nigł Lmax 9.6 3.2	14.3 5.2
	ompactor	Equipment Total (ground) Jaw	Calculated (df Lmax* L1 89.6 83.2 89.6	3A) 10 L 88.3 79.2	Das max 85.0 85.0 85.0	Rece , L10 83.0 83.0 83.0	eptor #1: Noise Lim Ever Lmax 85.0 85.0 85.0	N-231 in its (dBA) inq L10 80.0 80.0 80.0	C17A6 Nigh Lmax 80.0 80.0 80.0	t L10 74.0 74.0 74.0	Day Lmax 4.6 None 4.6	Noise L10 5.3 None 2.6	Limit Exce Even Lmax 4.6 None 4.6	edance (c ing L10 8.3 None 5.6	IBA) Nigh Lmax 9.6 3.2 9.6	t L10 14.3 5.2 11.6
	ompactor oncrete 5 ozer	Equipment Total (ground) aw	Calculated (df Lmax" L1 89.6 83.2 89.6 81.7	3A) 10 L 88.3 79.2 85.6 80.7	Das max 85.0 85.0 85.0 85.0	Rece , L10 83.0 83.0 83.0 83.0 83.0	Eptor #1: Noise Lim Ever Lmax 85.0 85.0 85.0 85.0 85.0	N-231 in its (dBA) L10 80.0 80.0 80.0 80.0 80.0	C17A6 Niał Lmax 80.0 80.0 80.0 80.0	t L10 74.0 74.0 74.0 74.0 74.0	Day Lmax 4.6 None 4.6 None	Noise L10 5.3 None 2.6 None	Limit Exce Even Lmax 4.6 None 4.6 None	edance (c L10 8.3 None 5.6 0.7	IBA) Lmax 9,6 3,2 9,6 1,7	L10 14.3 5.2 11.6 6.7
	ompactor oncrete S ozer lat Bed T	Equipment Total (ground) Jaw	Calculated (df Lmax* L1 89.6 83.2 89.6 81.7 74.3	3A) 10 L 88.3 79.2 85.6 80.7 73.3	Das 85.0 85.0 85.0 85.0 85.0 85.0	Rece , L10 83.0 83.0 83.0 83.0 83.0 83.0	eptor #1: Noise Lim Ever Lmax 85.0 85.0 85.0 85.0 85.0 85.0	N-231 in its (dBA) inq L10 80.0 80.0 80.0 80.0 80.0 80.0	C17A6 Nidr Lmax 80.0 80.0 80.0 80.0 80.0 80.0	t L10 74.0 74.0 74.0 74.0 74.0 74.0	Day Lmax 4.6 None 4.6 None None	Noise L10 5.3 None 2.6 None None	Limit Exce Even Lmax 4.6 None 4.6 None None	edance (c Ing L10 8.3 None 5.6 0.7 None	IBA) Lmax 9.6 3.2 9.6 1.7 None	t L10 14.3 5.2 11.6 6.7 None
	ompactor oncrete S ozer lat Bed T xcavator	Equipment Total (ground) aw ruck	Calculated (df Lmax* L1 89.6 83.2 89.6 81.7 74.3 80.7	3A) 10 L 88.3 79.2 85.6 80.7 73.3 79.7	Das max 85.0 85.0 85.0 85.0 85.0 85.0 85.0	Rece , L10 83.0 83.0 83.0 83.0 83.0 83.0 83.0 83.	eptor #1: Noise Lim Ever 100 85.0 85.0 85.0 85.0 85.0 85.0 85.0	N-231 in ing L10 80.0 80.0 80.0 80.0 80.0 80.0 80.0 80	C17A6 Nidf Lmax 80.0 80.0 80.0 80.0 80.0 80.0 80.0 80.	t L10 74.0 74.0 74.0 74.0 74.0 74.0 74.0	Day Lmax 4.6 None 4.6 None None None	Noise L10 5.3 None 2.6 None None	Limit Exce Even 4,6 None 4,6 None None None None	edance (c ing L10 8.3 None 5.6 0.7 None None	IBA) Lmax 9.6 3.2 9.6 1.7 None 0.7	t L10 14.3 5.2 11.6 6.7 None 5.7 •

Figure 17. L10 Adjustment dialogue box

• Noise Limits

The "Noise Limits" command button opens a display window that looks exactly like the "Noise Limit Criteria" dialogue box, except that it is not editable, and the only button in the opened window is "Ok". The values in the cells are based on the criteria set in the Noise Limit Criteria window and the baseline levels for the selected receiver, as in Figure 18. (If a receiver is not selected, the dialogue box is unavailable for viewing.)

