ACKNOWLEDGEMENTS

Much of the material for this manual comes from the earlier Caltrans manual, "User Instructions for SOUND32." Considerable material for that manual came from the "Noise Barrier Cost Reduction Procedure STAMINA 2.0/OPTIMA: User's Manual FHWA-DP-58- 1, Arlington, VA, April 1982.

We wish to acknowledge the contributions made by Vanderbilt University towards the completion of this version of the programs. Under the direction of Dr. William Bowlby and Dr. Roger L. Wayson, programmers Dr. Hung Ming Sung and Jinsheng Li are responsible for the modification of the heavy truck grade adjustments to the new Calgrade levels. The conversion and modification of the mainframe SOUND32 FORTRAN program to PC, as well as the conversion and PC front-end for the LOS program.

We wish to give special recognition to Robert Dawson for his efforts in developing the front-end used with PC version of SOUND32. Once the users have tried out Bob's input screens we are sure that they will agree that they are intuitive, consistent and easy to use.

Rudy Hendricks of Caltrans developed the problem sets, barrier design procedures, and barrier cost data in SOUND32, and conducted the research which led to the development of both the Calveno reference energy mean emission levels as well as the Calgrade heavy truck emission level data base, which are now incorporated into SOUND32.

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1.0 Introduction

This is the user's manual for the computer programs SOUND32 and LOS.

This manual is not intended to set policy for Caltrans, but simply to be a

guide to setting up the necessary inputs and running the computer

programs. Users of these programs should have an understanding of and

be familiar with:

- the theory presented in the " 108" report (including its simplifications and limitations)
- FHWA's guidelines as spelled out in FHPM 7-7-3
- Caltrans Design Manual Chapter 1100 requirements
- the suggested procedures and methods spelled out in the Caltrans Noise Technical Analysis Notes (No-TANs)

SOUND32 is the Caltrans version of the FHWA highway noise prediction and barrier cost reduction (BCR) procedure programs, STAMINA 2.0/OPTlMA-1

The two FHWA programs were modified and combined in the Caltrans version. Modifications and improvements incorporated into SOUND32 include:

- the ability to use either the California reference energy mean emission levels (Calveno curves) or the National reference energy mean emission levels
- the calculation of the extra 3 dBA attenuation that is attributed to berms in the "108" report
- addition of California specific barrier cost data and the ability to easily modify the data by editing a data file rather than changing the program code
- a solution to the inaccuracies in STAMINA 2/OPTIMA that occur when there is more than one barrier between the

receiver and the roadway

- correction of the error that occurs in STAMINA with low barriers which causes the program to skip the calculation of medium truck barrier attenuation when there is no heavy truck barrier attenuation
- addition of the Calgrade emission levels for heavy trucks on positive grades[3] and the ability to easily modify the Calgrade levels by editing of a data file rather than changing the program code
- development of a screen prompt form program for easy creation and revision of input data files for the PC version with an easily understood menu structure

LOS is the Caltrans truck stack Line-Of-Sight program. Its purpose is to aid in the design of noise barriers which meet the Caltrans Design Manual Chapter 1100 requirement that noise barriers be built high enough to shield the exhaust stacks of heavy trucks from view to avoid a visual distraction.

Chapter 2 of this manual presents the basic concepts that are used to model a site for input into the computer programs. Chapter 3 describes the format of the input file that is used in SOUND32. Chapter 4 discusses how to run the manimrame version of the program. Chapter 5 presents instructions on using the PC version. Chapter 6 describes the SOUND32 FORTRAN modules menus. Chapter 7 presents some general considerations on the use of SOUND32. Appendix A provides discussions and detailed printouts on a set of sample problems, while Appendix B gives the file structure for the California barrier cost and Calgrade emission level files.

1.1 Purpose

SOUND32 allows the prediction of highway traffic noise for complex geometric sites. SOUND32 also allows the user to examine the effectiveness and cost of many different barrier heights more quickly than in the past. for easier development of an optimum barrier design.

SOUND32 includes calculations for barrier effectiveness and cost information for each barrier at several heights. After initial data entry, the user selects a set of barrier heights and the program calculates a noise level at each receiver and the total cost of the barrier system. Based on these results the user can change barrier heights to improve (optimize) the effectiveness and cost efficiency of the barrier system.

1.2 Background

SOUND32 is an evolutionary version of FHWA’s STAMINA 2.0/OPTIMA computer programs. .

SOUND32 is based on the FHWA Highway Traffic Noise Prediction Model (the "108" report) and users should be familiar with the theory presented in that report.[4]

2.0 PROBLEM FORMULATION

SOUND32 calculates traffic noise based on site geometry consisting of lanes, receivers and barriers. In addition, diffraction may occur and ground interference may change. This chapter provides background information for the user on each of these aspects of noise prediction. Many additional details may be found in the FHWA manual, "Highway Traffic Noise Prediction Model[4].

2.1 Traffic Noise (Source)

The traffic noise is defined by the traffic flow and traffic lanes. Heavy trucks on positive grades may also be considered. The following discussion better details these needed inputs to the model.

2.1.1 Traffic Flow

Traffic flow is input as hourly volumes and speeds of automobiles, medium trucks and heavy trucks. SOUND32 calculates noise emission levels from the traffic flow using either the FHWA or the Calveno reference energy mean emission levels[3]. These reference energy emission levels are based on steady state speed conditions and SOUND32 is not appropriate for traffic or highways which are not free flowing. The user is referred to NCHRP Report 311 for a procedure to use SOUND32 for stop and go traffic[5].

2.1.2 Traffic Lanes

Each **lane or lane group is approximated by using** a series of straight line segments defined at their end points by x. y and z coordinates. Since computing time is directly related to the number of lane segment receiver pairs, users should attempt to use as few

lane segments as can adequately define the problem. Considerable time savings can be made by grouping roadways into equivalent lanes where appropriate.

2.1.3 Grade Corrections

The reference energy mean emission levels are based on vehicles operating under cruise conditions on flat terrain. For up-grade lane segments the user may request that the program use heavy truck upgrade emission levels, called Calgrade levels[3]. If a grade adjustment is requested, the program will calculate a linear grade from the length of the lane segment and the change in elevation from the end point coordinates. The Calgrade emission levels for heavy trucks are:

Table 2-1 Heavy Truck Emission levels

Grade (%)	Emission Level (dBA)
1	84.0
2	84.4
3	84.7
4	84.1
5	83.9
6	83.9
7	83.9

Speed and emission level distributions are shown in Table 2-2. The data is incorporated into a separate data file as described in Appendix B.

Table 2-2 Speed Distributions and Emission Levels as a Function of Grade

	Speed	% Frequency	
Grade	Class	of	LOE
%	(mph)	Occurrence	(dBA)
+2	11-20	0	83.9
	21-30	0	83.4
	31-40	400	83.8
	41-50	454	84.5
	51-60	150	85.4
	>60	0	85.9
+3.0	11-20	0	--
	21-30	3.2	83.4
	31-40	25.0	83.8
	41-50	32.1	84.5
	51-60	32.9	85.4
	>60	6.8	85.9
+4.2	11-20	1.9	83.8
	21-30	20.0	83.4
	31-40	43.8	83.7

	41-50	20.5	84.5
	51-60	13.8	85.3
	>60	0	--
+4.5	11-20	4.1	83.9
	21-30	34.9	83.4
	31-40	37.5	83.7
	41-50	11.4	84.5
	51-60	11.1	85.3
	>60	1.0	85.8
+5.6	11-20	5.2	83.9
	21-30	48.6	83.4
	31-40	19.6	83.6
	41-50	13.8	84.5
	51-60	12.2	85.2
	>60	0.7	85.8
+6.0	11-20	22.5	83.9
	21-30	49.0	83.4
	31-40	17.1	83.8
	41-50	7.7	84.6
	51-60	3.7	85.3
	>60	0	--
+7.0	11-20	15.2	84.1
	21-30	27.4	83.4
	31-40	31.9	83.8
	41-50	23.6	84.5
	51-60	1.9	85.1
	>60	0	--

2.2 Barriers

For the purpose of calculating sound diffraction each barrier is coded as a series of straight line segments along the top edge of the barrier. The barrier segments are defined by end point x, y and z coordinates. Barrier effectiveness and cost calculations also use the elevations of the bottom of the barrier Z(O).

2.2.1 Barrier Attenuation

SOUND32 can consider two types of barrier diffraction; either thin screens (walls) or mounds of earth (berms). For a given source and barrier receiver path berms will provide 3 dBA more attenuation than walls. Walls are limited to a maximum of 20 dBA attenuation and berms to 23 dBA.

2.2.2 Barrier Materials

Each barrier is initially coded with a barrier material type number. This allows the first set of barrier effectiveness and cost calculations to be performed and determines if the barrier attenuation should be calculated as a berm or wall. The barrier material type numbers are matched to the barrier type that the program reads in from the barrier cost file. After the first set of results has been calculated, the user has the option of changing the barrier material type number for any barrier element. However, the program will not allow the user to change from a berm to a wall or vice-versa because of the difference in calculation methods. To do this, a new problem must be defined**.**

2.2.3 Barrier Cost File

Each run of SOUND32 requires a barrier cost file in addition to the site data input file. The barrier cost file contains the cost information for each barrier material type. The program has been set up to default to the barrier cost file CALIF.DTA. Program code to allow use of the FHWA cost data[1] in the file FHWA$.DTA is also available. See Appendix B for details on these two files.

2.2.4 Multiple Barrier Heights

In SOUND32 the user can select a trial barrier height 0 and change this height in fixed increments, above and below the trial height. For each barrier, the user specifies an incremental height change DELZ) and the number of height changes or perturbations (P) to be made in each direction (up and down). The maximum number of height changes is 3. Thus, the program can calculate:

1 barrier height (P = 0)

3 barrier heights (P = 1)

5 barrier heights (P = 2)

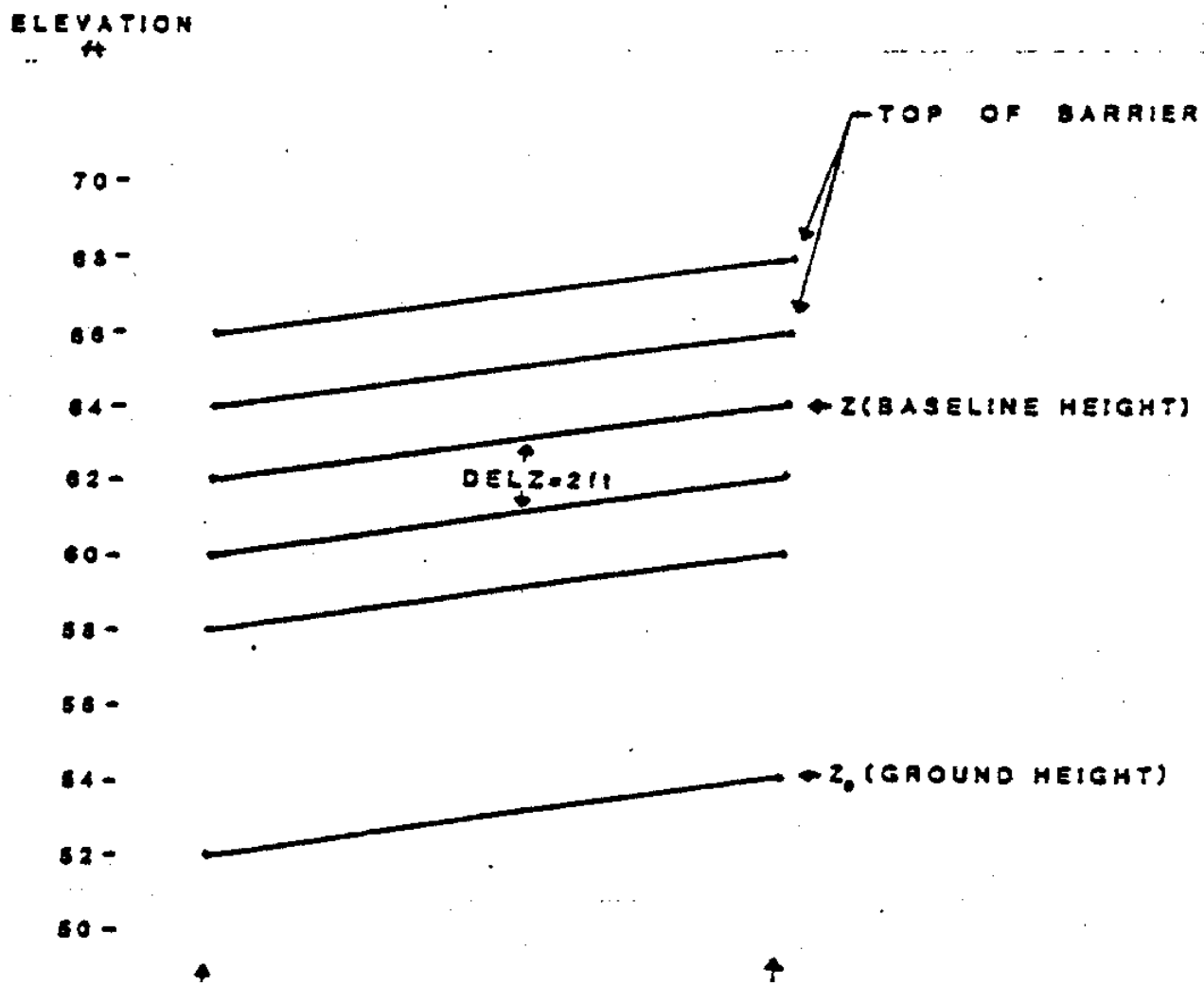
or 7 barrier heights (P = 3)

See Figure 2-1 for an example.

SOUND32 automatically prints the results of the Z-height barrier case (base case) as the first set of results.

Figure 2-1. Barrier Height Perturbation Process.

DELZ= 2 ft., And P = 2.



B1-STA90 B2-STA99

2.2.5 Barriers on Structure

The SOUND32 program treats barriers as semi-infinite in the vertical plane: the barrier extends from the defined top edge infinitely downward: no sound energy can pass beneath the barrier. In designing complicated barrier systems, however, it is often desirable to include as part of the system, a barrier built along the edge of an elevated portion of a roadway. Often there are at-grade lanes located on the far side of the elevated structure and sound energy would in fact pass beneath the structure to the receiver (See Figure 2-2). In these situations, the barriers located on the structures will be identified in the input data as "structure" barriers. The "structure" barriers will reduce only the sound energy emanating from traffic on user defined roadways (i.e., the elevated structure). Sound energy from all other lanes (dependent upon user input) will not be affected by the "structure" barrier.

2.2.6 Multiple Barriers

SOUND32 is not capable of calculating multiple path length diffraction. If more than one barrier is encountered in the receiver to source path, SOUND32 will retain only the most effective barrier in terms of reduction in the sound energy resulting from diffraction.

As an example: in Figure 2-3, Ray-A crosses segments 3, 4 and 5 of Barrier-1. In this case SOUND32 will determine which barrier segment is the most effective and ignore the other two for that receiver. In the case of first results calculations the choice is based on the baseline (Z) heights. Internally SOUND32 sets a barrier conflict flag when more than one barrier is encountered in this receiver to source path and will recalculate. Thus users may find the program extremely slow with large problems and barrier conflicts.

Figure 2-2. Structural Barrier for Lanes 2 and 3, but not Lane I

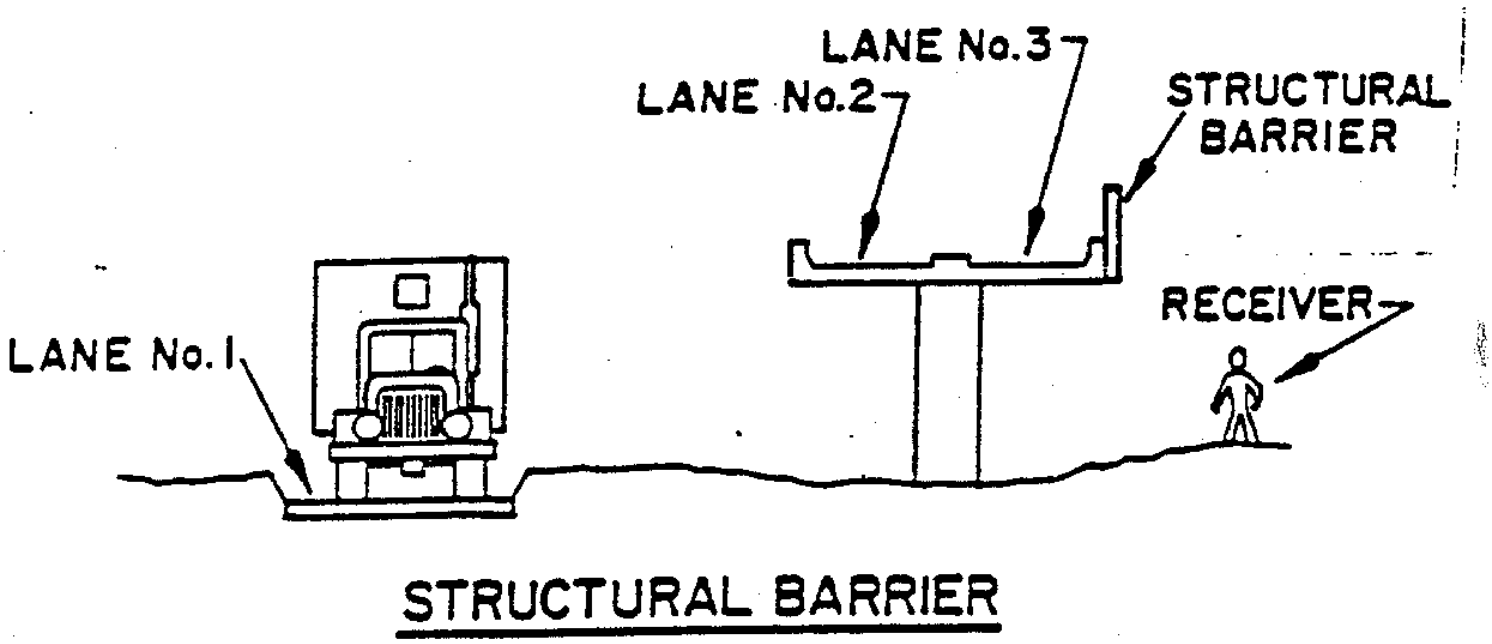
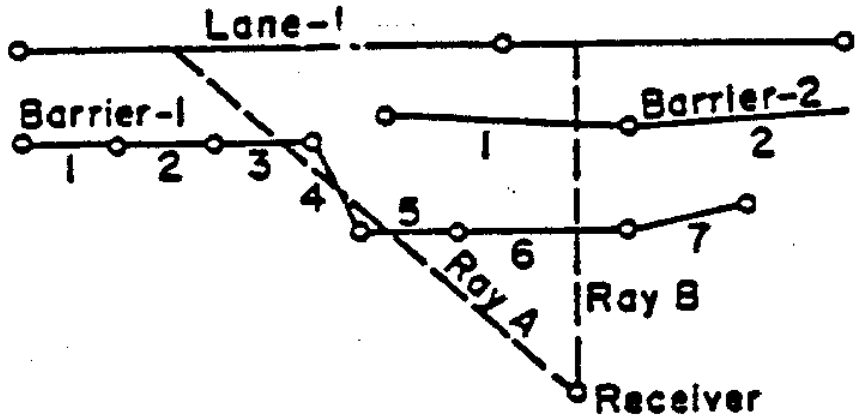


Figure 2-3. Barrier Decision Process for Multiple Diffraction



2.3 Receivers

Receivers (receptors of sound) are points in space defined by a set of x, y, and z coordinates. For the purpose of calculating barrier effectiveness, each receiver has an associated Design Noise Level (DNL) and number of people per receiver weighing factors.

