STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION
DIVISION OF ENGINEERING SERVICES
OFFICE OF TRANSPORTATION LABORATORY

USER INSTRUCTIONS FOR SOUND32

(Caltrans Version of FHWA Highway Noise Prediction and Barrier Cost Reduction Procedure, STAMINA 2.0 / OPTIMA)

E-250

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TECHNICAL REPORT STANDARD TITLE PAGE

1. REPORT NO.	2. GOVERNMENT ACCESSION NO.	3. RECIPIENT'S CATALOG NO
FHWA/CA/TL-83/06		

4. TITLE AND SUBTITLE	5. REPORT DATE
USER'S INSTRUCTIONS FOR SOUND32 (Caltrans Version of FHWA Highway Noise Prediction and Barrier Cost Reduction Procedure, STAMINA 2.0/OPTIMA)	June 1983
	6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S) D. S. Wood, R. W. Hendriks	8. PERFORMING ORGANIZATION REPORT NO. 19702-604211
9. PERFORMING ORGANIZATION NAME AND ADDRESS Office of Transportation Laboratory California Department of Transportation Sacramento, California 95819	10. WORK UNIT NO
	11. CONTRACT OR GRANT NO. E82TL06
12. SPONSORING AGENCY NAME AND ADDRESS California Department of Transportation Sacramento, California 95807	13. TYPE OF REPORT & PERIOD COVERED Final
	14. SPONSORING AGENCY CODE

15. SUPPLEMENTARY NOTES

This study was conducted in cooperation with the U. S. Department of Transportation, Federal Highway Administration

16. ABSTRACT The FHWA Barrier Cost Reduction (BCR) Procedure was modified to be compatible with the California Department of Transportation (Caltrans) timeshare computer system and current policies and procedures in highway noise prediction and barrier design. In the modification process the FHWA programs STAMINA 2.0 and OPTIMA have been merged into one program named SOUND32. Major modifications and improvements in the Caltrans version include:

°progam's ability to calculate correct accoustic results in multiple barrier situations such as barriers behind top of cut sections or overlapping barriers.

°zero height barrier yielding same accoustical results as no barrier.

°earth berm calculations per FHWA-RD-77-108.

°1980 California barrier cost factors for various materials.

°revised input to permit greater compatibility with input files of earlier Caltrans programs.

°development of a separate program, Line of Sight (LOS), which uses SOUND32 input data files and calculates line of sight breaks between 11.5' truck stack heights and receivers along the barrier alignment (a current California requirement)

°greater program versatility through expanded data change options.

SOUND32 is now operational and accessible on the California statewide VM/CMS timeshare computer system. This report comprises the user's instructions for SOUND32 and its applications.

The User's Manual was used to conduct four training courses for Caltrans personnel in July 1983. It is anticipated this procedure will save 5 to 15 percent in the cost of barrier design and construction.

17. KEY WORDS	18. DISTRIBUTION STATEMENT
Highway noise prediction, highway noise barrier design, noise barrier optimization, barrier cost reduction procedure.	No restrictions

19. SECURITY CLASSIF. (OF THIS REPORT)	20. SECURITY CLASSIF. (OF THIS PAGE)	21. NO. OF PAGES	22. PRICE
Unclassified	Unclassified		

DS-TL-1242 (Rev.6/76)