			MIC7						uun
Lmax (dBA)							-		
	D	ay	Eve	ning	Nic	aht			MIC7
	Impact	Non-Impact	Impact	Non-Impact	Impact	Non-Impact		Noi	se Limits
Residential	90	85	85	85	80	80	-		
Commercial	N/A	N/A	N/A	N/A	N/A	N/A	_		
Industrial	N/A	N/A	N/A	N/A	N/A	N/A		- Terrer (1	
							Actual	Distance to	
							Actual Lmax (dBA)	Distance to Receptor (feet)	Shieldin (dBA)
L10 (dBA)	D	ay	Eve	ning	Nic	aht	Actual Lmax (dBA)	Distance to Receptor (feet)	Shieldin (dBA)
L10 (dBA)	D. Impact	av Non-Impact	Eve Impact	ning Non-Impact	Nic Impact	aht Non-Impact 70	Actual Lmax (dBA)	Distance to Receptor (feet)	Shieldin (dBA)
L10 (dBA) Residential	D- Impact Exempt	ay Non-Impact 83	Eve Impact 82	ning Non-Impact 82	Nic Impact 78	ght Non-Impact 78	Actual Lmax (dBA)	Distance to Receptor (feet)	Shieldir (dBA)

Figure 18. Noise Limits display window

Again, these limits may be changed by the user through the Noise Limit Criteria data entry window.

4 Results

Once the data for one receptor and up to 20 pieces of equipment have been specified in the Input Data portion of the main screen, the RCNM will automatically calculate the Results readout displayed in the bottom portion of the main screen, as in Figure 19. Any changes to the Input Data will automatically cause the RCNM to update the Results. The results for only one receptor will be displayed at a time; results for other receptors can be displayed by selecting the desired receptor in the Receptor window (click in any cell in the desired receptor row). Results for up to 100 receptors can be saved in a case. If Noise Limit Criteria information has been specified, the corresponding results (limits and exceedance values) will be updated as well.

		Care	escription														
Rec	eptor	Cuac D	cachpuon												1.10	-	
		Description		Land	Use	D B	aytime aseline (dBA)	Evening Baseline (dBA)	Vening Nig Baseline Ba (dBA) (*		-		Noise	metric: loise Lir	nit Criter	ia di	
1	N-231 i	n C17A6	Resid	ential		-	78.0	75	.0	71.	2			L10 Ca	lculation	n	
2						-			_		-		-			_	
3	-					-			_		-				Recep	tor #1	
4			1			-		2	_22						Noise	imits	1
Equ	ipment	Recepto	#1: N-23	in C17A	6												
	Active	Des	scription		Impact Device	Usage(%)	Spec Lmax (dBA)			Actual Lmax (dBA)		Distance to Receptor (feet)	Estima Shield (dBA	ing		
1		Compactor (ground	l)	-	11	20)% 🔳		80.0	V		83.2	50.0	1	0.0		
2	×	Concrete Saw		-	1	20)% 🔳		90.0	V		89.6	50.0		0.0		
3	Ľ	Dozer		-		40)% 📃		85.0	V		81.7	50.0		0.0		
4	Ľ	Flat Bed Truck		-		40)% 📃		84.0	V		74.3	50.0		0.0		
5	1	Excavator		-	-	40	1% 🔳		85.0	V		80.7	50.0		0.0		
6	1			-	1		1			110					•		
lts						Rece	eptor #1:	N-231 in	C174	16			Noise	imit Evce	vedance (r	(Rá)	
			Calcula	ed (dBA)	D.	NU	Eve	ning		Night		D	AU	Even	ina	Niak	,
		Equipment	Lmax*	L10	Lmax	L10	Lmax	L10	Lma	(L	10 L	max	L10	Lmax	L10	Lmax	L10
		Total	89.6	88.3	85.0	83.0	85.0	80.0	8	0.0	74.0	4.6	5.3	4.6	8.3	9.6	14.3
	Compactor	(ground)	83.2	79.2	85.0	83.0	85.0	80.0	8	0.0	74.0	None	None	None	None	3.2	5.2
2 1	Concrete S	iaw	89.6	85.6	85.0	83.0	85.0	80.0	8	0.0	74.0	4.6	2.6	4.6	5.6	9.6	11.6
3 1	Dozer		81.7	80.7	85.0	83.0	85.0	80.0	8	0.0	74.0	None	None	None	0.7	1.7	6.7
. 1	Flat Bed Ti	ruck	74.3	73.3	85.0	83.0	85.0	80.0	8	0.0	74.0	None	None	None	None	None	None
5 1	Excavator		80.7	79.7	85.0	83.0	85.0	80.0	8	0.0	74.0	None	None	None	None	0.7	5.7 🕶