In general, receivers should be located to represent relatively homogeneous groups of houses, parts of schools, or portions of parks, such that the propagation characteristics via drop-off rates (see Section 2.4) and Kconstants (see Section 2.5) are representative.

Problems should be set up so that each neighborhood is examined in a separate run. SOUND32 calculates Effectiveness/ Cost (E/C) ratios based on the sound energy reduction and the number of people at all receiver locations. E/C ratios are only calculated for locations where the people per receiver is greater than 0. Therefore, the E/C ratios will be most useful if all receivers are in the same general area.

2.4 Drop-Off Rates

When the drop-off rates are greater than 3 dB/Doubling of Distance (DD) in conjunction with barriers, the program computes as follows. For each vehicle type, lane, barrier, receiver combination, the program computes both the barrier attenuation and the ground-effect attenuation and stores only the larger of the two. (The ground-effect attenuation is the difference in levels that results from using a 4.5 dB/DD rate as compared to a 3 dB/DD propagation rate).

This procedure provides a smoothly varying sound level at the receiver as the barrier height is increased if the barrier is effective. In fact, the barrier only appears effective (causes a decrease in the no-barrier sound level) when it is high enough to overcome the loss of ground-effect attenuation. In other words, no insertion loss will be reported until the calculated barrier attenuation exceeds the calculated ground-effect.

2.5 K-Constants

SOUND32 allows for the input of a constant, in dBA, to be applied between each lane/receiver pair. This constant, called the "K-constant" can be used to apply additional attenuation caused by shielding of buildings, row of houses, trees or other terrain features. The use of K-constants is appropriate only when terrain shielding is clearly additive to the attenuation provided by a barrier adjacent to a lane, as SOUND32 cannot accurately deal with two barriers between the source and receiver.

Another appropriate use of K-constants is to adjust the model results to field measurements. If a K-constant is specified, no conditions of the program, such as the presence of a barrier, will override it. Negative K-constants will always be subtracted and positive K-constants added to the calculated L_{eq} of the coded receiver/lane pair.

3.0 INPUT FILE STRUCTURE

SOUND32 requires that prior to running the program the user create an input data file containing all of the necessary data defining the problem. This file may be created using a text editor, a word processor, a spreadsheet program that writes an ASCII output file, or the screen editor that comes with SOUND32-PC. The file structure is defined in this section. Use of the screen form editor, which

automatically writes this file in the required format is described in Section 4.2.

For all data except the tide line, a "keyword" letter defines the type of data that is contained in each part of the file. Any data that is required follows each keyword.

The following rules apply to all types of data in the file:

1. The delimiter between data items must be a comma.

2. Data item descriptions are optional, and. if not contained in the input data file, will be generated by the program.

3. All x and y coordinates should be limited to the range of 99,999,999.9 through -9,999,999.9 and z coordinates to the range of 99,999.9 through -9,999.9.

As a minimum, each input file should contain:

1. A title line

2. Traffic data for lane 1

3. Geometric data for lane 1

4. Geometric data for receiver 1

These required inputs as well a; other optional inputs (barrier data, drop-off rates, and K-constants) are defined in this chapter.

3.1 TITLE

line-a	title	first line of file

Where:

Title is any string of from 1 to 80 characters.

Usage Notes:

The title is required as the first line of the data file and may only appear on the first line of the file.

3.2 TRAFFIC

line-a	Traffic, lane-number	first line
line-b	a-v, a-s, mt-v, mt-s, ht-v, ht-s	second line

Where:

Traffic is a string of characters of which the first non-blank character must be a "T."

Lane-number is the lane number which the traffic data is to be assigned. Valid range is 1 through 30.

a-s, mt-v, mt-s, ht-v, ht-s is the hourly volume and speed for autos, medium trucks and heavy trucks. Volumes may be 0. Speeds must be between 30 and 60 MPH for any vehicle types whose volume is greater than 0.

Usage Notes:

1. Traffic data may be placed anywhere in the data file after the title line and need not be in ascending lane-num order.

2. For each lane defined there must be a corresponding traffic definition. Traffic for lane I must be defined. The highest lane-num used must equal the total number of sets of traffic data defined.

Examples:

T,2, NORTHBOUND 1405 *TRAFFIC FOR* N-BOUND LANES,2

1500,55,50,55,120,55 1750,55,0,0,100,55

t,l

2500,55, 123,50, 200,50

t,2

2800,55, 130,50, 250,50

3.3 Lanes

line-a	Lane, lane-num	first line
line-b	Grade-cor. x, y, z, pt-des	1-15 lines
line-c	x. y, z, pt-des	last line

Where:

Lane is any string of characters of which the first non-blank character must be an "L".

Lane-num is the lane number of the data. Valid range is 1-30.

Grade-cor is the request for heavy truck positive grade adjustment. Code a "Y"to request the correction or code an "N" to bypass the grade adjustment calculation. Not included for last end point.

x, y, z are the coordinates of an end point of a lane segment.

Pt-des is description of the lane segment end point. The pt-des is optional and, if omitted, the program will assign a description of *"Ln Ps"* where *n* is replaced with the lane-num and Ps is the segment number.

Usage Notes:

1. The file may contain from 1 to 30 lanes of from 1 to 15 segments each.
2. Each block of lane data is composed of 1 line-a, from 1 to 15 line-b's and 1 line-c.
3. For each lane defined there must be corresponding traffic data. Lane data for lane 1 must be defined. The highest lane-num. used must equal the total number of sets of lane data defined.
4. If the grade-cor is omitted from line-b the program will set grade-cor to N and print a warning message.

Examples:

L,5, NORTHBOUND I405

N,-2000,120,12.6

N,-1500,122,12.7

N, 2000,126,12.9

3100,128,12.6

LANE, 3

NO,-1850,204,101.3, BEG. SB OUTSIDE

NO,500,204,101.8,BCR = 5000

NO,700,200,100.9,PT ON CURVE

NO,900,196,100.8,PT ON CURVE

1300,192,100.6,END

1,1

N	-10,000	1000	0
N	-8000	1200	2
N	-2000	1150	3

1000 3

3.4 Barriers

Line-a	Barrier, bar-num, btype, delz, pert	first line
Line-b	1num1, 1num2, 1num3, 1num.12	for str. bars only
Line-c	bx. by, bzO, bz bar-id	2-11 lines

Where:

Barrier is any string of characters of which the first non-blank character must be a "B."

Bar-num is the number of the barrier. Valid range is 1-20.

Btype is the barrier code number of the barrier material. For non-structure barriers valid btype's are 1 through tnb, where tnb is the total number of barriers defined in the barrier cost file. For structure barriers add 90 to the btype number. Thus, valid btype's are 91 through (90+tnb). (See Appendix B for the barrier material types currently available in the default barrier cost file, SOUND32.DTA.)

Delz is the incremental height change to be used in the barrier perturbation calculations. If pert is greater than 0 then delz must be greater than 0.

Pert is the number of height changes or perturbations in each direction (up and down) to be calculated. Pert must be 0, 1, 2, or 3.

1num1, 1num2, etc. is the list of lane numbers for which the "structure" barrier is to be considered. Maximum number of 1nums that may be assigned to a "structure" barrier is 12.

Bx, by, bz0, and bz are the coordinates of the endpoint. Bz0 is the elevation of the bottom of the barrier and bz is the elevation of the top of the barrier.

Bar-id is the barrier endpoint description. Valid range is 0 to 8 characters. If bar-id is omitted the program will assign a bar-id of "Bn-Ps" with n and s replaced with the barrier and segment number, respectively. For example, barrier 5, segment 3 would be assigned a bar-id of B5 P3 by the program.

Usage Notes:

1. Each file may contain from 1 to 20 barriers of from 1 to 10 segments each.
2. For non-structure barriers omit line-b. Each block of barrier data will contain:

   For non-structure barriers, 1 line-a and 2 to 11 line-cs. For structure barriers, 1 line-a, 1 line-b, and 2 to 11 line-c.
3. The lowest perturbed barrier elevation must be greater than bz0 (bz0 < [bz- (bdelz) (pert)].
4. The highest bar-num used must be equal to the total number of barriers defined.

Examples:

BARRIER AT SCHOOL, 5, 2, 2, 2

300,87,100,110,SCH B

500,89,101,111,END

B,4,92.,O,O

3,4,5,8

400,1000,200.4,108.4

500,1010,195.3,203.3

3.5 Receivers

Line-a	Receiver, rec-num, drd, people	first line
Line-b	rx. xy, rz, rec-id	second line

Where:

Receiver is any string of characters of which the first non-blank character must be a "R".

Rec-num is the number assigned to the receiver. Valid range is 1 to 40.

Dnl is the design noise level. Valid range is 40 dBA through 100 dBA. If people are omitted dnl is optional. If dnI is omitted the program assigns a value of 67 dBA.

People is the number of people that the receiver is to represent. Valid range is 0-1000. The parameter people is optional and if omitted the program will assign a value of 500.

Rx, ry, and rz are the coordinates of the receiver.

Rec-id is a 0 - 8 character receiver description. Rec-id is optional and if omitted will be assigned an id of R-n with n replaced with the rec-num.

Examples:

R,1 RECEIVER-1,1,67,23

300,25,5 100,100,4,HOUSE-#l

3.6 Drop-Off Rates

Line-a	Drop-off, d-rate	first line
Line-b	Lane-num, recl, rec2, rec3	1-30 lines

Where:

Drop-off is any string of characters of which the first non-blank character must be a "D."

D-rate is the drop-off rate in dBA/DD. The default drop-off rate for all lane receiver pairs is 3 dBA. Only those pairs not 3 dBA need be coded.

Lane-num is the lane number. Lane-num may be any of the coded lanes or the world, All (or A).

Recl, rec2, etc. is the list of receiver numbers that are to be paired with the lane-num. May be the word,All (or A).

Usage Notes:

1. Drop-off rates greater than 3 dBA will not always be applied when barriers are present. See Section 2.4.

Examples:

D, 4, 5 DROP-OFF, 4.5

A, A 3,1,2,3

3.7 K-Constants

Line-a	K-constant, k	first line

Line-b	Lane-num, recl, rec2, rec3	1-30 lines

Where:

K-constant is any string of characters of which the first non-blank character must be a "K".

K is the constant, in dBA, that is to be added to the lane receiver pair. The default K-constant for all lane receiver pairs is 0 dBA.

Lane-num is the lane number. Lane-num may be any of the coded lanes or the word All (or A).

Rec1, rec2, etc. is the list of receiver numbers that are to be paired with the lane-num. May be the word All (or A).

Examples:

K, -2 K-CONSTANT, -3 K, -4.5

A, 3, 5, 6 5,A A, A

6,1,2

3.8 Processing & Emission Level Options

Line-a	Process, emis-lev	last line of file

Where:

Process signals the type of processing desired. May be:

a) VC or End - This prints formulated copy of input data before proceeding to calculations.

b) C - Skips print of input data.

Emis-lev indicates the source of the emission levels to be used. May be:

a) C- Calveno reference energy mean emission levels

b) F- FHWA national reference energy mean emission levels

Usage Notes:

1. Currently, the mainframe version of the program automatically assumes that a formatted input file will be produced (thus the V or VC is ignored). The PC version will produce a formatted input listing and send it to the printer and or to a file depending on the settings in the options portion of the edit menu.

2. In the mainframe version, if the emission level code is omitted from the file the calculations will be made using the Calveno curves.

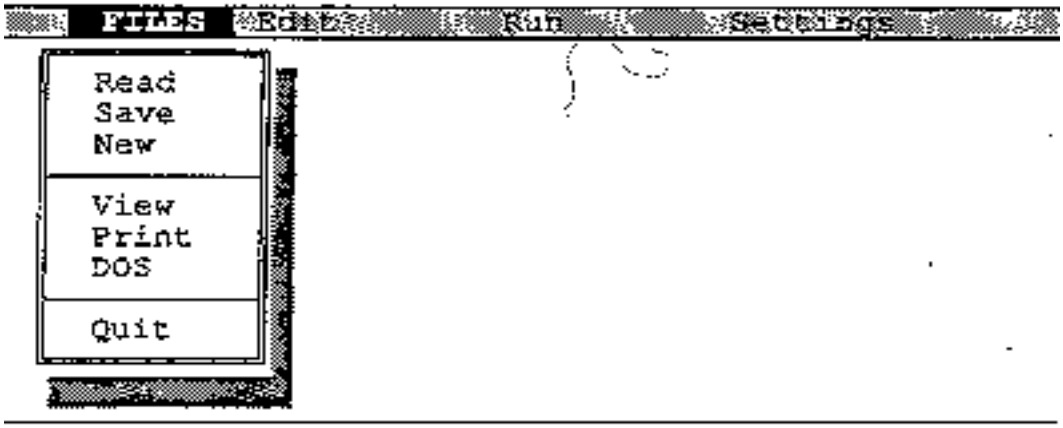
Examples:

VC, C c, c

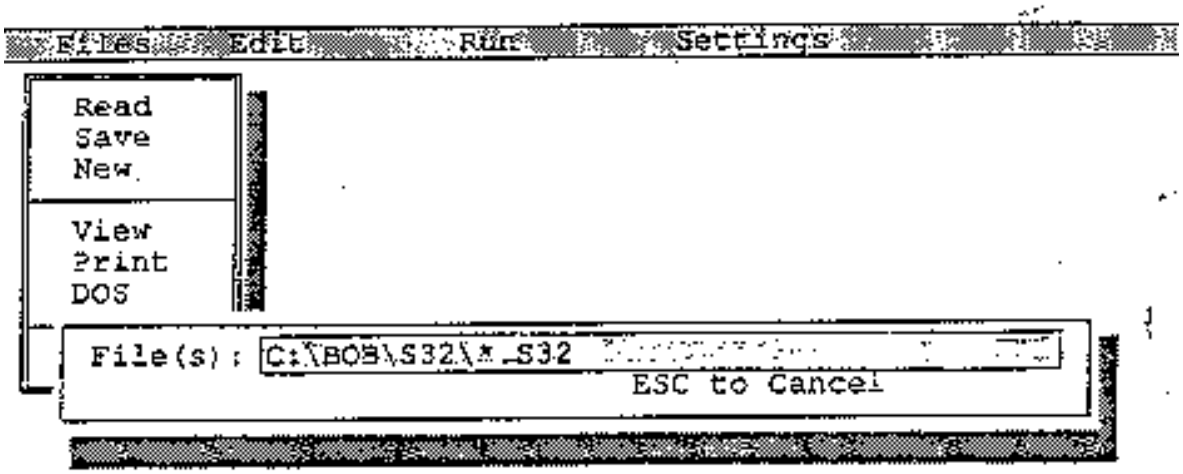
5.0 USING THE PC VERSION

5.1 Files

The files menu is automatically pulled down when the program is first run and is also used to exit the program.



The *Read, Save, View,* and *Print* menu selections will all open a file selection box which gives the user the opportunity to specify the drive, path. file name, and file extension to use. The *Read, Print,* and *View* file specifications may contain standard DOS wild cards. Correct the file specification as necessary and hit the [Return] key. The program will then display all of the file names which satisfy the file specification as well as a change directory option to the directory above and any directories below the specified directory. Use the arrow keys to highlight the desired file or directory and hit [Return].



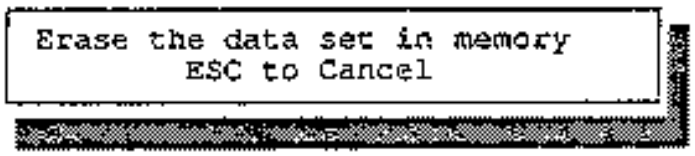
5.1.1 Read

Read is used to load in the data from previously saved data files. In addition to files created within the PC version of SOUND32 files created for the main frame version should also load successfully.

5.1.2 Save

Save is used to store the data that is currently in memory. As with read, view and print, selecting *Save* will open a file specification box where the drive, path, file name, and file extension are specified. Unlike the other options, *Save will* not except wild cards in the file name or extension. If data has been previously loaded into the program Using *Read, Save* will offer the file name used for the *Read,* otherwise a default file name of UNTITLED.S32 will be displayed.

5.1.3 New



New is used to clear out any data currently in memory. Selecting *New* is the equivalent of leaving the program and running it again.