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CONVERSION FACTORS

English to Metric System (SI) of Measurement

Quantity	English unit	Multiply by	To get metric equivalent
Length	inches (in)or(")	25.40	millimetres (mmm)
		.02540	metres (m)
	feet (ft)or(')	.3048	metres (m)
	miles (mi)	1.609	kilometres (km)
Area	square inches (in^2)	6.432×10^{-4}	square metres (m^2)
	square feet (ft^2)	.09290	square metres (m^2)
	acres	.4047	hectares (ha)
Volume	gallons (gal)	3.785	litres (l)
	cubic feet (ft^3)	.02832	cubic metres (m^3)
	cubic yards (yd^3)	.7646	cubic metres (m^3)
Volume/Time			
(Flow)	cubic feet per second (ft^3/s)	28.317	litres per second (l/s)
	gallons per minute (gal/min)	.06309	litres per second (l/s)
Mass	pounds (lb)	.4536	kilograms (kg)
Velocity	miles per hour (mph)	.4470	metres per second (m/s)
	feet per second (fps)	.3048	metres per second (m/s)
Acceleration	feet per second squared (ft/s^2)	.3048	metres per second squared (m/s^2)
	acceleration due to force of gravity (G)	9.807	metres per second squared (m/s^2)
Weight Density	pounds per cubic (lb/ft^3)	16.02	kilograms per cubic metre (kg/m^3)
Force	pounds (lbs)	4.448	newtons (N)
	kips (1000 lbs)	4448	newtons (N)
Thermal Energy	British thermal unit (BTU)	1055	joules (J)
Mechanical Energy	foot-pounds (ft-lb)	1.356	joules (J)
	foot-kips (ft-k)	1356	joules (J)
Bending Moment or Torque	inch-pounds (ft-lbs)	.1130	newton-metres (Nm)
	foot-pounds (ft-lbs)	1.356	newton-metres (Nm)
Pressure	pounds per square inch (psi)	6895	pascals (Pa)
	pounds per square foot (psf)	47.88	pascals (Pa)
Stress Intensity	kips per square inch square root inch (ksi $\sqrt{in}$)	1.0988	mega pascals $\sqrt{metre}$ (MPa $\sqrt{m}$)
	pounds per square inch square root inch (psi $\sqrt{in}$)	1.0988	kilo pascals $\sqrt{metre}$ (KPa $\sqrt{m}$)
Plane Angle	degrees (°)	0.0175	radians (rad)
Temperature	degrees fahrenheit (F)	$\frac{tF - 32}{1.8} = tC$	degrees celsius (°C)

ACKNOWLEDGEMENT

This manual was prepared through the conscientious efforts of Dick Wood who was the principal author. Dick also did all of the computer programming necessary to make the procedure operational.

Rudy Hendriks developed the problem sets, barrier design procedures, barrier cost data, and provided significant input to complete the manual.

Much of the material came from the "Noise Barrier Cost Reduction Procedure STAMINA 2.0/OPTIMA:User's Manual", FHWA-DP-58-1, April 1982.

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1. INTRODUCTION

This report is the user's manual for the computer program SOUND32. SOUND32 is the Caltrans version of the FHWA highway noise prediction and barrier cost reduction (BCR) procedure programs STAMINA 2.0 / OPTIMA.

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

* Correct results of noise levels in multiple barrier situations.
* 1980 California cost factors and the ability to change barrier cost factors through a user supplied file.
* Zero height barriers yielding the same results as no barrier.
* Earth berm calculations per FHWA-RD-77-108.
* Revised input to permit greater compatibility with earlier Caltrans programs.
* Greater versatility through expanded data change options.
* Development of a separate computer program (LOS) which enables the user to obtain line of sight breaks between 11.5 ft. truck stack heights and receivers along a barrier alignment. This is currently a requirement in

California. The LOS program operates on SOUND32 input data files.

The reflective barrier calculations currently available in STAMINA 2.0 have been omitted from SOUND32 because of their limitations, small effect, and their increase in the cost of running the program.

1.1 PURPOSE

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

SOUND32 includes calculations for barrier effectiveness and cost information for each noise barrier at several heights. The user selects a set of barrier heights and is given the 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 cost efficiency of the barrier system.

1.2 BACKGROUND

SOUND32 is an evolutionary version of SOUND3 (2) and users should find little difference in the answers from SOUND3 and SOUND32 except for problems involving low barriers used with soft site drop-off rates (see Section 3.6).

SOUND32 is based on FHWA report FHWA-RD-77-108,'FHWA HIGHWAY TRAFFIC NOISE PREDICTION MODEL' (3) and users should be familiar with the theory presented therein.

1.3 IMPLEMENTATION

1. The SOUND32 program is operational and available to all Caltrans District personnel through the California statewide VM/CMS timeshare computer system.

2. This report is a user's manual for SOUND32. It has been distributed to persons taking the SOUND32 training classes. The report will also be widely distributed as part of the Caltrans Noise Manual.

2. PROBLEM FORMULATION

SOUND32 calculates traffic noise based on site geometry consisting of lanes, receivers and barriers.