Figure 19. The RCNM main-page Results display

If there is insufficient input data for RCNM to compute a result, then a "Check Input Data" button will appear in the middle of the screen. Clicking on this button will provide the user with an indication of what additional input data are required.

The Results are presented in a read-only spreadsheet that contains the following fields, all applicable to the selected receptor:

- Equipment the name/description of the equipment type
- Calculated Lmax the calculated Lmax value for the equipment type. This is calculated from the "Spec" or "Actual" equipment Lmax, distance, and estimated shielding.

- Calculated Leq or L10 the calculated Leq or L10 value (depending on what is selected in the Noise Metric pull-down menu) for the equipment type. This is calculated from the Calculated Lmax values, equipment usage factors, and selected adjustment factor.
- Day Lmax Noise Limit the daytime Lmax noise limit for the equipment type.
- Day Leq or L10 Noise Limit the daytime Leq or L10 noise limit for the equipment type.
- Evening Lmax Noise Limit the evening Lmax noise limit for the equipment type.
- Evening Leq or L10 Noise Limit the evening Leq or L10 noise limit for the equipment type.
- Night Lmax Noise Limit the nighttime Lmax noise limit for the equipment type.
- Night Leq or L10 Noise Limit the nighttime Leq or L10 noise limit for the equipment type.
- Day Lmax Noise Limit Exceedance the daytime Lmax noise limit exceedance for the equipment type. If the criteria limit was not exceeded, the value is "None".
- Day Leq or L10 Noise Limit Exceedance the daytime Leq or L10 noise limit exceedance for the equipment type. If the criteria limit was not exceeded, the value is "None".
- Evening Lmax Noise Limit Exceedance the evening Lmax noise limit exceedance for the equipment type. If the criteria limit was not exceeded, the value is "None".
- Evening Leq or L10 Noise Limit Exceedance the evening Leq or L10 noise limit exceedance for the equipment type. If the criteria limit was not exceeded, the value is "None".
- Night Lmax Noise Limit Exceedance the nighttime Lmax noise limit exceedance for the equipment type. If the criteria limit was not exceeded, the value is "None".
- Night Leq or L10 Noise Limit Exceedance the nighttime Leq or L10 noise limit exceedance for the equipment type. If the criteria limit was not exceeded, the value is "None".

The user may scroll down to view equipment results that are not visible, or the $\langle View \rangle / \langle Zoom + \rangle$ menu may be used to zoom in on the Results display only (see Section 3.1.3). There is a row at the top of the Results display, highlighted in yellow, that calculates the total for all equipment combined. This row is always visible during scrolling of the Results spreadsheet. (Calculations for totals are explained in Section 5.3.)

Again, users may export a case's input information and results to a comma separated value (CSV) report file ([name].csv) by choosing the <Export Results> option from the <File> menu. The user can also save the case results to a text file (TXT), which saves the results to a space-separated text format ([name].txt). Results may be saved for a single receptor or all receptors in the case.

5 Calculations in the RCNM

The RCNM uses the primary equation described in the CA/T Construction Noise Control Specification 721.560 [1] for the construction noise calculations.

5.1 Metric Calculation

$\underline{LmaxCalc} = selected_Lmax - 20log(D/50) - shielding$ (1)

where

selected_Lmax is the "Spec" or "Actual" maximum A-weighted sound level at 50 ft., listed in Table 1 for all pieces of equipment, in dBA,

D is the distance between the equipment and the receptor, in feet, shielding is the insertion loss of any barriers or mitigation, in dBA (see Appendix A).