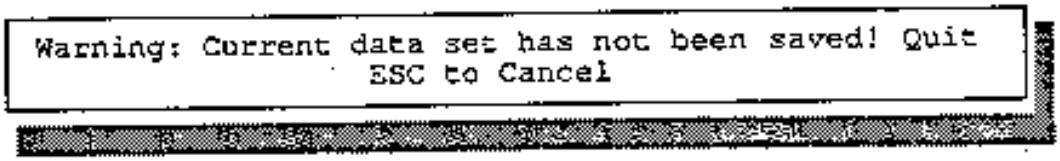
5.1.4 View

View can be used to examine the contents of files without leaving the program. *View* is useful examining the output files from LOS or other SOUND32 runs without having to quit the program.

The viewing of files is accomplished using the routine called VIEW.COM. When the file is displayed by this routine, the user may move around in the file using the arrow keys, page-up, page-down, home, and end keys. Pressing the [Escape] key will return the user to SOUND32 main menu.

5.1.5 Print

Print will send the selected file to the printer. The selected file may be a LOS output file, a SOUND32 input or output file or any other file that the user selects. If you wish to print the data that's currently in memory then first save it using the *Save* command and then use *Print* to send the saved file to the printer.



5.1.5 DOS

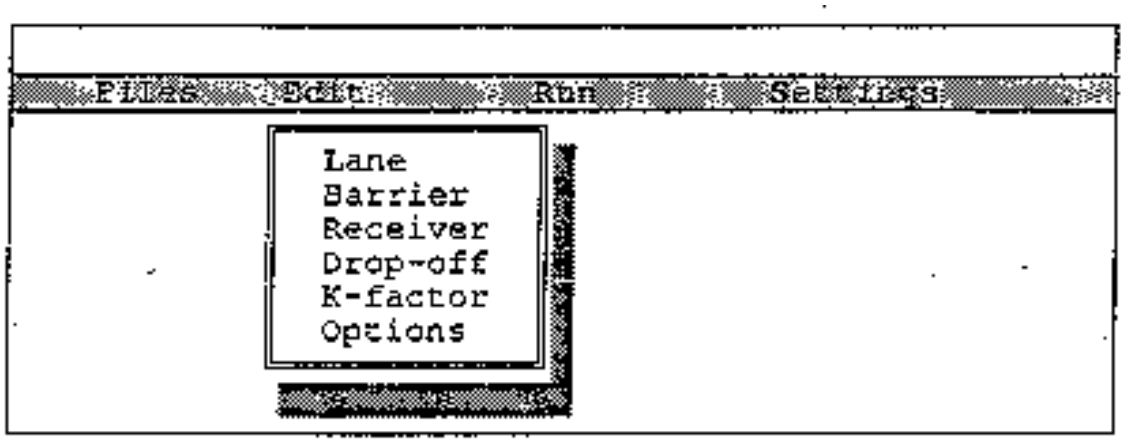
The DOS option takes the user to the DOS Shell. That is, the SOUND32 program is retained in memory but the user is taken to the DOS prompt. This can be useful for doing small housekeeping chores such as formatting a blank diskette while still retaining data in SOUND32. Return to SOUND32 by typing EXIT at the DOS prompt. DO NOT enter S32. This will load a fresh copy of SOUND32 into memory along with the existing copy. If you run SOUND32 from Windows 3, 386 mode, it's probably preferable to temporarily suspend SOUND32 using Ctrl-Esc rather than the DOS shell. Running other programs from the SOUND32 DOS shell from inside of windows may result in undesirable effects.

REMEMBER: If you select DOS from the Files menu use Exit to return to the program.

5.1.5 Quit

As you might suspect, *Quit* takes you out of the program. If there is data currently in memory that has not been saved a warning dialog box will open to insure that you don't lose any data. Hit the [Escape] key to back-out of *Quit* if you need to save the data or hit [Return] to exit the program and lose any data that's in memory.

5.2 Edit



The *Edit* pull-down menu provides access to all of the input data screens. The following techniques are common to all of the edit screens and are used to enter/revise data and to navigate around the various screens: [Escape] invoke pull-down menus at top of screen.

A common feature of the *Edit* screens is the pull-down *Exit* menu which is used to leave the current screen and return to the main menu. Use *Save* to retain any data which has been entered or revised, use *Abort* to lose any data changes that have been made. If you have just dropped into an edit screen to examine the data either *Save* or *Abort* will work equally well to back you out. Note: *Save* merely retains the data in memory, it does NOT store the data in a data file.

[Page Up] and [Page Down]

Use these keys to move between the multiple screens within a data type (e.g. if you are on page 3 of 8 of the barrier data. hitting [Page-Down] will display page 4 of 8). When entering new data, fill in the data on the first screen and hit [Page-Down] to go to the second screen. Both the lane data screens and the barrier data screens show the screen number being displayed and the total number of screens in use (Lane 2 of 5, Barrier 5 of 8 etc.). The receiver data screens don't show the screen number but you can determine where you are by looking at the receiver numbers, 1-20 are on the first page, 21-40 on the second.

If you inadvertently page past the last screen in your data and it's not your intention to add another screen full of data then the following steps will back you out: a) hit [Page-Up], b) hit [Escape], c) hit return.

Within each screen movement is accomplished as follows:

[Tab] move to next field

[Return] move to next field

[Down Arrow] move to field below current field

[Up Arrow] move to field above current field

[Shift][Tab] move to previous field

[Ctrl][Return] insert a blank line of fields, pushing data below down a row

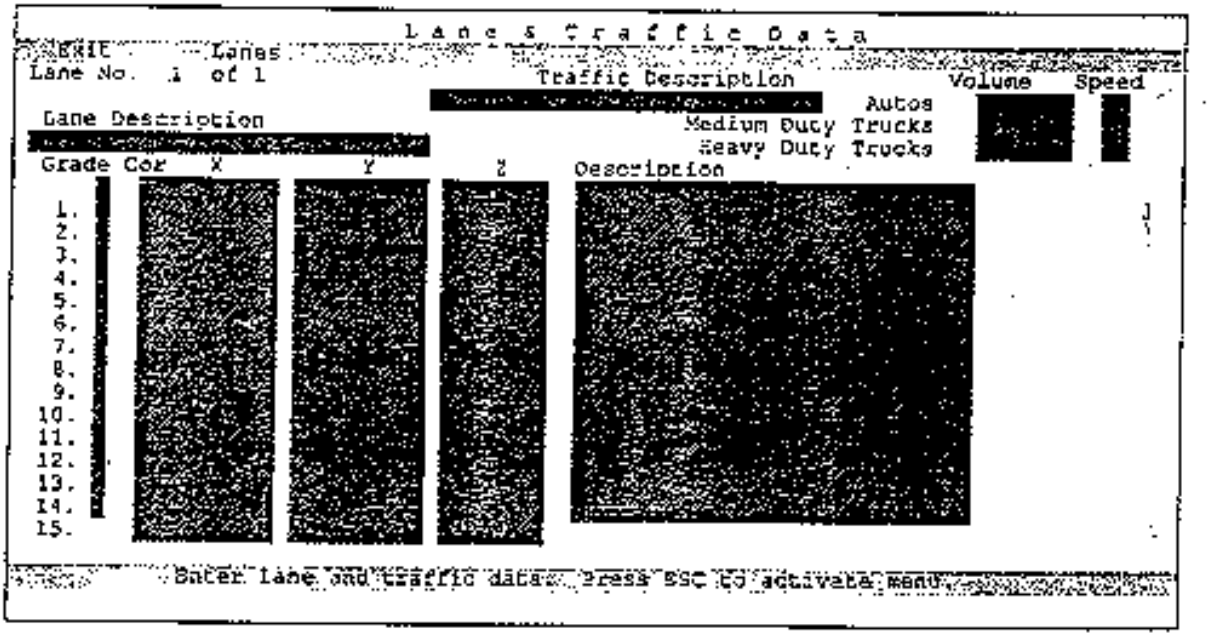
[Ctrl][Backspace] delete row, pulling data below up a row

[Left Arrow] move left within a field

[Right Arrow] move right within a field

5.2.1 Lane

Selecting *Lane* from the *Edit* menu will bring up the following screen:

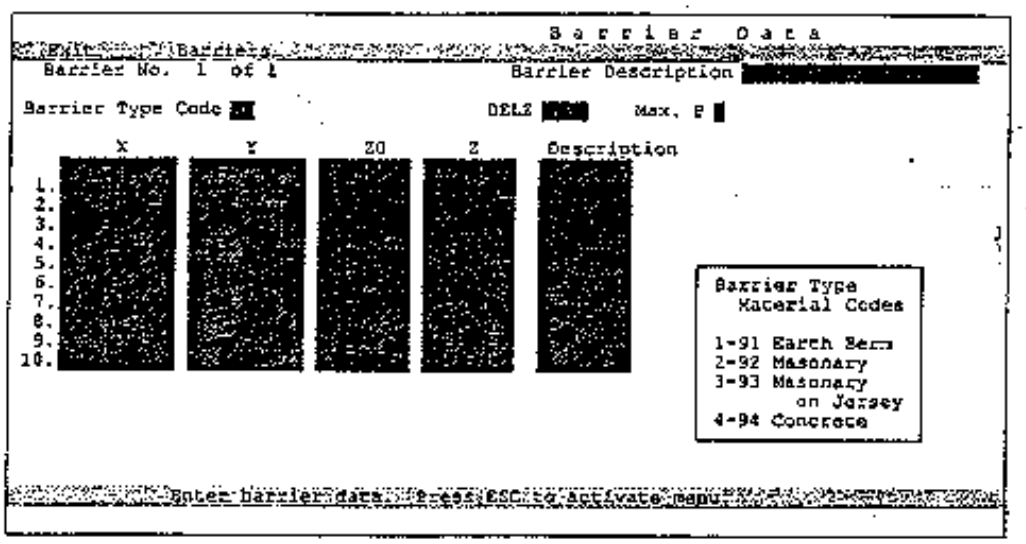


Fill-in the data fields as necessary.

You can leave blank any fields that are not required to define the traffic and lane data. Both the Traffic Description and Lane Description fields at the top may be left blank. Any traffic data not needed may also be left blank. As a minimum you will need to fill in at least one volume and speed and the first two sets of coordinate fields in order to define a lane.

The Grade correction fields will only except a ‘Y’ yes or a ‘N’ for no. When entering data into these fields the keyboard input is mapped to upper case, so you don't need to use a shifted 'y' or 'n'. The grade correction fields may be left blank but when you run SOUND32 you will get warning messages that tell you that the data is missing and has been set to ‘N’.

5.2.2 Barrier



Fill in the necessary barrier data. The barrier description field is nonessential data and may be left blank.

If barrier type number which indicates a structure barrier is entered (a barrier type number greater than 90) then an additional field win open up near the bottom of the screen where the lane numbers affected by the barrier should be entered. If more than one lane is affected by the barrier then separate the list of lanes with commas.

Example:

Lanes affected by Structure Barrier:

2,3,5

As a minimum the user will need to fill in the barrier type code, DELZ, Max-P, and two sets of coordinate fields. If the barrier is a structure barrier then at least one lane will need to be indicated in the lanes affected by field.

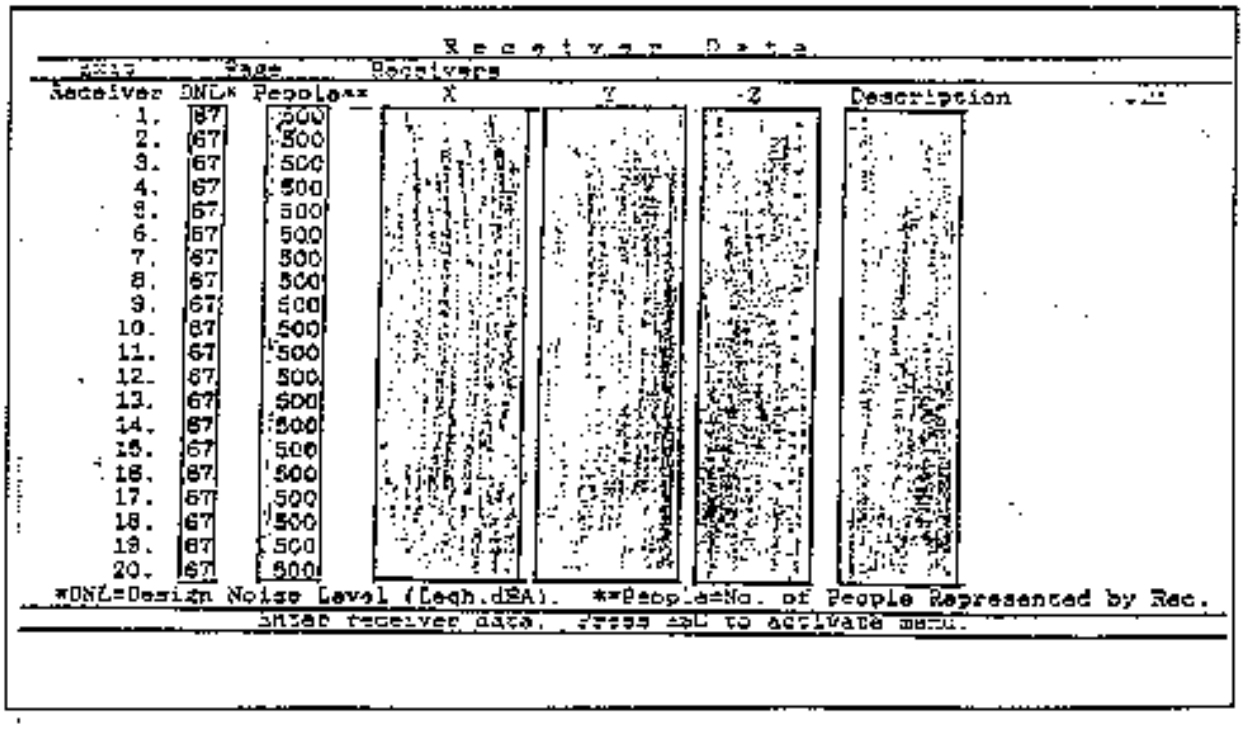
5.2.3 Receiver

Fill in the coordinates for each receiver.

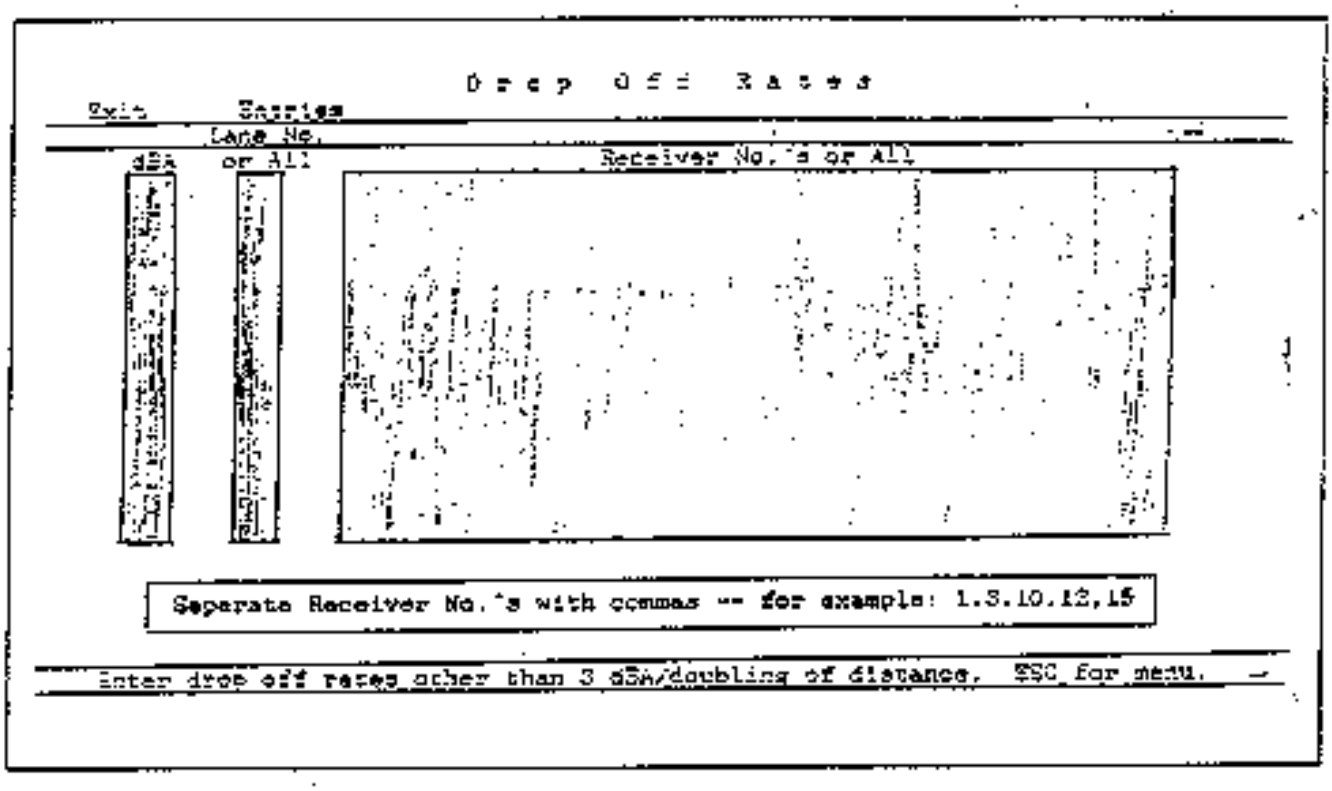
The receiver description is optional and may be omitted.

The design noise level and number of people per receiver are set to default to 67 and 500. Change these values as necessary.

If there are more than 20 receivers use the [Page-Down] key to display the second receiver screen for receivers 21-40.