2.1 TRAFFIC NOISE (SOURCE)

The traffic noise is defined by the traffic flow and traffic lanes.

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 the national reference energy mean emission levels (3). These reference energy emission levels are based on steady state speed conditions and SOUND32 is not appropriate for stop-and-go city traffic or highways which are not free flowing.

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 cost and time savings can be made by grouping

roadways into equivalent lanes. (See Section 10-3.4 of 'USER INSTRUCTIONS FOR SOUND3' (2).)

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 calculate a heavy truck grade adjustment. If a grade adjustment is requested, the program will calculate the grade from the length of the lane segment and the change in elevation from the end point coordinates. The adjustment added to the heavy trucks is then:

Grade < 2% ------ Adjustment = 0
Grade > 2% & < 7% Adjustment = (Grade-2%)dBA
Grade > 7% ------ Adjustment = 5 dBA

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 their end point x, y and z coordinates.

For barrier effectiveness and cost calculations, the elevations of the bottom of the barrier (Z0) end points are also required.

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, 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 Material.** Each barrier is initially coded with a barrier material type number in order to determine if the barrier attenuation should be calculated for a berm or a wall and, to make the first set of barrier effectiveness and cost calculations. 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.

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 per linear foot information for each barrier material type. The program has been set up to default to the barrier cost file CALIF BAR$, but users may optionally provide their own cost file. See Appendix B.2 for the required file structure.

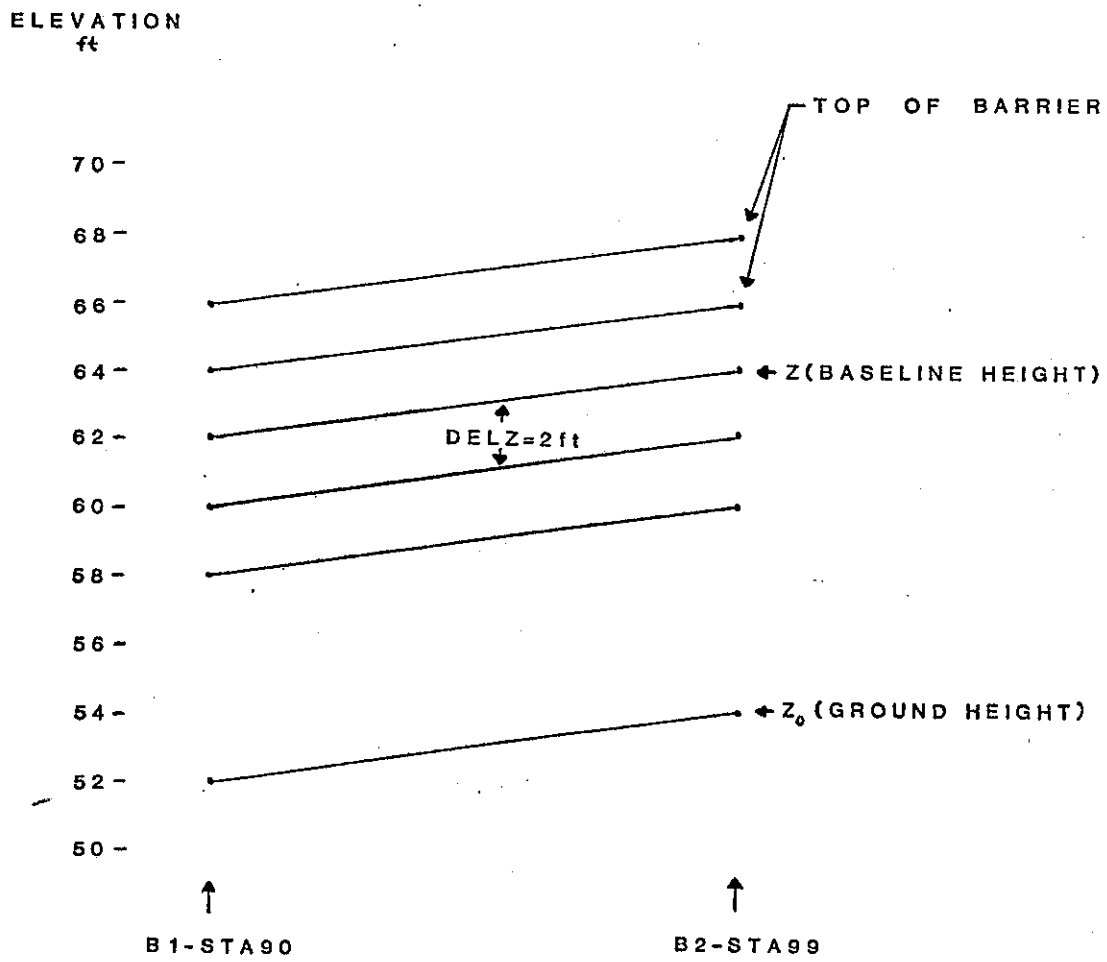
2.2.4 **Multiple Barrier Heights.** In SOUND32 the user can select a trial barrier height (Z) and change this height in fixed increments, above and below the trial height. For each barrier, the user specifies an incremental height change (DELZ) and the number of height changes (P) to be made in each 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.