$\underline{Leq} = LmaxCalc + 10log(U.F.\%/100)$ (2)

where

U.F.% is the time-averaging equipment usage factor, in percent (see footnote 1 on p 7).

$\underline{L10} = \text{Leq} + 3 \text{ dBA adjustment factor}$ (3)

The RCNM calculates L10 by adding 3 dBA to the Leq, where the 3 dBA default L10 adjustment factor was empirically derived by comparing extensive CA/T construction noise data. This adjustment factor may be changed in the RCNM at the user's discretion.

5.2 Exceedance Calculation

Daytime Lmax Exceedance = LmaxCalc – Daytime Lmax Limit	(4)
Daytime Leq or L10 Exceedance = Leq or L10 – Daytime Leq or L10 Limit	(5)
Evening Lmax Exceedance = LmaxCalc – Evening Lmax Limit	(6)
Evening Leq or L10 Exceedance = Leq or L10 – Evening Leq or L10 Limit	(7)
<u>Nighttime Lmax Exceedance</u> = LmaxCalc – Nighttime Lmax Limit	(8)
<u>Nighttime Leq or L10 Exceedance</u> = Leq or L10 – Nighttime Leq or L10 Limit	(9)

5.3 Totals Calculation

The Total values in the Results section are determined in the following manner:

- 1) Total Leq = $10*\log(\Sigma \text{ (individual equipment Leq values}^3))$
- 2) Total L10 = $10 \times \log(\Sigma \text{ (individual equipment L10 values}^3))$
- 3) Total Lmax = Maximum among individual equipment Lmax values
- 4) Total noise limits and limit exceedances:
 - a. Determine whether or not total is impact or non-impact
 - i. If all the equipment is non-impact, label the total as non-impact.
 - ii. If all the equipment is impact, label the total as impact.
 - iii. If the equipment is mixed non-impact and impact, label the total as non-impact.

b. Determine total noise limits and limit exceedances the same way as with individual pieces of equipment (see Section 5.2), only use the calculated total sound levels (Total Leq or Total L10) and the impact or non-impact label according to the criteria specified in i through iii.

³ The Leq and L10 levels are energy averages.

6 References

- [1] Construction Noise Control Specification 721.560, Central Artery/Tunnel Project, Massachusetts Turnpike Authority, Boston, MA, 2002.
- Thalheimer, Erich. "Construction Noise Control Program and Mitigation Strategy at the Central Artery/Tunnel Project". Noise Control Engineering Journal, Vol. 48, No. 5, pp 157-165, September - October 2000.
- [3] "Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety", Environmental Protection Agency, ONAC 550/9-74-004. Washington, DC, March 1974.
- [4] "Power Plant Construction Noise Guide". Bolt, Beranek, and Newman Inc. and Empire State Electric Energy Research Corp., Report No. 3321. New York, NY May 1977.

Appendix A: Best Practices for Calculating Estimated Shielding for Use in the RCNM

This Appendix presents some simplified shielding factors for use in the RCNM. These suggestions are "rules of thumb" based on experience gathered by CA/T construction noise experts working in the field [2].

1) If a noise barrier or other obstruction (like a dirt mound) just barely breaks the line-ofsight between the noise source and the receptor, use 3 dBA.

2) If the noise source is completely enclosed OR completely shielded with a solid barrier located close to the source, use 8 dBA. If the enclosure and/or barrier has some gaps in it, reduce the effectiveness to 5 dBA.

3) If the noise source is completely enclosed AND completely shielded with a solid barrier located close to the source, use 10 dBA.

4) If a building stands between the noise source and receptor and completely shields the noise source, use 15 dBA.

5) If a noise source is enclosed or shielded with heavy vinyl noise curtain material (e.g., SoundSeal BBC-13-2" or equivalent), use 5 dBA.

6) If dilapidated windows are replaced with new acoustical windows, or quality internal or exterior storm sashes, use an incremental improvement of 10 dBA for an overall Outside-to-Inside Noise Reduction (OINR) of 35 dBA.

7) If work is occurring deep inside a tunnel using the "top-down" construction method (i.e. cover the tunnel work with concrete roadway decks to allow surface traffic and then excavate underneath the roof deck), use 12 dBA.