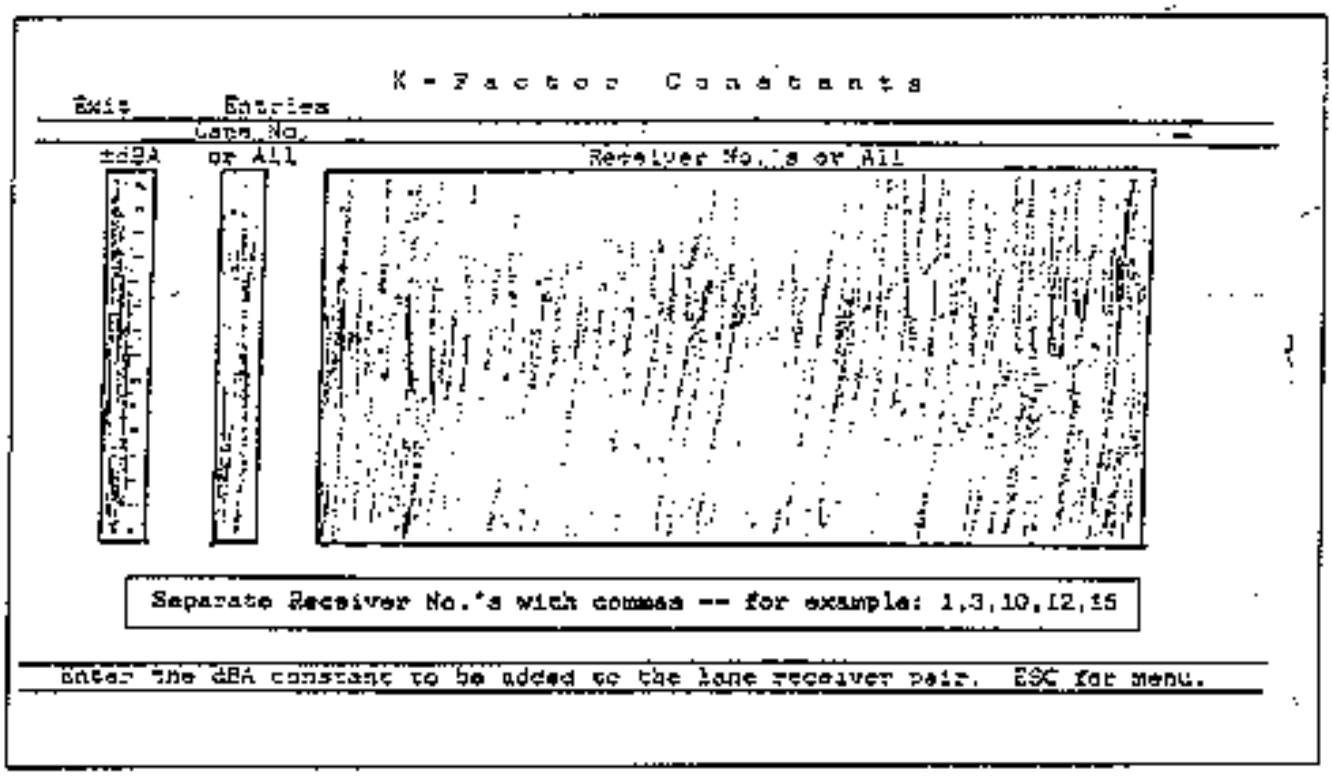


5.2.4 Drop-off



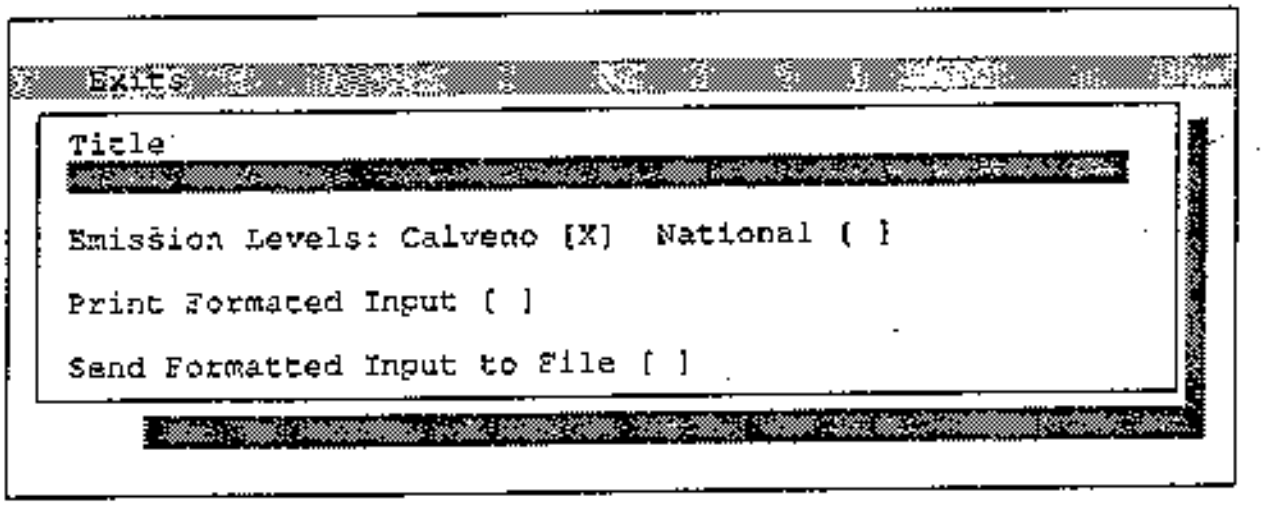
For all lane-receiver pairs where the drop-off rate is not 3 dBA/DD enter the drop-off rate. In the affected lane column enter the lane number, or A or All for all lanes. In the receiver field enter the list of affected receivers separated by commas. Use A or All to designate all receivers.

5.2.5 K-Factor



Enter any K-factors (plus or minus). In the affected lane column enter the lane number, or A or All for all lanes. In the receiver field enter the list of affected receivers separated by commas. Use A or All to designate all receivers.

5.2.6 Options



The Options screen is used to:

a. Enter the problem title.

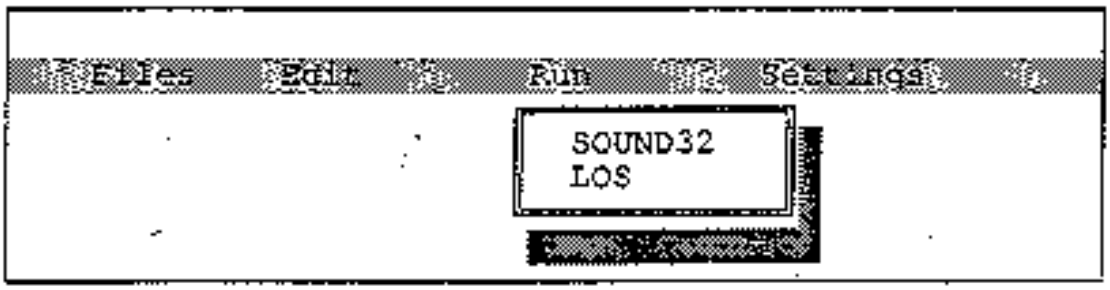
b. Select Calveno or National reference energy mean emission levels.

c. Specify if a formatted copy of the input data is to be sent to the printer, to a file or to both.

Use the arrow or tab keys to move around between options. Use the [Space Bar] or [Return] key to toggle choices on or off.

If the last option, formatted input to file, is toggled-on a field will open where the name of the output file can be specified.

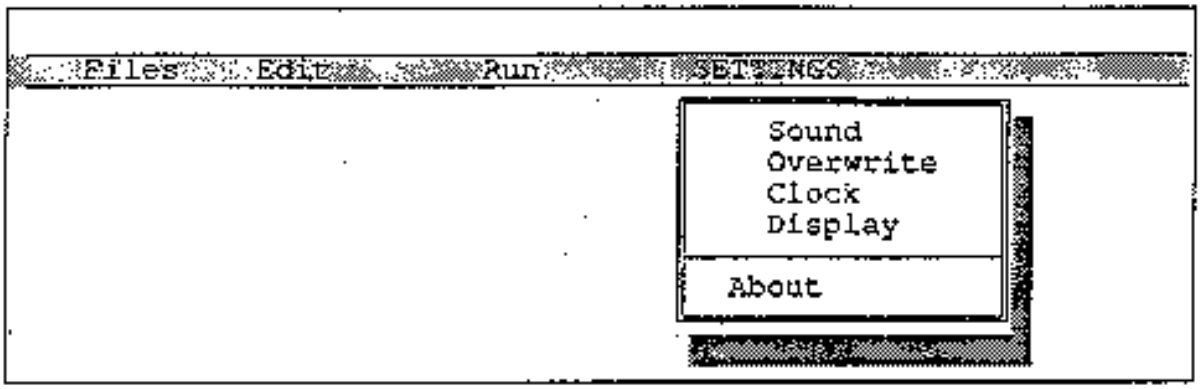
5.3 Run



Run offers the option of executing SOUND32 or LOS. Once either of these program has terminated control will return here to the initial menu.

It is considered prudent to open the *Files* menu and do a Save BEFORE running SOUND32 or LOS so that no data is lost if a problem develops.

5.4 Settings



The menu choices in the settings menu, with the exception of *About*, all toggle on and off by moving the arrow to the choice and hitting [Return].

5.4.1 Sound

Toggling Sound will turn off the notes that play as the user cycles through the menu choices.

5.4.2 Overwrite

Overwrite is the warning message that is displayed when a *Save* is about to write data on top of existing data in a file.

5.4.3 Clock

Toggling the *Clock* turns the display of the time and date on and off.

5.4.4 Display

This toggles between color display and monochrome display.

5.4.5 About

About displays the Release number of the program so that the users may assertion if they have the latest version.

6.0 USING SOUND32

SOUND32 performs the noise level calculations and allow the user to design a noise barrier if desired.

The initial steps followed in FORTRAN module of SOUND32 are:

1. Read in the input data from the "pass" file created by the preprocessor

2. Check the data for illegal intersections of lanes and barriers

3. Read in the barrier cost data and Calgrade emission levels from the appropriate files

4. Calculate the first set of results. If errors occur, the user will be notified. The first results are then printed to the screen and contain the Leq and barrier cost based on the Z barrier heights. It should be noted that some time is required for calculations depending on data input file and may easily be more than 30 seconds per receiver on an IBM-AT level machine.

The data for the first set of results may "scroll" off the screen too quickly to be viewed. However, this is not a problem since a BROWSE option is available. After the first results are printed, pressing the [RETURN] key will present the user with the SOUND32 menu.

Once the user has reached the SOUND32 menu, the user may select any of the nine menu options. Upon completion of any of the requested menu activity (except STOP) the program will always loop back to the menu. The menu options are:

ENTER MENU SELECTION

1) CHANGE BARRIER HEIGHT INDEX

2) CHANGE BARRIER TYPES

3) CHANGE PEOPLE PER RECEIVER

4) CHANGE DESIGN NOISE LEVELS

5) RECOMPUTE AND DISPLAY LEQS

6) RECOMPUTE AND DISPLAY BARRIER SEGMENT CONTRIBUTIONS

7) RECOMPUTE AND DISPLAY E/C MATRIX

8) ....BROWSE OUTPUT FILE

9) STOP

To select, the user simply types the desired option number and presses [RETURN]. Typical problems are presented in Appendix A,

Sample Problems. These problems show the user interaction with the program, including the menu options.

The user should be aware that any time data is requested for the SOUND32 program, the user may use the FORTRAN "list-directed" read. With list-directed read, data may be entered using a multiplier, the multiplication symbol, and then the data. For example: if the user is changing the DNIL and there are 10 receivers, instead of entering:

67 67 67 67 67 67 62 67 67 67

the user may enter:

6*67 62 3*67

6.1 Change Barrier Heights

When the user originally creates the input data, barriers are coded using separate barriers with barrier segments within each barrier. When SOUND32 executes, each barrier segment of each barrier is assigned sequentially to a barrier "element." Each barrier element is identified by the beginning segment endpoint description. For example: if the user has coded 3 barriers of 4 segments each, there will be 12 barrier elements. Element 1 would be barrier 1, segment 1 and element 12 would be barrier 3, segment 4. This is an important concept the user must grasp to properly complete this menu option.

To change barrier heights, the user must select menu option 1. SOUND32 will then interactively prompt the user for a description of this case (allows the user to keep track of changes) and for the list of barrier height index number for each barrier element. Execution will not occur until the proper number of height index values, in the correct range, have been entered.

Example:

ENTER MENU SELECTION

1

ENTER DESCRIPTION OF THIS CASE (80 CHARACTERS OR LESS)

ALL SEGMENTS SET AT INDEX 7 EXCEPT LAST ONE

ENTER BARRIER INDEX FOR EACH BARRIER ELEMENT

(LIST DIRECTED)

10*7 1

The user is then returned to the main menu. These changes are then in working memory. To include these changes in the output file and calculate corresponding Leq's, the user must select option 5) RECOMPUTE AND DISPLAY LEQS. Either of the other recompute options could also be selected. Option 5 recalculates and displays receiver parameters, new Leq data, barrier type, cost, and height indexes with corresponding barrier heights. To review the new results, the user may select the BROWSE option (number 8). .

6.2 Change Barrier Types

The user may change the barrier material of the barrier elements by selecting option 2 from the menu. SOUND32 will then prompt the user for the list of barrier material type numbers for each barrier element. If this is the first recompute, or occurs immediately following a recompute, the user is first asked to supply a description for later reference.

Because of the differences in diffraction attenuation, berms may not be changed to walls and walls may not be changed to berms. The program will remind the user if this is attempted. Similarly, structure barriers may not be changed to non-structure barriers, and vice versa, in option 2. The user must return to make these changes in the input file, using S32ED.EXE or some other editor.

After selecting and inputting the type for each barrier element, the user is shown the type changes that have been made for each barrier segment. After review, the user may recompute. It should be noted that if the BROWSE option is selected at this time, only the new title will be displayed. Only after a recompute option has been selected does additional information get added to the output file. This avoids adding erroneous information to the output file which may be confusing when reviewing at a later date.

Example:

ENTER MENU SELECTION

2

ENTER DESCRIPTION OF THIS CASE (80 CHARACTERS OR LESS)

TEST

ENTER TYPE NUMBER FOR EACH BARRIER ELEMENT

(LIST DIRECTED)

5*2 1

CHANGE FROM/TO BERM IGNORED

1 1 BERM

2 1 BERM

3 2 MASONRY

4 2 MASONRY

5 2 MASONRY

6 1 BERM

Execution suspended: PRESS <<RETURN>> to continue

It should be noted that the berm elements (elements 1 and 2) did not change even though a new material type code was input. Remember this occurs because of the differences in calculating the diffraction attenuation. The user is shown this to avoid possible confusion.

6.3 Option to Change People Per Receiver

To change the number of people per receiver, select menu option 3. The program will then request the number of people per receiver for each receiver location and return to the menu. Again to avoid confusion, the change for the number of people is not shown in the output file until a recompute option is selected.

6.4 Change Design Noise Levels

To change the DNL's, select menu option 4. The program will request the DNL for each receiver and return to the menu after data entry. Values not in the proper limits will not be accepted.

6.5 Recompute and Display Results

If the user selects menu option 5 (RECOMPUTE AND DISPLAY LEQS), SOUND32 will recompute all Leq data, display receiver information, new Leq results, the barrier height indexes, and corresponding barrier heights. Pressing [RETURN] again returns the user to the main menu. If SOUND32 encounters multiple barriers or a complex file during calculation, users may notice a time delay before the Leq is printed. This is because the program re-calculates any receivers when multiple barriers were encountered and the barrier height indexes have been changed.

Menu option 6 causes the program to recompute each barrier segment contribution. After the user has entered 6 and pressed [RETURN], a prompt asks for the desired receiver. The user must input the appropriate receiver number (assigned sequentially by the program to each receiver) and press [RETURN]. The Leq contribution over each barrier segment for the selected receiver is then displayed along with the ID of each barrier segment, its length, and its type of material. The generated table displays these barrier contributions for each possible height selection (based on perturbations selected). Also at the bottom of this table NBAR and the total contribution (each height) is shown. The user may scrutinize this output by using the BROWSE option.

6.6 Barrier Segment Contributions

Menu option 6 causes the program to recompute each barrier segment contribution. After the user has entered 6 and pressed [RETURN], a prompt asks for the desired receiver. The user must input the appropriate receiver number (assigned sequentially by the program to each receiver) and press [RETURN]. The Leq contribution over each barrier segment for the selected receiver is then displayed along with the ID of each barrier segment, its length, and its type of material. The generated table displays these barrier

contributions for each possible height selection (based on perturbations selected). Also at the bottom of this table NBAR and the total contribution (each height) is shown. The user may scrutinize this output by using the BROWSE option.

6.7 Recompute and Display E/C Matrix

If menu option 7 is selected, the E/C matrix is recomputed (if input has changed) and redisplayed. If no changes have been made, the original E/C matrix will be displayed. The ratios are displayed with the barrier elements running down and the barrier height index across. An asterisk is printed behind the used set barrier height index. This permits the user to optimize his barrier design based on both effectiveness and cost. Reference 1 should be consulted for additional information on the E/C matrix. Pressing [RETURN] returns the user to the main menu.

6.8 Option to Browse Output File

The BROWSE option allows the user to review the contents of the output file. This not only compensates for the rapid screen scroll during normal execution but allows the user to study his or her past iterative designs during the session. Accordingly, BROWSE permits the user to "look" at all of the work during the session to guide future design decisions. The output file is continually appended each time the user chooses a RECOMPUTE option during a session.

BROWSE is activated by typing: 8 [RETURN].

The output file can then be reviewed, sequentially, one screen at time. Pressing [RETURN] scrolls to the next screen. In the PC version of the program scrolling back is not permitted but the user may BROWSE as many times as needed.

6.9 STOP

To end execution (and the current session) of SOUND32 the user selects STOP by typing 9 and pressing [RETURN]. The program execution is terminated and the user is returned to the DOS environment.

7.0 CONSIDERATIONS WHEN USING SOUND32

7.1 Introduction

However, to assist in the decision-making process involving the use of SOUND32, common considerations are discussed in this chapter.