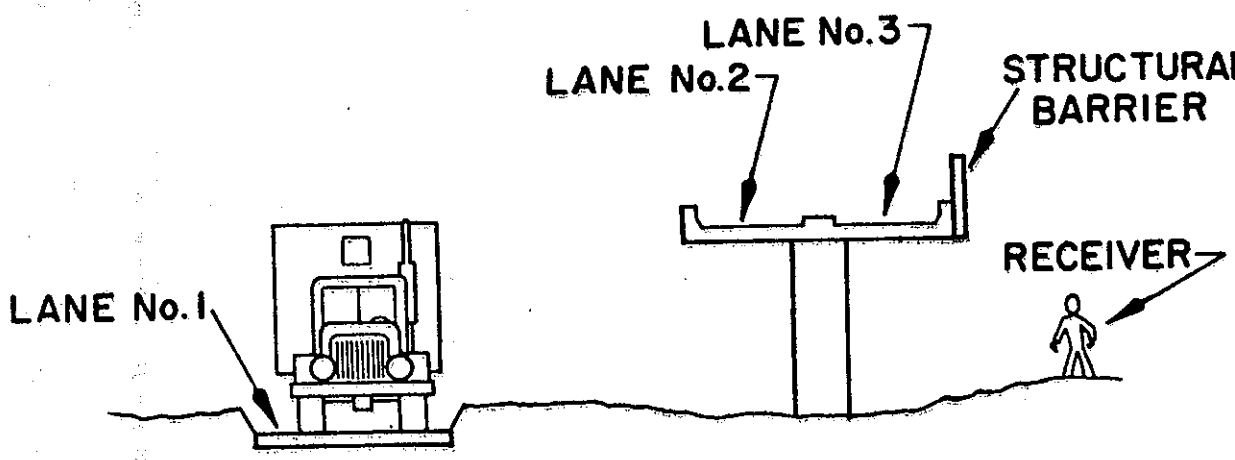
SOUND32 automatically prints the results of the Z height barrier case as the first set of results.

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; 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'



BARRIER HEIGHT PERTURBATION PROCESS,
DELZ= 2 FT., AND P= 2.

FIGURE 2-1



STRUCTURAL BARRIER

FIGURE 2-2

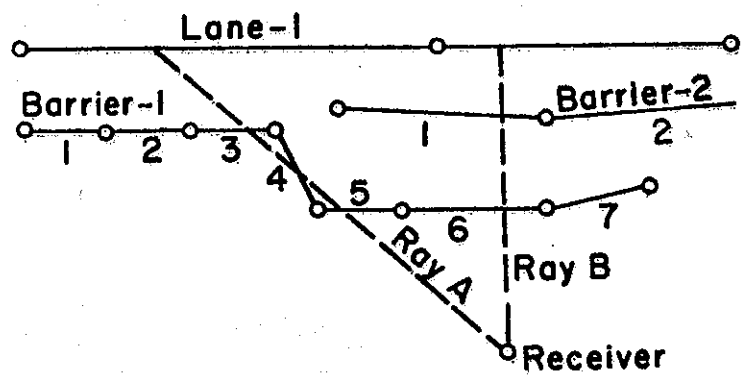


FIGURE 2-3

barriers. The 'structure' barriers will reduce the sound energy emanating from traffic on the elevated structure. Sound energy from all other lanes will not be affected by the 'structure' barrier.