7.2 Geometric Data Inputs

Although SOUND32 has provisions for lane-by-lane traffic input, these data are usually not readily available for most projects. It has been shown, also, that generally, maximum differences of only a few tenths of a decibel resulted between different lane distribution methods. It is suggested that, as a minimum, directional traffic located along the centerlines of each direction be used.

A convenient three-dimensional coordinate system should be set up to locate roadways, barriers and receivers. In complicated geometry there are the constant dilemmas of too much detail vs. oversimplification of the problem. Unfortunately, there are no rigid rules for dealing with these dilemmas. Common sense and experience may be the best guides in deciding the amount of detail required for the problem. When in doubt, additional computer runs may be made to assess different levels of detail.

7.3 Barrier Need Determination

First, an input file should be created to run the "without barrier" condition. This condition should be examined to determine whether or not noise mitigation (a barrier) is needed. The file should include future design year traffic, proposed roadway receiver geometry, selected receivers, design noise levels (DNL), and number of people represented by each receiver. Do not include any noise barrier data. However, do include barriers created by hinge points, cut/fills, structures, ramps, etc., (i.e., any permanent barrier that will be created as a result of constructing the project, or that will remain after construction). (Set Z = ZO, DELZ = 0, and P = 0). Results of this computer run will identify if noise abatement measures are needed.

If existing noise measurements with simultaneous traffic counts are available, the prediction results can be calibrated to "fit" the actual measurements using K-constants. If at all possible, noise and traffic measurements should be taken. Model calibration procedures greatly increase the accuracy of the predictions. Additionally, the need for mitigation should be identified.

Create an input file including the traffic counts taken during the noise measurements (expanded to hourly volumes), existing roadway receiver geometry, measured sites as receivers, design noise levels (DNL), and people represented by the receivers. Do not include any noise barrier data because calibration of the model is to be performed. Be sure to include any existing barriers (Z = ZO, DELZ = 0, P = 0).

Run the SOUND32 program. The results are the noise predicted noise levels at the measurement sites, using the traffic counts. They should be compared with the measured noise values. The difference (measured minus predicted) between the two should be used as positive or negative adjustments or correction constants (K-constants), applied to each measured site (receiver).

If no measurements were available a SOUND32.INP input file needs to be created with the following pertinent information:

1. Design year traffic (future highway capacity) or existing peak traffic (highway already at capacity).

2. Existing roadway receiver configuration. Include existing natural or artificial barriers (set Z = ZO, DELZ = 0, P = 0).

3. Selected receivers, design noise levels (DNL) and people represented by each receiver.

If measurements were available, the same information as above would be required, plus the K-constants used. Generally, more receivers will be required in addition to the measuring sites. The user should decide which of the K-constants best represents each additional receiver and input accordingly.

At this point the user is ready to compare the resulting predicted noise levels with appropriate standards or DNL for compliance. If the predicted noise levels are at or below the DNL, no mitigation is required and the barrier design process terminates. However, if the DNL is exceeded at one or more receivers, mitigation should be considered.

The location of the barrier is governed by guidelines in the Caltrans Highway Design Manual Chapter 1100.5. Within these guidelines several alignments are often permissible, each of which will affect the cost or performance of the barrier. However, other factors such as maintenance access, community acceptance, or aesthetics, may be overriding elements. Therefore, it is recommended that several representative alignments, on shoulder, along the R/W or somewhere in between be considered. Barrier materials should be decided at this point.

Choose one of the alternatives for barrier alignment and materials. Determine Z0 (proposed ground elevations along barrier alignments), choose Z heights, perturbation increment (DELZ), and number of increments above and below Z (no. of perturbations, P) and modify previously created input file with these data.

Design Manual Chapter 1100 requires that barriers should be high enough to break the line of sight (L.O.S.) between a 5 ft. high receiver and an 11.5 ft. high truck stack. In some instances such as geometry involving deep cuts, it is obvious that the L.O.S. break is sufficiently low and therefore need not be considered. In other cases the L.O.S. break requirement may not be feasible. The LOS program may also be run to determine appropriate barrier heights to break the line of sight.

7.4 Optimizing Barrier Heights

To guide the user in selecting a cost-efficient barrier design, SOUND32 computes a factor for each barrier section at each of its heights. This factor, called the Effectiveness/ Cost (E/C) ratio, is the "effectiveness" of the barrier divided by its cost.

The E/C ratios have been presented in the matrix as 10 log (E/Q). The logarithm is used to collapse the large range of values E/C that occur and to make 10 log (E/C) act like decibels. A difference of 3 in 10 log (E/C) means a factor of 2 difference in E/C, a difference of 10 means a factor of 10 difference in E/C.

A high E/C ratio means that the barrier section-height has low effectiveness at a low cost. A low E/C ratio means high effectiveness at a high cost.

The user is cautioned against comparing E/C ratios between different SOUND32 PC runs. Usually, only E/C ratios in the same matrix should be compared, unless the SOUND32 input is the same in a subsequent run. The E/C ratios are designed to be used to balance a barrier design for cost effectiveness in a single SOUND32 run. There is no significance to the actual value of effectiveness/cost for a barrier section, except in comparison to the E/C ratios for barrier sections in the same matrix.

The user should use the E/C ratios only as a guide to designing a cost-effective barrier system. The E/C ratios will not always point the way to a barrier design that is acceptable to all involved parties (design, maintenance, construction, locals. etc.). Many times, in order to meet predetermined noise abatement criteria, a user will have to choose barrier sections with E/C ratios that are not similar to the others he has chosen.

When choosing the first barrier design, the user should consult the optional effectiveness/cost (E/C) ratios for each barrier element at

each height. The purpose of the E/C ratios is to allow for a "balanced" design. A balanced design is achieved when the user chooses barrier heights that all have the same (or nearly the same) E/C ratios. It is the most effective design for the least cost; that is no transfer of money from one barrier element to another will result in an increase in effectiveness, expressed by noise reduction per person. However, a balanced design does not necessarily provide adequate protection or fall within reasonable height requirements. The user should only use the E/C ratios as a guide toward a reasonable, cost effective barrier design.

After the initial designs the user should rely less on E/C ratios. With the aid of a plan map of the study area with the barrier elements and receiver locations clearly identified, the user can home-in on the minimum cost barrier offering the required noise protection. This is accomplished by changing the barrier heights or materials of each barrier segment (also called barrier element) within the limits of DELZ and P. Barrier design is optimized by interactive sessions where various barrier height designs are analyzed. Optimum design for a given barrier alignment and material(s) will be achieved when all receivers are at or below the DNL and the barrier cost is at a minimum.

7.4.1 Barrier Effectiveness

Three elements contribute to the "effectiveness" of the barrier, as SOUND32 defines it. Those elements are sound energy going over the barrier, number of people affected, and the DNL. Each of these elements must be associated with a receiver. The algorithm that computes effectiveness starts with the first barrier at the ground elevation Z0. It then looks at the sound energy going to the first receiver. This energy is then weighted by the number of people and DNL for that receiver. The program then sums the weighted energies over all receivers to determine a single "effectiveness" for the first barrier section. Therefore, the effectiveness of each barrier is based on the reduction in total community sound energy.

Consequently, receivers exposed to the highest noise levels are most influential in determining the effectiveness of the barriers. Similarly, since population and DNL are also figured into the effectiveness, receivers representing a large number of people or having a low DNL will influence the E/C ratios more than receivers with small population or higher DNL.

7.4.2 Barrier Cost

The cost portion of the effectiveness/cost ratio is simply based on the total material and construction cost of the barrier section at a specific height. The barrier height and length information are calculated from the input data, the material selection from the user input, and the cost from the barrier cost file. For those users who wish to provide their own barrier cost data, Appendix B shows the format used in the barrier cost files.

7.4.3 Population Weighting

The user supplies a population weighting value for each receiver as input to SOUND32. This value is used to multiply the sound energy values for that receiver in order to weight the E/C ratios with respect to the number of people affected by the barrier. If the user specifies a zero population weighting value for a receiver, the sound energy values for that receiver are given no significance in the calculation of the E/C ratios. Therefore, the user significantly influences the E/C ratios through his choice of population weighting.

If the user wishes to have a meaningful, balanced noise barrier design care should be taken to choose appropriate population weightings. The population weightings having meaning only with respect to each other and how they affect the E/C ratios. For example, if a user has placed one receiver at each dwelling unit, and he knows there are 2.5 people per dwelling unit in the study area. It makes no difference to the barrier design process whether he assigns 1, 2.5, or 100 people to each receiver, since each receiver receives the same weighing. The only difference will be the size of each E/C ratio; the difference among them will remain constant.

SOUND32 can be used to examine noise barrier options for a single receiver, if desired. The user simply assigns zero population weighting to all other receivers. The resulting E/C ratios will apply only to the receiver of interest, and the critical barrier sections will appear as the ones with the highest E/C ratios. This approach can be helpful if a single receiver is a problem, and with the normal population weightings, the user cannot easily identify which barrier sections are the most important for the problem receiver.

Finally, it should be pointed out that in many cases the optimum acoustical design may have to be compromised because of the Design Manual Chapter 1100 requirement of 11.5 ft. stack height L.O.S. break. In these cases the optimum barrier height is represented by the L.O.S. break, which compromises the value of the SOUND32 optimization procedures.

8.0 LOS- THE LINE OF SIGHT PROGRAM

The LOS program calculates noise barrier elevations at various points along the noise barrier, which intercepts the line of sight (L.O.S) between an 11.5 ft. truck stack and various receivers. By using these elevations and the barrier top profile the user can design a noise barrier which meets the truck stack L.O.S requirements of Caltrans Highway Design Manual Chapter 1100.5.

The LOS program uses a standard SOUND32 input data file, containing information on the location of the lane occupied by the trucks, the location of the barrier, and the locations of receivers.

If the user is creating a file solely to run LOS, the file need only contain the following:

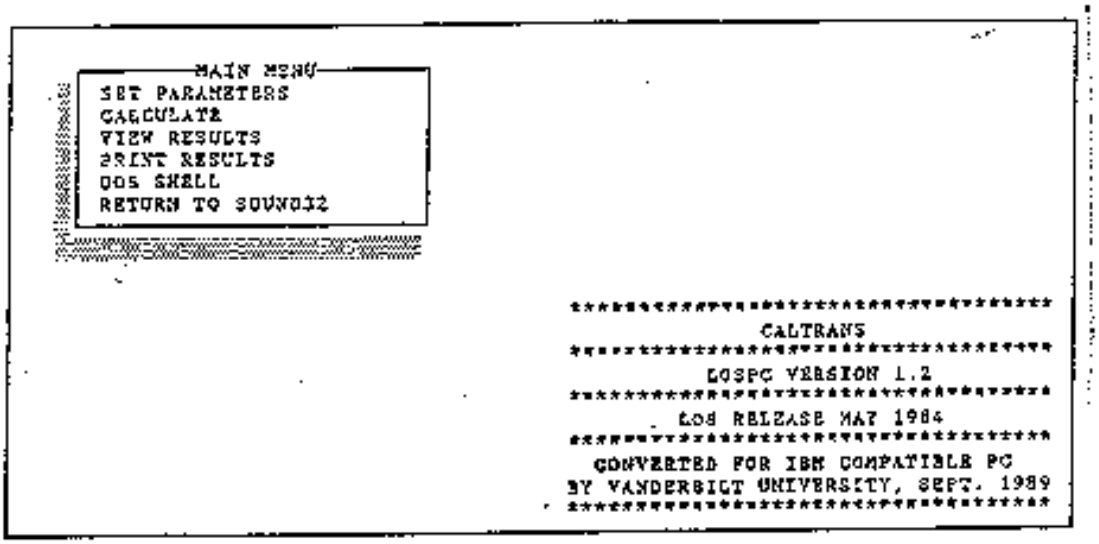
1. A title line

2. Lane data for at least one lane.

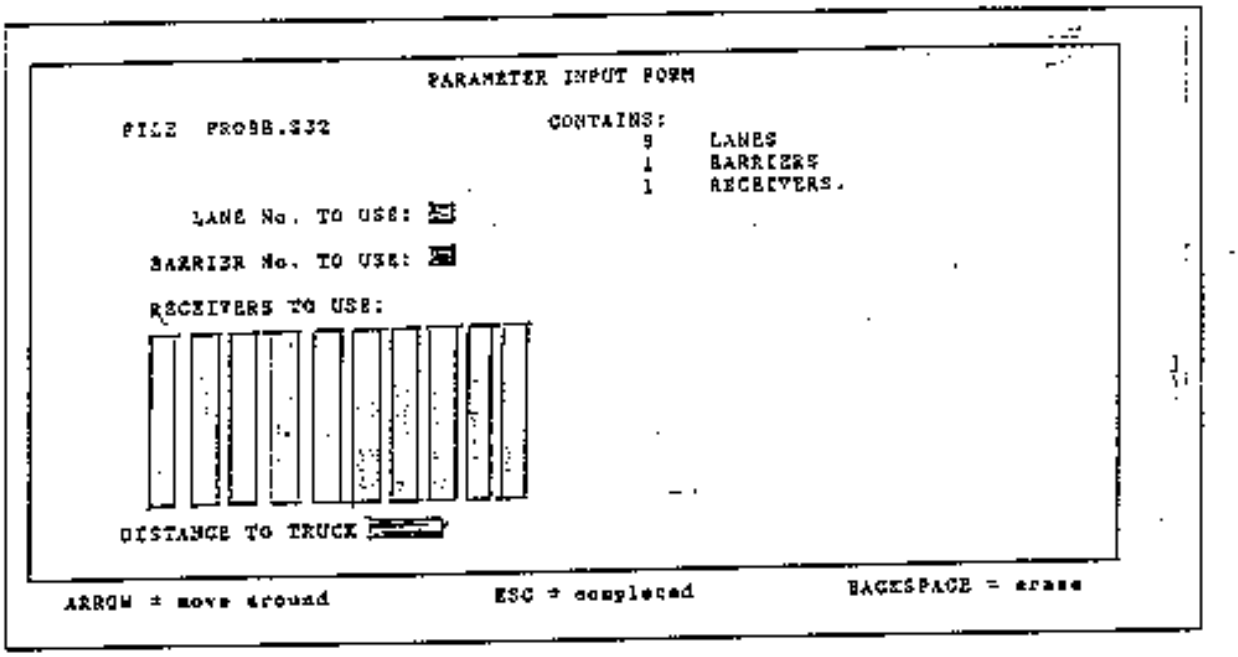
3. Barrier data for at least one barrier.

4. 1 or more receiver definitions.

The LOS program may be run by selecting LOS from the Run menu. Upon entry into LOS the program displays the LOS main menu of options (see Figure 8-1).



The first step is to define the LOS input parameters. This is accomplished by using the arrow keys to select SET PARAMETERS from the main menu and pressing [RETURN]. A screen will be displayed which permits the user to input the LOS parameters (see Figure 8-2). The input data consists of lane number, barrier number, a list of receiver numbers to use, as well as the maximum receiver-to-truck distance that should be calculated. The upper right comer of the screen displays the number of roads, barriers, and receivers in the selected data.



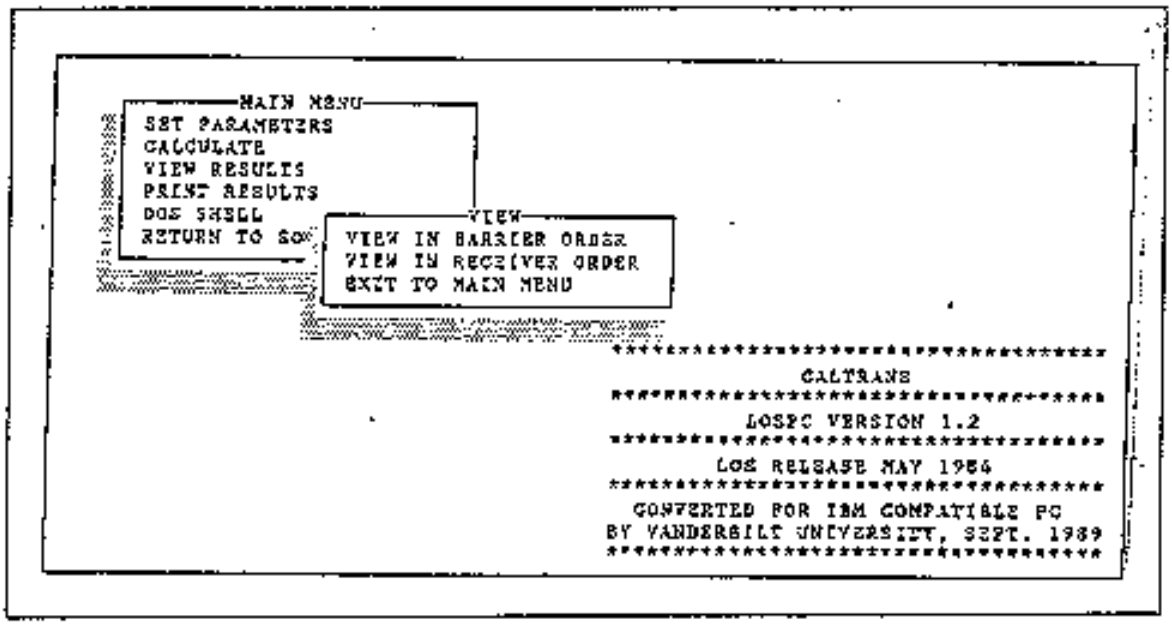
The truck-to-receiver distance is used to limit the L.O.S listing to areas adjacent to each receiver where truck stack noise is a problem. Since truck stack noise is a point source it can be expected to drop-off at a rate of approximately 6 dBA/DD and thus, "blend" into the noise from the line sources. Thus, truck stack line of sight probably does not need to be considered to distances greater than the distance where the stack noise falls to within 3 dBA of the line source noise.

After the user inputs the maximum truck to receiver distances, the [Escape] key is pressed to return the user to the LOS main menu.

The RETURN TO SOUND32 option simply returns the user back to the SOUND32 initial menu.

After setting the parameters to be used, the user is ready to use the CALCULATE option. This option will notify the user that calculation is in progress at the bottom of the screen. After calculation, the program will first display how many points were calculated for the barrier order and then the receiver order, also at the bottom of the screen.

After calculation, the user may then VIEW RESULTS. Selection of this option causes a second level screen to be displayed (see Figure 8-3). The user may review the LOS output file in barrier order or receiver order, or exit back to the LOS main menu.



If VIEW IN BARRIER ORDER or VIEW IN RECEIVER ORDER are selected, an output screen is displayed that shows the lane, barrier, and receiver number selected and all calculated parameters. From a review of either of these files the user can decide if the line of site is broken and if not, how much more barrier height would be required. Pressing [Escape] returns the user to the second level menu.

The LOS output is always written to two file named IBO.DAT, which has the output in barrier order, and IRO.DAT which has the output in receiver order. For any given run of LOS these files are overwritten for the first calculation and subsequent calculations are appended to the end of the files. Thus, any data in the files from previous runs of LOS is lost. To retain data from previous runs rename or copy these two files before re-executing LOS.

Also included in the LOS main menu is a DOS SHELL option which is the same as the previously defined DOS SHELL in the SOUND32 front-end.

REFERENCES

1. Bowlby, W., Higgins, J. Reagan, J.; "Noise Barrier Cost Reduction Procedure, STAMINA 2.0/OPTIMA; Users Manual," FHWA-DP-58-1, Federal Highway Administration, April 1982.
2. Wood, D.S., Hendriks, R.W., "User's Instructions for SOUND32 (Caltrans Version of FHWA Highway Noise Prediction and Barrier Cost Reduction Procedure, STAMINA 2.0/OPTIMA," FHWA/CA/TL-83/06, California Department of Transportation.
3. Hendriks, R.W., "California Vehicle Noise Emission Levels (Final Report)," California Dept. of Transportation, FHWA/CA/TL-87/03, January 1987.

4. Barry, T.M., Reagan J.A.,"FHWA Highway Traffic Noise Prediction Model," FHWA-RD-77-108, Federal Highway Administration, December 1978.
5. Bowlby, W., R.L. Wayson, and R.E. Stammer, Jr., "Predicting Stop-and-Go Traffic Noise Levels," NCHRP Report 311, Transportation Research Board, Washington, D.C., 1989.
6. Caltrans Highway Design Manual Chapter 1100, California Department of Transportation.

APPENDIX A

SAMPLE PROBLEMS

A.1 EXAMPLE PROBLEMS

A.1.1 Introduction

The following example problems will illustrate the barrier design process with practical applications. Problem No. 1 is a simple example problem primarily designed for first hands-on experience with the program. Problem No. 2 is an actual barrier project, which will be used as a case study.

A.1.2 Problem No. 1

Sample problem 1 represents a barrier proposal in conjunction with a new highway alignment. The first page shows a scale drawing layout of roadways, barriers, receivers, traffic data, and x-y-z coordinates (x, y, Z0 and Z for the barrier). The subsequent pages follow the design procedures for new alignment projects. A table of contents is included for convenience on page A-14.

A.1.3 Problem No. 2 - Case Study

Problem No. 2 is a case study of a Caltrans retrofit barrier project. The problem is presented in 4 parts: (1) Problem No. 2 is the without barrier case (comparison with noise measurements and K-constant included); (2) Problem No. 2A is the actual barrier design; (3) Problem No. 2B is an example design using SOUND32 procedures with the 11.5 ft. LO.S. break constraint; and (4) Problem No. 2C is an example design using SOUND32 procedures without the 11.5 ft. L.O.S. break constraint, but using a minimum height of 6 ft. The 2.7 ft. high New Jersey barrier at the end is required to meet an existing bridge railing.

The first page of this example shows a scale drawing of the layout of the roadways, existing and actual design barriers and receivers. To avoid crowding, the calculated coordinates and traffic data have been omitted, but they are shown on subsequent work sheets. The same page also shows profiles of the near lane, existing barriers (berms), and the Z0 of the wall. The actual design alignment and materials of the barrier are maintained throughout the problem.

In the actual design, the number of people protected by the barrier was not considered. In the example designs, the number of people represented by each receiver were estimated on the basis of four people per residence.

Usually, only first row residences need be considered in noise analyses. It is assumed that second and third row residences are effectively shielded by the first row. In this case study, however, the freeway was partially on a high fill and it was not readily apparent whether nearby receivers were exposed to higher noise levels than those a little farther away. Some second and even third row receivers were therefore considered in Problem No. 2.

The results would appear to indicate that the actual barrier was over designed. However, it must be pointed out that the actual design includes aesthetic considerations, community input and possibly other factors not considered in the example design using SOUND32.

There is also a temptation to credit all apparent cost savings in the example designs to the SOUND32 procedures. However, pre-SOUND32 design procedures could have arrived at optimum barrier designs through trial and error, the difference being the greater amount of design time required.

In Problem No. 2, the cost difference between actual design and SOUND32 with and without LO.S -designs, showed savings of 33.0% and 48.3% respectively.

For user convenience a table of contents for Problem No. 2 is included on page A-28.

PROBLEM NO. 1

TABLE OF CONTENTS

ACKNOWLEDGEMENTS

I

Problem layout and data

Without barrier

Input data, S32PRE and SOUND32

SOUND32 OUTPUTS

With barrier

Input data, S32PRE

Input data, SOUND32

LOS run

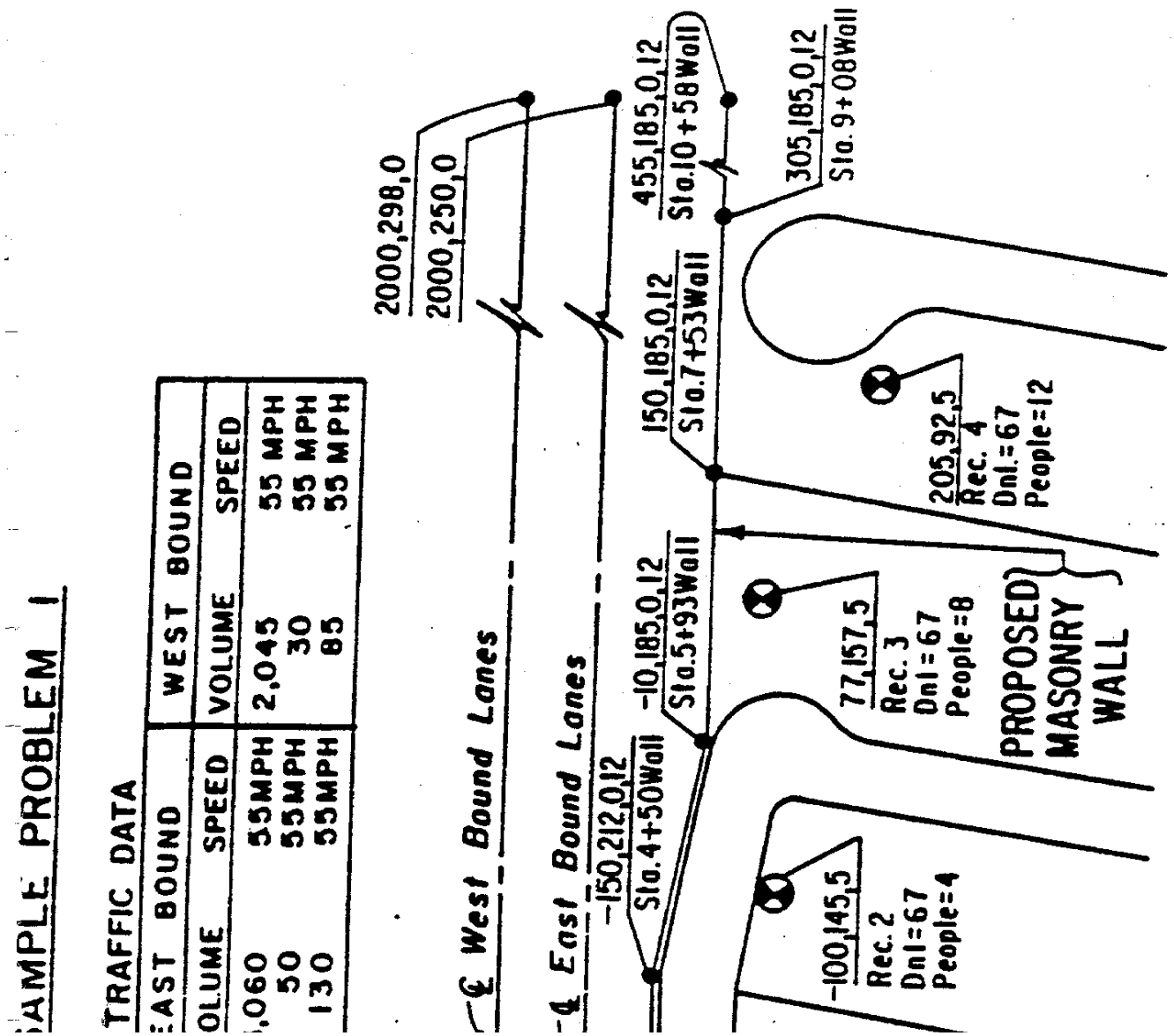
LOS plot

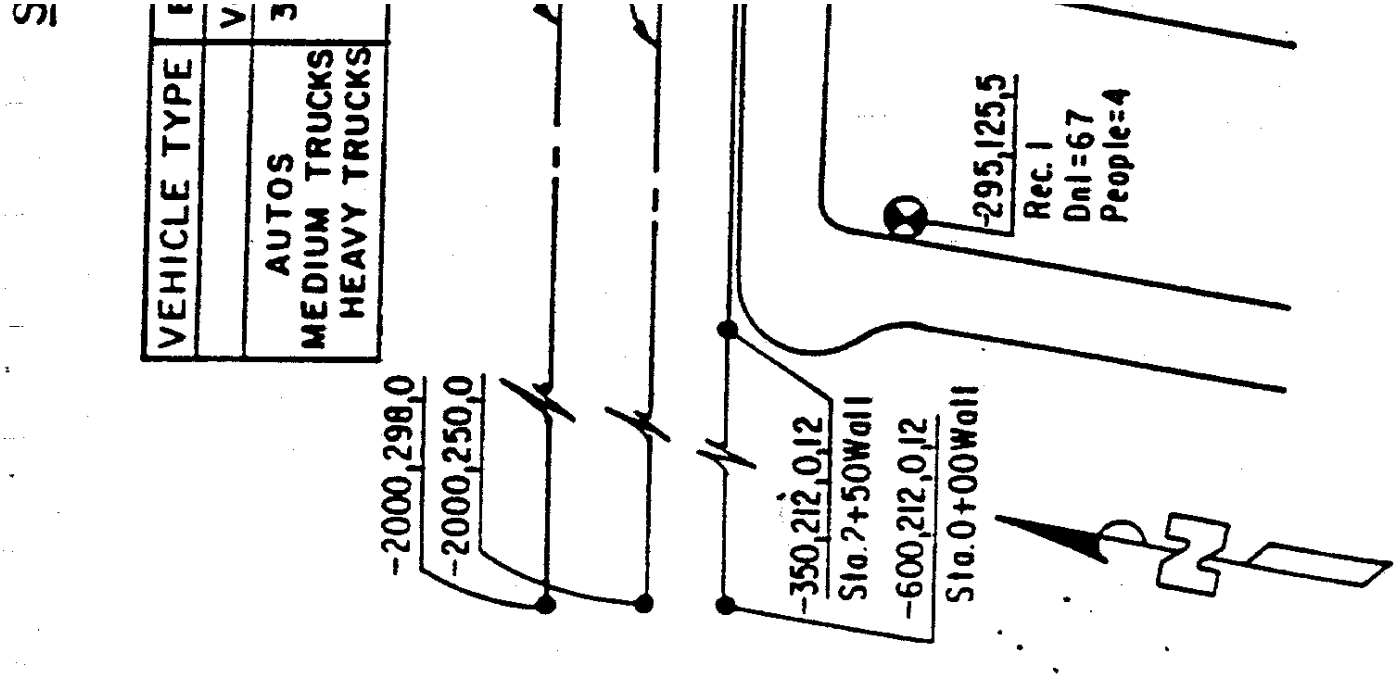
Profile worksheet for barrier design

SOUND32 initial run

SOUND32 looping for optimum barrier heights

Final barrier design profile and cost per SOUND32





Input File

```
BCR SAMPLE PROBLEMI WITHOUT BARRIER.
T,1
3063.SS
50,55
130,55
T,2
2045,55
30,55
85,55
L,l
N,-2000.0,250.0,.0,E/B LANES
2000.0,250.O,.O
L,2
N,-2000.0,298.0,0,W/B LANES
2000.0,298.0,.0
R,1.67,4
-295.0,125.0,5.0,RECl
R,2,67,4
-100.0,145.0,5.0,REC2
R,3,67,8
77.0,l57.0,5.0,REC3
```

```
R,4,67,12
205.0,92.0,5.0,REC4
BCR SAMPLE PROBLEM WITHOUT BARRIER
01,2
  3060  55
    50  55
   130  55
  2045  55
    30  55
    85  55
02,2
2
   -2000    250.0  0.0    0
    2000    250.0  0.0    0
2
   -2000    298.0  0.0    0
    2000    298.0  0.0    0
05, 4
 REC1      -295.0    125.0      5.0       67        4
 REC2      -100.0    145.0      5.0       67        4
 REC3        77.0    157.0      5.0       67        8
 REC4       205.0     92.0      5.0       67       12
    08, 2
2
SOUND32
ENTER INPUT FILE NAME (DATA.S32):BCRll.S32
ENTER OUTPUT FILE NAME (S32.OUT):BCR11.OUT
             ä READING DATA
             ä END OF DATA INPUT
             ä PROCESSING BEGINS
BASED ON FHWA-RD-108 AND
CALIFORNIA REFERENCE ENERGY MEAN EMISSION LEVELS
```

RECEIVER	LEQ
REC1	74.5
REC2	75.2
REC3	75.7
REC4	73.5

```
Execution terminated:0
```

Input File

```
BCR SAMPLE PROBLEM1 WITH BARRIER
T,1
3060, 55
50, 55
130, 55
T, 2
2045, 55
30, 55
85, 55
L, 1
N,-2000.0,250.0,.O,E/B LANES
L.2
N,-2000.0,298.0,.O,W/B LANES
2000.0, 298.0,.0
B, 1,2,1.0,3
-600.0,212.0,0.0,12.0,STA0+00
-350.0,212.0,0.0,12.0,STA2+50
-150.0,212.0,0.0,12.0,STA4+50
-10.0,185.0,0.0,12.0,STA5+93
150.0,185.0,0.0,12.0,STA7+53
305.0,185.0,0.0,12.0,STA9+08
455.O,l85.0,0.0,12.0,STAl0+58
R,1,67,4
-295.0,l25.0,5.0,RECl
R,2,67,4
-100.0,145.0,5.0,REC2
```

```
R,3,67,8
77.0,157.0,5.0,REC3
R,4,67,12
205.0,92.0,5.0,REC4
C,C
BCR SAMPLE PROLEM1 WITH BARRIER
01, 2
  3060  55
    50  55
   130  55
  2045  55
    30  55
    85  55
02, 2
2
   -2000    250.0  0.0    0
    2000    250.0  0.0    0
2
   -2000    298.0  0.0    0
    2000    298.0  0.0    0
03,1
 7         2         1.0       3


 STAO+00           -600.0        212.0       0.0       12.0
 STA2+50           -350.0        212.0       0.0       12.0
 STA4+50           -150.0        212.0       0.0       12.0
 STA5+93            -10.0        185.0       0.0       12.0
 STA7+53            150.0        185.0       0.0       12.0
 STA9+08            305.0        185.0       0.0       12.0
 STA10+58           455.0        185.0       0.0       12.0
05, 4
```

REC1	-295.0	125.0	5.0	67	4
REC2	-100.0	145.0	5.0	67	4
REC3	77.0	157.0	5.0	67	8
REC4	205.0	92.0	5.0	67	12

08,2

2

11.5 TRUCK STACK LINE-OF-SIGHT CALCULATIONS

PAGE 1

INPUT FILE BCR12.INP,LANE NO.1, BARRIER NO.1, MAX. DT 500

RECEIVER(S): 1 2 3 4

BCR SAMPLE PROBLEM1 WITH BARRIER

X	**Y**	**Z0**	**REC**	**DT**	**LOS Z**	**HEIGHT**	**BD**	**DESC.**
BAR. SEGMENT 1								
-600	212	0.0	1	456	9.5	9.5	0	Bar. End STA0+00
-350	212	0.0	2	406	9.1	9.1	250	Bar. End STA2+50
-350	212	0.0	1	148	9.5	9.5	250	Bar. End STA2+50
BAR. SEGMENT 2								
-295	212	0.0	1	125	9.5	9.5	55	NEAR PT.
-150	212	0.0	3	395	8.8	8.8	200	Bar. End STA4+50
-150	212	0.0	2	131	9.1	9.1	200	Bar. End STA4+50
-150	212	0.0	1	243	9.5	9.5	200	Bar. End STA4+50
-150	212	0.0	4	493	9.9	9.9	200	Bar. End STA4+50
BAR. SEGMENT 3								
-100	202	0.0	2	105	8.6	8.6	51	NEAR PT
-10	185	0.0	3	304	7.0	7.0	143	Bar. End STA5+93
-10	185	0.0	2	259	7.5	7.5	143	Bar. End STA5+93
-10	185	0.0	4	398	8.8	8.8	143	Bar. End STA5+93
BAR. SEGMENT 4								
77	185	0.0	3	93	7.0	7.0	87	NEAR PT.
150	185	0.0	3	260	7.0	7.0	160	Bar. End STA7+53
150	185	0.0	4	184	8.8	8.8	160	Bar. End STA7+53

BAR. SEGMENT 5

205	185	0.0	4	158	8.8	8.8	55	NEAR PT.
305	185	0.0	4	232	8.8	8.8	155	Bar. End STA9+08

BAR. SEGMENT 6

455	185	0.0	4	453	8.8	8.8	150	Bar. End STA10+58

DT = Distance to Truck (from Rec.)

BD = Barrier Distance (along Bar. from Segment pt.)

11.5' TRUCK STACK LINE-OF-SIGHT CALCULATIONS

PAGE 1

INPUT FILE BCR12.INP, LANE NO. 1, BARRIER NO. 1, MAX. DT 500

RECEIVER(S): 1 2 3 4

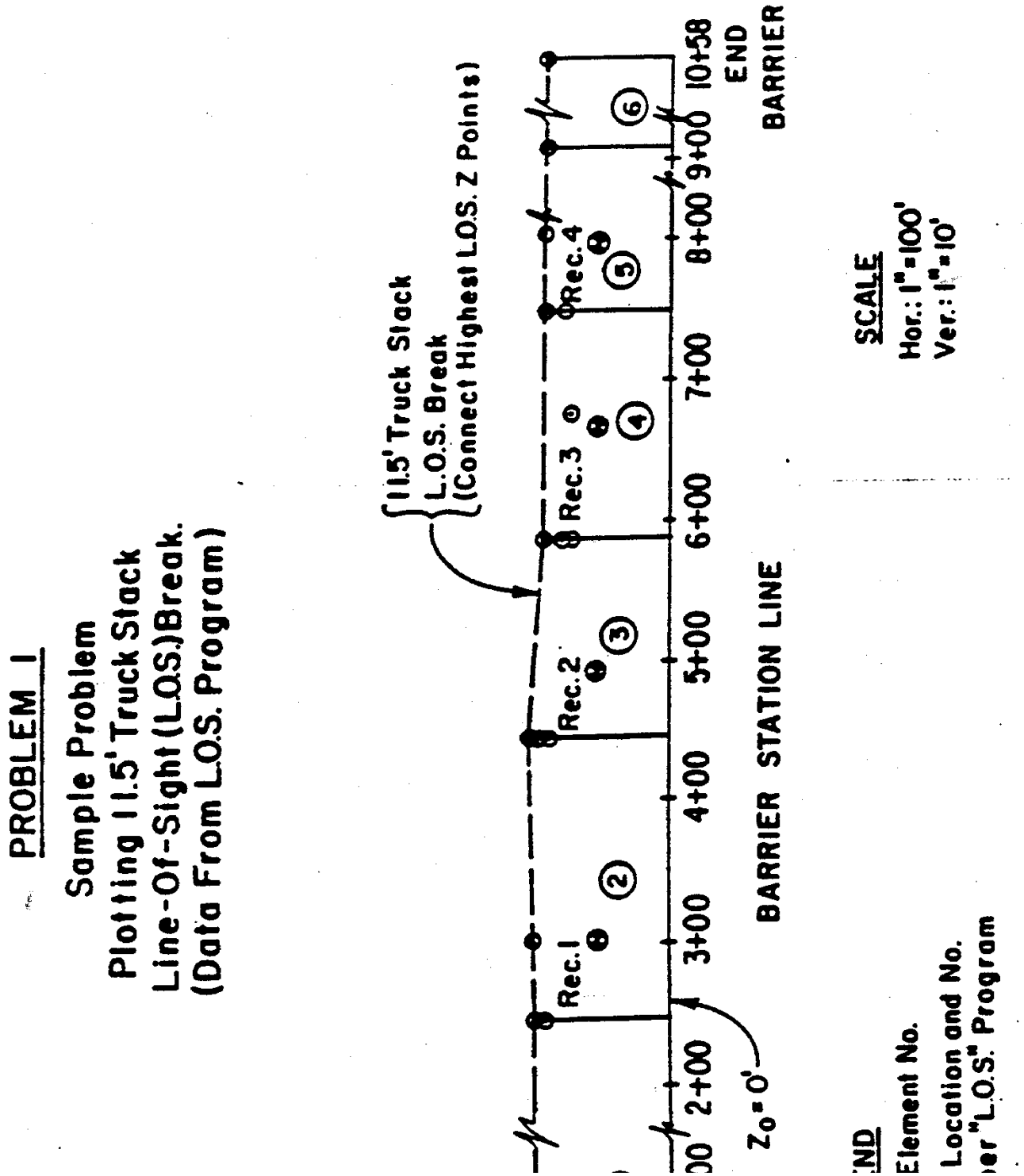
BCR SAMPLE PROBLEM1 WITH BARRIER

X	**Y**	**Z0**	**REC**	**DT**	**LOS Z**	**HEIGHT**	**BD**	**DESC.**
BAR. SEGMENT 1								
-600	212	0.0	1	456	9.5	9.5	0	Bar. End STA0+00
-350	212	0.0	1	148	9.5	9.5	250	Bar. End STA2+50
-295	212	0.0	2	125	9.5	9.5	55	NEAR PT.
-150	212	0.0	2	243	9.5	9.5	250	Bar. End STA4+50
BAR. SEGMENT 2								
-350	212	0.0	1	406	9.1	9.1	250	Bar. End STA2+50
-150	212	0.0	2	131	9.1	9.1	200	Bar. End STA4+50
-100	212	0.0	3	105	8.6	8.6	51	NEAR PT.
-10	212	0.0	3	250	7.5	7.5	143	Bar. End STA5+93
BAR. SEGMENT 3								
-150	212	0.0	2	395	8.8	8.8	200	Bar. End STA4+50
-10	185	0.0	3	304	7.0	7.0	143	Bar. End STA5+93
77	185	0.0	4	93	7.0	7.0	87	NEAR PT.
150	185	0.0	4	250	7.0	7.0	160	Bar. End STA7+53
BAR. SEGMENT 4								
-150	212	0.0	2	493	9.9	9.9	200	Bar. End STA4+50

-10	185	0.0	3	398	8.8	8.8	143	Bar. End STA5+93
150	185	0.0	4	184	8.8	8.8	160	Bar. End STA7+53
205	185		5	158	8.8	8.8	55	NEAR PT.
305	185		5	232	8.8	8.8	155	Bar. End STA9+08
455	185		6	453	8.8	8.8	150	Bar. End STA10+58

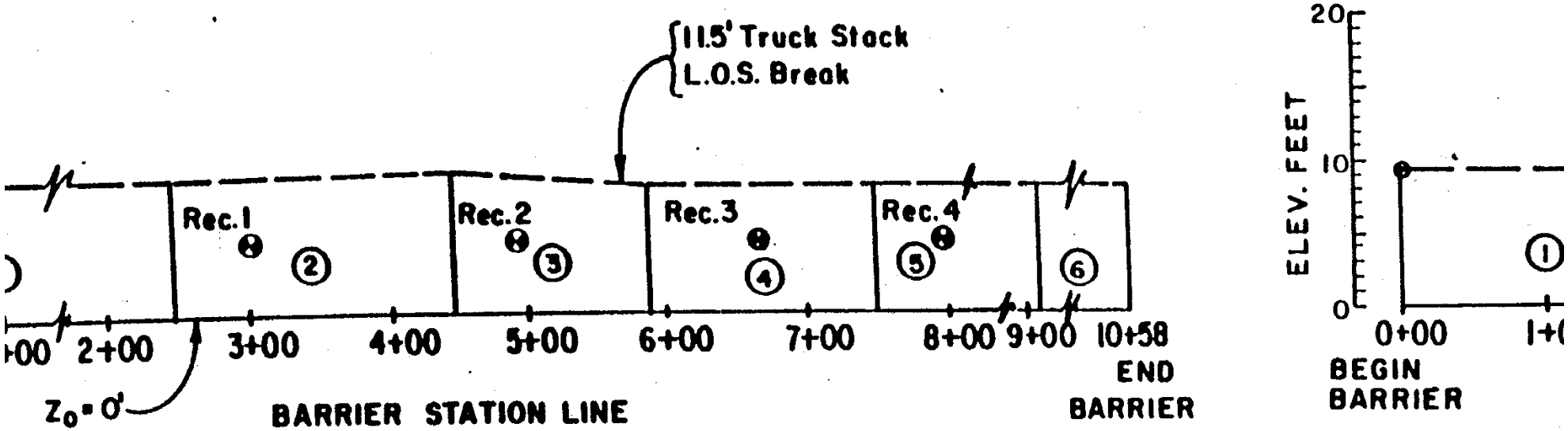
DT = Distance to Truck (from Rec.)

BD = Barrier Distance (along Bar. from Segment pt.)



PROBLEM I

Sample Problem
Profile Work Sheet For Barrier Design



GEND

Element No.

r Location and No.

SCALE

Hor.: 1" = 100'

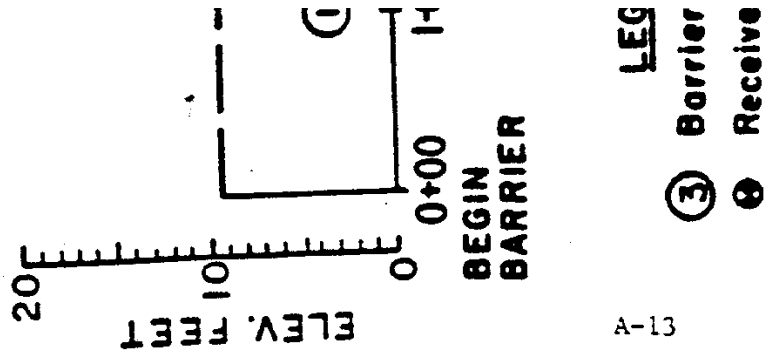
Ver.: 1" = 10'

LEGE

③ Barrier I

Receiver

⊙ L.O.S. Z p



A-13

SOUND32

ENTER INPUT FILE NAME (DATA.S32): bcr12.s32

ENTER OUTPUT FILE NAME (S32.OUT): bcrl2.out

**READING DATA

**END OF DATA INPUT

**PROCESSING BEGINS

EFFECTIVENESS/COST RATIOS

BAR ELE	0	1	2	3	4	5	6	7	
1	-	29	26	26	24	21	21	20	STA0+00
2	-	35	32	31	28	26	25	24	STA2+50
3	-	36	33	32	29	27	26	25	STA4+50
4	-	41	38	36	33	30	29	29	STA5+93
5	-	38	35	34	31	28	27	27	STA7+53
6	-	32	29	28	26	24	23	23	STA9+08
	0	1	2	3	4	5	6	7	

BARRIER DATA

BAR ELE	BARRIER HEIGHTS								BAR ID	LENGTH	TYPE
	0	1	2	3	4	5	6	7			
1	-	9	10	11	12	13	14	15	STA0+00	250.0	masonary
2	-	9	10	11	12	13	14	15	STA2+50	200.0	masonary
3	-	9	10	11	12	13	14	15	STA4+50	142.6	masonary
4	-	9	10	11	12	13	14	15	STA5+93	160.0	masonary
5	-	9	10	11	12	13	14	15	STA7+53	155.0	masonary
6	-	9	10	11	12	13	14	15	STA9+08	150.0	masonary

	0	1	2	3	4	5	6	7			

REC	REC ID	DNL	PEOPLE	LEQ (CAL)
1	REC1	67	4	66.2
2	REC2	67	4	65.4
3	REC3	67	8	64.9
4	REC4	67	12	66.3

BARRIER TYPE	COST
BERM	0
MASONRY	111,046
MASONRY/JERSEY	0
CONCRETE	0

TOTAL COST = $111,000

BARRIER HEIGHT INDEX FOR EACH BARRIER SECTION

4 4 4 4 4 4

CORRESPONDING BARRIER HEIGHTS FOR EACH SECTION

12 12 12 12 12 12

Execution Suspended : PRESS << ENTER >> TO CONTINUE

1. CHANGE BARRIER HEIGHT INDEX
2. CHANGE BARRIER TYPES
3. CHANGE PEOPLE PER RECEIVER
4. CHANGE DESIGN NOISE LEVELS
5. RECOMPUTE AND DISPLAY LEQS
6. RECOMPUTE AND DISPLAY BARRIER SEGMENT CONTRIBUTION
7. RECOMPUTE AND DISPLAY E/C MATRIX
8. BROWSE OUTPUT FILE
9. STOP

ENTER MENU SELECTION

7

EFFECTIVENESS/COST RATIOS

BAR ELE	0	1	2	3	4	5	6	7	
1	-	29	26	26	24	21	21	20	STA0+00
2	-	35	32	31	28	26	25	24	STA2+50

3	-	36	33	32	29	27	26	25	STA4+50
4	-	41	38	36	33	30	29	29	STA5+93
5	-	38	35	34	31	28	27	27	STA7+53
6	-	32	29	28	26	24	23	23	STA9+08
	0	1	2	3	4	5	6	7	

```
Execution Suspended: PRESS <<ENTER>> TO CONTINUE
 1.  CHANGE BARRIER HEIGHT INDEX
 2.  CHANGE BARRIER TYPES
 3.  CHANGE PEOPLE PER RECEIVER
 4.  CHANGE DESIGN NOISE LEVELS
 5.  RECOMPUTE AND DISPLAY LEQS
 6.  RECOMPUTE AND DISPLAY BARRIER SEGMENT CONTRIBUTION
 7.  RECOMPUTE AND DISPLAY E/C MATRIX
 8.  BROWSE OUTPUT FILE
 9.  STOP

ENTER MENU SELECTION

1

ENTER DESCRIPTION OF THIS CASE (80 CHARACTERSOR LESS) bcr12 case-1

ENTER BARRIER INDEX FOR EACH BARRIER ELEMENT (LIST DIRECTED) 6*0
 1.  CHANGE BARRIER HEIGHT INDEX
 2.  CHANGE BARRIER TYPES
 3.  CHANGE PEOPLE PER RECEIVER
 4.  CHANGE DESIGN NOISE LEVELS
 5.  RECOMPUTE AND DISPLAY LEQS
 6.  RECOMPUTE AND DISPLAY BARRIER SEGMENT CONTRIBUTION
 7.  RECOMPUTE AND DISPLAY E/C MATRIX
 8.  BROWSE OUTPUT FILE
 9.  STOP

ENTER MENU SELECTION

5
```

REC	REC ID	DNL	PEOPLE	LEQ (CAL)
1	REC1	67	4	74.3
2	REC2	67	4	75.1
3	REC3	67	8	75.5
4	REC4	67	12	73.4

BARRIER TYPE	COST
BERM	0
MASONRY	0
MASONRY/JERSEY	0
CONCRETE	0

TOTAL COST = $0

BARRIER HEIGHT INDEX FOR EACH BARRIER SECTION

0 0 0 0 0 0

CORRESPONDING BARRIER HEIGHTS FOR EACH SECTION

0 0 0 0 0 0

Execution suspended: PPESS << ENTER >> TO CONTINUE
1. CHANGE BARRIER HEIGHT INDEX
2. CHANGE BARPIER TYPES
3. CHANGE PEOPLE PER RECEIVER
4. CHANGE DESIGN NOISE LEVELS
S. RECOMPUTE AND DISPLAY LEQS
1. RECOMPUTE AND DISPLAY BARRIER SEGMENT CONTRIBUTION
2. RECOMPUTE AND DISPLAY E/C MATRIX
3. BROWSE OUTPUT FILE
4. STOP

ENTER MENU SELECTION

7

EFFECTIVENESS/COST RATIOS

BAR ELE	0	1	2	3	4	5	6	7	
1	-	29	26	26	24	21	21	20	STA0+00
2	-	35	32	31	28	26	25	24	STA2+50
3	-	36	33	32	29	27	26	25	STA4+50
4	-	41	38	36	33	30	29	29	STA5+93
5	-	38	35	34	31	28	27	27	STA7+53
6	-	32	29	28	26	24	23	23	STA9+08
	0	1	2	3	4	5	6	7	

Execution suspended: PPESS << ENTER >> TO CONTINUE
1. CHANGE BARRIER HEIGHT INDEX
2. CHANGE BARPIER TYPES

```
3.  CHANGE PEOPLE PER RECEIVER
4.  CHANGE DESIGN NOISE LEVELS
5.  RECOMPUTE AND DISPLAY LEQS
6.  RECOMPUTE AND DISPLAY BARRIER SEGMENT CONTRIBUTION
7.  RECOMPUTE AND DISPLAY E/C MATRIX
8.  BROWSE OUTPUT FILE
9.  STOP

ENTER MENU SELECTION

1

ENTER DESCRIPTION OF THIS CASE (80 CHARACTERS OR LESS)

bcrl2 case-3

ENTER BARRIER INDEX FOR EACH BARRIER ELEMENT (LIST OIRECTED)3,5,5,4,5,4
1.  CHANGE BARRIER HEIGHT INDEX
2.  CHANGE BARPIER TYPES
3.  CHANGE PEOPLE PER RECEIVER
4.  CHANGE DESIGN NOISE LEVELS
5.  RECOMPUTE AND DISPLAY LEQS
6.  RECOMPUTE AND DISPLAY BARRIER SEGMENT CONTRIBUTION
7.  RECOMPUTE AND DISPLAY E/C MATRIX
8.  BROWSE OUTPUT FILE
9.  STOP

ENTER MENU SELECTION

5
1.  CHANGE BARRIER HEIGHT INDEX
2.  CHANGE BARPIER TYPES
3.  CHANGE PEOPLE PER RECEIVER
4.  CHANGE DESIGN NOISE LEVELS
5.  RECOMPUTE AND DISPLAY LEQS
6.  RECOMPUTE AND DISPLAY BARRIER SEGMENT CONTRIBUTION
7.  RECOMPUTE AND DISPLAY E/C MATRIX
8.  BROWSE OUTPUT FILE
9.  STOP

ENTER MENU SELECTION

1

ENTER DESCRIPTION OF THIS CASE (80 CHARACTERS OR LESS)

bcrl2 case-3

ENTER BARRIER INDEX FOR EACH BARRIER ELEMENT (LIST OIRECTED)3,5,6,7,7,4
1.  CHANGE BARRIER HEIGHT INDEX
2.  CHANGE BARPIER TYPES
3.  CHANGE PEOPLE PER RECEIVER
4.  CHANGE DESIGN NOISE LEVELS
5.  RECOMPUTE AND DISPLAY LEQS
```

6. RECOMPUTE AND DISPLAY BARRIER SEGMENT CONTRIBUTION
7. RECOMPUTE AND DISPLAY E/C MATRIX
8. BROWSE OUTPUT FILE
9. STOP

ENTER MENU SELECTION

5

REC	REC ID	DNL	PEOPLE	LEQ (CAL)
1	REC1	67	4	65.9
2	REC2	67	4	64.5
3	REC3	67	8	63.2
4	REC4	67	12	65.7

BARRIER TYPE	COST
BERM	0
MASONRY	136922
MASONRY/JERSEY	0
CONCRETE	0

TOTAL COST = $137,000

BARRIER HEIGHT INDEX FOR EACH BARRIER SECTION

3 5 6 7 7 4

CORRESPONDING BARRIER HE16HTS FOR EACH SECTION

11 13 14 15 15 12

Execution suspended: PRESS <<ENTER>> TO CONTINUE

REC	REC ID	DNL	PEOPLE	LEQ (CAL)
1	REC1	67	4	66.0
2	REC2	67	4	65.0
3	REC3	67	8	64.7
4	REC4	67	12	66.2

BARRIER TYPE	COST
BERM	0
MASONRY	118582
MASONRY/JERSEY	0
CONCRETE	0

TOTAL COST = $119,000

BARRIER HEIGHT INDEX FOR EACH BARRIER SECTION

3 5 5 4 5 4

CORRESPONDING BARRIER HEIGHTS FOR EACH SECTION

11 13 13 12 13 12

Execution suspended: PRESS <<ENTER>> TO CONTINUE

1. CHANGE BARRIER HEIGHT INDEX
2. CHANGE BARPIER TYPES
3. CHANGE PEOPLE PER RECEIVER
4. CHANGE DESIGN NOISE LEVELS
5. RECOMPUTE AND DISPLAY LEQS
6. RECOMPUTE AND DISPLAY BARRIER SEGMENT CONTRIBUTION
7. RECOMPUTE AND DISPLAY E/C MATRIX
8. BROWSE OUTPUT FILE
9. STOP

ENTER: MENU SELECTION

7

EFFECTIVENESS/COST RATIOS

BAR ELE	0	1	2	3	4	5	6	7	
1	-	29	26	26	24	21	21	20	STA0+00
2	-	35	32	31	28	26	25	24	STA2+50
3	-	36	33	32	29	27	26	25	STA4+50
4	-	41	38	36	33	30	29	29	STA5+93
5	-	38	35	34	31	28	27	27	STA7+53
6	-	32	29	28	26	24	23	23	STA9+08
	0	1	2	3	4	5	6	7	

Execution suspended: PRESS <<ENTER>> TO CONTINUE

1. CHANGE BARRIER HEIGHT INDEX

```
2.  CHANGE BARRIER TYPES
3.  CHANGE PEOPLE PER RECEIVER
4.  CHANGE DESIGN NOISE LEVELS
5.  RECOMPUTE AND DISPLAY LEQS
6.  RECOMPUTE AND DISPLAY BARRIER SEGMENT CONTRIBUTION
7.  RECOMPUTE AND DISPLAY E/C MATRIX
8.  BROWSE OUTPUT FILE
9.  STOP
ENTER MENU SELECTION
1
ENTER DESCRIPTION OF THIS CASE (80 CHARACTERSOR LESS)
Bcrl2 case-5
ENTER BARRIER INDEX FOR EACH BARRIER ELEMENT
(LIST DIRECTED )3 5 3 4 5 4
1.  CHANGE BARRIER HEIGHT INDEX
2.  CHANGE BARRIER TYPES
3.  CHANGE PEOPLE PER RECEIVER
4.  CHANGE DESIGN NOISE LEVELS
5.  RECOMPUTE AND DISPLAY LEQS
6.  RECOMPUTE AND DISPLAY BARRIER SEGMENT CONTRIBUTION
7.  RECOMPUTE AND DISPLAY E/C MATRIX
8.  BROWSE OUTPUT FILE
9.  STOP
ENTER MENU SELECTION
5
```

REC	REC ID	DNL	PEOPLE	LEQ (CAL)
1	REC1	67	4	66.1
2	REC2	67	4	65.3
3	REC3	67	8	64.8
4	REC4	67	12	66.2

BARRIER TYPE	COST
BERM	0
MASONRY	115778
MASONRY/JERSEY	0

CONCRETE	0

TOTAL COST = $116,000

BARRIER HEIGHT INDEX FOR EACH BARRIER SECTION

3 5 4 4 5 4

CORRESPONDING BARRIER HEIGHTS FOR EACH SECTION

11 13 12 12 13 12

Execution suspended: PRESS <<ENTER>> TO CONTINUE

1. CHANGE BARRIER HEIGHT INDEX
2. CHANGE BARRIER TYPES
3. CHANGE PEOPLE PER RECEIVER
4. CHANGE DESIGN NOISE LEVELS
5. RECOMPUTE AND DISPLAY LEQS
6. RECOMPUTE AND DISPLAY BARRIER SEGMENT CONTRIBUTION
7. RECOMPUTE AND DISPLAY E/C MATRIX
8. BROWSE OUTPUT FILE
9. STOP

ENTER MENU SELECTION

7

EFFECTIVENESS/COST RATIOS

BAR ELE	0	1	2	3	4	5	6	7	
1	-	29	26	26	24	21	21	20	STA0+00
2	-	35	32	31	28	26	25	24	STA2+50
3	-	36	33	32	29	27	26	25	STA4+50
4	-	41	38	36	33	30	29	29	STA5+93
5	-	38	35	34	31	28	27	27	STA7+53
6	-	32	29	28	26	24	23	23	STA9+08
	0	1	2	3	4	5	6	7	

Execution suspended: PRESS <<ENTER>> TO CONTINUE

1. CHANGE BARRIER HEIGHT INDEX
2. CHANGE BARRIER TYPES
3. CHANGE PEOPLE PER RECEIVER
4. CHANGE DESIGN NOISE LEVELS
5. RECOMPUTE AND DISPLAY LEQS
6. RECOMPUTE AND DISPLAY BARRIER SEGMENT CONTRIBUTION
7. RECOMPUTE AND DISPLAY E/C MATRIX
8. BROWSE OUTPUT FILE
9. STOP

ENTER MENU SELECTION

1

ENTER DESCRIPTION OF THIS CASE (80 CHARACTERS OR LESS)

bcr12 case-5

ENTER BARRIER INDEX FOR EACH BARRIER ELEMENT

(LIST DIRECTED)3,5,3,4,5,4

1. CHANGE BARRIER HEIGHT INDEX
2. CHANGE BARRIER TYPES
3. CHANGE PEOPLE PER RECEIVER
4. CHANGE DESIGN NOISE LEVELS
5. RECOMPUTE AND DISPLAY LEQS
6. RECOMPUTE AND DISPLAY BARRIER SEGMENT CONTRIBUTION
7. RECOMPUTE AND DISPLAY E/C MATRIX
8. BROWSE OUTPUT FILE
9. STOP

ENTER MENU SELECTION

5

REC	REC ID	DNL	PEOPLE	LEQ (CAL)
1	REC1	67	4	66.1
2	REC2	67	4	65.7
3	REC3	67	8	64.8
4	REC4	67	12	66.2

BARRIER TYPE	COST
BERM	0
MASONRY	114494
MASONRY/JERSEY	0
CONCRETE	0

TOTAL COST = $114,000

BARRIER HEIGHT INDEX FOR EACH BARRIER SECTION

3 5 3 4 5 4

CORRESPONDING BARRIER HEIGHTS FOR EACH SECTION

11 13 11 12 13 12

```
Execution suspended: PRESS <<ENTER>> TO CONTINUE
1.  CHANGE BARRIER HEIGHT INDEX
2.  CHANGE BARRIER TYPES
3.  CHANGE PEOPLE PER RECEIVER
4.  CHANGE DESIGN NOISE LEVELS
5.  RECOMPUTE AND DISPLAY LEQS
6.  RECOMPUTE AND DISPLAY BARRIER SEGMENT CONTRIBUTION
7.  RECOMPUTE AND DISPLAY E/C MATRIX
8.  BROWSE OUTPUT FILE
9.  STOP

ENTER MENU SELECTION

7



EFFECTIVENESS/COST RATIOS
```

BAR ELE	0	1	2	3	4	5	6	7	
1	-	29	26	26	24	21	21	20	STA0+00
2	-	35	32	31	28	26	25	24	STA2+50
3	-	36	33	32	29	27	26	25	STA4+50
4	-	41	38	36	33	30	29	29	STA5+93
5	-	38	35	34	31	28	27	27	STA7+53
6	-	32	29	28	26	24	23	23	STA9+08
	0	1	2	3	4	5	6	7	

```
Execution suspended: PRESS <<ENTER>> TO CONTINUE
1.  CHANGE BARRIER HEIGHT INDEX
2.  CHANGE BARRIER TYPES
3.  CHANGE PEOPLE PER RECEIVER
4.  CHANGE DESIGN NOISE LEVELS
5.  RECOMPUTE AND DISPLAY LEQS
6.  RECOMPUTE AND DISPLAY BARRIER SEGMENT CONTRIBUTION
7.  RECOMPUTE AND DISPLAY E/C MATRIX
8.  BROWSE OUTPUT FILE
9.  STOP

ENTER MENU SELECTION

1

ENTER DESCRIPTION OF THIS CASE (80 CHARACTERSOR LESS)

bcrl1 case6
```

ENTER BARRIER INDEX FOR EACH BARRIER ELEMENT

(LIST DIRECTED)3,5,3,3,5,4

1. CHANGE BARRIER HEIGHT INDEX
2. CHANGE BARRIER TYPES
3. CHANGE PEOPLE PER RECEIVER
4. CHANGE DESIGN NOISE LEVELS
5. RECOMPUTE AND DISPLAY LEQS
6. RECOMPUTE AND DISPLAY BARRIER SEGMENT CONTRIBUTION
7. RECOMPUTE AND DISPLAY E/C MATRIX
8. BROWSE OUTPUT FILE
9. STOP

ENTER MENU SELECTION

5

REC	REC ID	DNL	PEOPLE	LEQ (CAL)
1	REC1	67	4	66.1
2	REC2	67	4	65.4
3	REC3	67	8	65.4
4	REC4	67	12	66.3

BARRIER TYPE	COST
BERM	0
MASONRY	11438
MASONRY/JERSEY	0
CONCRETE	0

TOTAL COST = $114,000

BARRIER HEIGHT INDEX FOR EACH BARRIER SECTION

3 5 3 4 5 4

CORRESPONDING BARRIER HEIGHTS FOR EACH SECTION

11 13 12 11 13 12

Execution suspended: PRESS <<ENTER>> TO CONTINUE

1. CHANGE BARRIER HEIGHT INDEX
2. CHANGE BARRIER TYPES
3. CHANGE PEOPLE PER RECEIVER
4. CHANGE DESIGN NOISE LEVELS
5. RECOMPUTE AND DISPLAY LEQS
6. RECOMPUTE AND DISPLAY BARRIER SEGMENT CONTRIBUTION
7. RECOMPUTE AND DISPLAY E/C MATRIX

8. BROWSE OUTPUT FILE
9. STOP

ENTER MENU SELECTION

7

EFFECTIVENESS/COST RATIOS

BAR ELE	0	1	2	3	4	5	6	7	
1	-	29	26	26	24	21	21	20	STA0+00
2	-	35	32	31	28	26	25	24	STA2+50
3	-	36	33	32	29	27	26	25	STA4+50
4	-	41	38	36	33	30	29	29	STA5+93
5	-	38	35	34	31	28	27	27	STA7+53
6	-	32	29	28	26	24	23	23	STA9+08
	0	1	2	3	4	5	6	7	

Execution suspended: PRESS <<ENTER>> TO CONTINUE
1. CHANGE BARRIER HEIGHT INDEX
2. CHANGE BARRIER TYPES
3. CHANGE PEOPLE PER RECEIVER
4. CHANGE DESIGN NOISE LEVELS
5. RECOMPUTE AND DISPLAY LEQS
6. RECOMPUTE AND DISPLAY BARRIER SEGMENT CONTRIBUTION
7. RECOMPUTE AND DISPLAY E/C MATRIX
8. BROUSE OUTPUT FILE
9. STOP

ENTER MENU SELECTION

1

ENTER DESCRIPTION OF THIS CASE (80 CHARACTERS OR LESS)

bcr12 case-7

ENTER BARRIER INDEX FOR EACH BARRIER ELEMENT (LIST DIRECTED)

3,5,4,3,5,5
1. CHANGE BARRIER HEIGHT INDEX
2. CHANGE BARRIER TYPES
3. CHANGE PEOPLE PER RECEIVER
4. CHANGE DESIGN NOISE LEVELS
5. RECOMPUTE AND DISPLAY LEQS
6. RECOMPUTE AND DISPLAY BARRIER SEGMENT CONTRIBUTION
7. RECOMPUTE AND DISPLAY E/C MATRIX
8. BROWSE OUTPUT FILE

9. STOP

ENTER MENU SELECTION

5

REC	REC ID	DNL	PEOPLE	LEQ (CAL)
1	REC1	67	4	66.1
2	REC2	67	4	65.4
3	REC3	67	8	65.4
4	REC4	67	12	66.2

BARRIER TYPE	COST
BERM	0
MASONRY	117288
MASONRY/JERSEY	0
CONCRETE	0

TOTAL COST = $117,000

BARRIER HEIGHT INDEX FOR EACH BARRIER SECTION 3 5 3 4 5 5

CORRESPONDING BARRIER HEIGHTS FOR EACH SECTION

11 13 12 11 13 13

Execution suspended: PRESS <<ENTER>> TO CONTINUE

1. CHANGE BARRIER HEIGHT INDEX
2. CHANGE BARRIER TYPES
3. CHANGE PEOPLE PER RECEIVER
4. CHANGE DESIGN NOISE LEVELS
S. RECOMPUTE AND DISPLAY LEQS
1. RECOMPUTE AND DISPLAY BARRIER SEGMENT CONTRIBUTION
2. REOOMPUTE AND DISPLAY E/C MATRIX
3. BROWSE OUTPUT FILE
4. STOP

ENTER MENU SELECTION

7

EFFECTIVENESS/COST RATIOS

BAR ELE	0	1	2	3	4	5	6	7	
1	-	29	26	26	24	21	21	20	STA0+00
2	-	35	32	31	28	26	25	24	STA2+50

3	-	36	33	32	29	27	26	25	STA4+50
4	-	41	38	36	33	30	29	29	STA5+93
5	-	38	35	34	31	28	27	27	STA7+53
6	-	32	29	28	26	24	23	23	STA9+08
	0	1	2	3	4	5	6	7	

```
Execution suspended: PRESS <<ENTER>> TO CONTINUE


        1) CHANGE BARRIER HEIGHT INDEX
        21) CHANGE BARRIER TYPES
        3) CHANGE PEOPLE PER RECEIVER
        4) CHANGE DESIGN NOISE LEVELS
        S) RECOMPUTE AND DISPLAY LEOS
        6) RECOMPUTE AND DISPLAY BARRIER SEGMENT CONTRIBUTION
        7) RECOMPUTE AND DISPLAY E/C MATRIX
        8) BROWSE OUTPUT FILE
        9) STOP
ENTER MENU SELECTION
9
Execution terminated
```

B.1. CALGRADE EMISSION LEVELS

The Calgrade emission levels in the SOUND32 file, CALG.DTA, were taken from information in the Caltrans report on vehicle noise emission levels. The report presented data collected by Caltrans at sites that had grades of +3%, +4.2%, +4.5%, +5.6%, +6% and +7%. The data were grouped in terms of 10-mph speed bands, ranging from 11-20 mph up to 51-60 mph, with an additional category for trucks with speeds over 60 mph. The data consisted of the percentage of all heavy trucks at each site in each speed band, and an associated reference energy mean emission level for those trucks in each band. Table 2-1 in the main text presents that data.

The table also includes data for a grade of +2%. The Calgrade emission levels are sued when the grade equals or,exceeds +2%. However, no sites with grades below +3.2% were used. In Reference 3, Caltrans interpolated to get a level at +2% based on the normal Calveno emission levels and the +3.2% data. The frequency of distribution data in Table 2-1 for the +2% grade were back-calculated to produce this interpolated level for the +2% grade.

Users of the SOUND32 program may wish to collect their own speed and level data as a function of grade and modify the `CALG.DTA` file. Communication with the appropriate personnel in the Caltrans Division of New Technology, Transportation Materials and Research is strongly recommended before beginning such a data collection program. The file must be named `CALG.DTA` to be recognized by the SOUND32 program. The `CALG.DTA` file must be formatted as follows:

line-a description of file (80 characters max.)
line-b number of sets of grade data to follow
line-c data header line: "GRADE SPEED BAND"
line-d header line showing the speed bands: "11-20 21-30 31-40 41-50 51-60 60"
line-e grade, percent of trucks in each speed band
line-f reference energy mean emission level in each speed band

Note: Repeat lines a and f for the number of sets of data on line-b.

The current default CALG.DTA file contains 7 sets of data and is as follows:

NUMBER OF SETS OF GRADE DATA:

7

GRADE SPEED BAND

	11-20	21-30	31-40	41-50	51-60	>60
.02,	0,	0,	40,	45,	15,	0
	83.9	83.4	83.8	84.5	85.4	85.9
.03	3.2	3.2	25	32.1	32.9	6.8
	83.4	83.4	83.8	84.5	85.4	85.9
.042	20.0	20.0	43.8	20.5	13.8	0
	83.4	83.4	83.7	84.5	85.3	0
.045	34.9	34.9	37.5	11.4	11.1	1
	83.4	83.4	83.7	84.5	85.3	85.8
.056	48.6	48.6	19.6	13.8	12.2	.7
	83.4	83.4	83.6	84.5	85.2	858
.06	49.0	49.0	17.1	7.7	3.7	0
	83.4	83.4	83.8	84.6	85.3	0
.07	27.4	27.4	31.9	23.6	1.9	0
	83.4	83.4	83.8	84.5	85.1	0