2.2.6 Multiple Barriers. SOUND32 is not capable of calculating multiple path length diffractions. If more than one barrier is encountered in the receiver, 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. The choice is based only on the barrier height index that the user has selected, or, in the case of first results calculations, on the baseline (Z) heights.

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 weighting factor.

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 k-constants (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 people for all receivers that have a people per receiver 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

The operation of the program when the drop-off rates are greater than 3 dB/Double Distance (DD) in conjunction with barriers has been revised in SOUND32. SOUND3 changes the drop-off rate to 3 dB/DD when a barrier provides any barrier attenuation. In some cases this has resulted in an increase in the sound level at a receiver until the barrier height was increased past the difference between the user input drop-off rate and 3 dB/DD. SOUND32 has been changed to operate in the following manner. 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. 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 and receiver. This constant, called the 'K-constant' can be used to apply additional attenuation caused by shielding by buildings, rows of houses, trees or other terrain features. The use of K-constants is appropriate 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 Leq of the coded receiver lane pair.

3. 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.

For all data except the title line a 'keyword' defines the type of data that is contained in the file. Any data that is required follows each keyword.

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

* The delimiter between data items must be a comma.
* Data item descriptions are optional and, if not contained in the input data file, will be generated by the program.
* All x and y coordinates should be limited to the range of 99,999,999.99 through -9,999,999.99 and z coordinates to the range of 99,999.99 through -9,999.99.

As a minimum each input file should contain:

* A title line.
* Traffic data for lane 1.
* Lane data for lane 1.
* Receiver data for receiver 1.

3.1 TITLE

line-a	title	first line of file

Where:

title
is any string of from 1 to 80 characters.

Usage Notes:

1. 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-num	first line
line-b	a-v, a-s, mt-v, mt-s, ht-v, ht-s	second line

Where:

Traffic
is any string of characters of which the first non-blank character must be a 'T'.

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

a-v, 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 1 must be defined. The highest lane-num used must equal the total number of sets of traffic data defined.

Examples:

```
T,2
1500,55,50,55,120,55

TRAFFIC FOR N-BOUND LANES ,2
1750,55,0,0,100,55
```

3.3 LANES

line-a	Lane, lane-num	first line
line-b "	grade-cor, x, y, z, lane-des " " " " "	1-15 lines
line-c	x, y, z, lane-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 up grade adjustment. Code a 'Y' to request the correction or code an 'N' to bypass the grade adjustment calculation.

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

lane-des
is description of the lane segment end point. The lane-des is optional and, if omitted, the program will assign a description of Ln Ps where n is replaced with with the lane-num and s with 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 a corresponding traffic definition. 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                     LANE,3
N,-2000,120,12.6        NO,-1850,204,101.3,BEG. SB OUTSIDE
N,-1500,122,12.7        NO,  500,204,101.8,BC R = 5000
N, 2000,126,12.9        NO,  700,200,100.9,PT ON CURVE
   3100,128,12.6        NO,  900,196,100.8, "  "   "
                        1300,192,100.6,END
```

3.4 BARRIERS

line-a	Barrier, bar-num, btype, delz, pert	first line
line-b	lnum1, lnum2, lnum3 ... lnum12	for str. bars only
line-c "	bx, by, bz0, 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 number of the barrier material to be assigned to the barrier. For non-structure barriers valid btype's are 1 through tnb. For structure barriers add 90 to the btype number. Thus, valid btype's are 91 through 90 + tnb, where tnb is the total number of barriers defined in the barrier cost file. (see Appendix A for the barrier material types currently available in the default barrier cost file, CALIF BAR$.)

delz
is the incremental height change (DELZ) 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 (P) in each direction (up and down) to be calculated. Pert must be 0, 1, 2 or 3.

lnum1, lnum2 etc.
is the list of lane numbers for which the 'structure' barrier is to be considered. Maximun number of lnum's that may be assigned to a 'structure' barrier is 12.

bx, by, bz0, 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 replaced by the bar-num and s replaced with the segment number. 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 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-c's.
   For structure barriers, 1 line-a, 1 line-b and 2 to 11 line-c's.

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:

```
B,3,1,1,3                BARRIER AT SCHOOL,5,2,2,2
-500,80,0,12             300,87,100,110,SCH B
-100,80,3,15             500,89,101,111,END
 150,50,2,14

B,4,92,0,0
3,4,5,8
400,1000,200.4,208.4
500,1010,195.3,203.3
600,1020,193.0,201.0
```

3.5 RECEIVERS

line-a	Receiver, rec-num, dnl, people	first line
line-b	rx, ry, 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 - 40.

dnl
is the design noise level. Valid range is 40 dBA through 100 dBA. If people is omitted dnl is optional. if dnl 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. People is optional and if omitted the program will assign a a value of 500.

rx, ry, 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-#1
```

3.6 DROP-OFF RATES

line-a	Drop-off, d-rate	first line
line-b "	lane-num, rec1, 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 3dBA. Only those pairs not 3dBA need be coded.

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 to be paired with the lane-num. May be the word All (or A).

Usage Notes:

1. Drop-off rates greater than 3dBA 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
                          4,1,2,3
                          5,A
```

3.7 K-CONSTANTS

line-a	K-constant, k	first line
line-b "	lane-num, rec1, 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 the lane receiver pair. The default k-constant for all lane receiver pairs is 0 dBA.

lan-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 to be paired with the lane-num. May be the word All (or A).

Examples:

K,-2	K-CONSTANT, -3
A,3,5,6	5,A
	6,1,2

3.8 VIEW AND CALCULATE

line-a	end-data	last line of file

Where:

end-data
signals the end of input data. May be:
a.) VC or End - This prints formated copy of input data before proceding to calculations.
b.) C - Skips print of input data.

Usage Notes:

1. If end-data is omitted the program will assign a value of VC and print a warning message.

4. RUNNING SOUND32

The SOUND32 program is installed on the statewide VM/CMS timesharing computer and may be accessed via the SOUNDSYS exec which is located on the Caltran's TRLIB library disk.

4.1 SOUNDSYS

The SOUNDSYS exec will provide access to the level 2 noise programs and related programs. In the case of SOUND32, the SOUNDSYS exec will:

a.) link the Translab noise account where the programs are stored,

b.) assign the user temporary disk space for passing data between program modules,

c.) run the SOUND32 pre-processor program and

d.) run SOUND32.

The SOUNDSYS exec may be invoked by typing RUN SOUNDSYS from CMS. SOUNDSYS will then display the menu of available programs. For users who make frequent use of SOUNDSYS and/or SOUND32 the program number and SOUND32 input file name may be appended to the SOUNDSYS command.

Examples:

```
RUN SOUNDSYS
   (will display SOUNDSYS menu)

RUN SOUNDSYS 2
   (will bypass SOUNDSYS menu and take user to the
    SOUND32 pre-processor program where the user
    will be prompted for the input data file name)

R SOUNDSYS 2 ALA580 WDATA
   (goes straight to processing input data file)
```

4.2 THE SOUND32 PRE-PROCESSOR

The SOUND32 pre-processor program reads the user input data file; does some preliminary data checking; writes a formated 'pass' file for the FORTRAN program; sends the SOUNDSYS exec the name of the barrier cost file to be used; and, if requested, prints a formated copy of the input data.

If the user has not included his input file name with the program selection in the SOUNDSYS menu, the pre-processor program will first prompt the user for the name of his input file. If the user does not include the filetype and filemode of his input file the program defaults to a filetype of SOUND32 and a filemode of A.

Example:

```
ENTER Input FILE NAME > BTEST

BTEST SOUND32 A  Found
```

Once the input file has been located, the pre-processor opens and reads the current barrier cost file, prints the barrier cost title, the valid barrier type numbers and descriptions.

The pre-processor then prints a menu with four options.

Example:

```
    Barrier Cost file = CALIF BAR$
    CALIFORNIA BARRIER COST (IN 1980 DOLLARS)
    Valid Barrier types
     1  -  91    BERM
     2  -  92    MASONRY
     3  -  93    MASONRY/JERSEY
     4  -  94    CONCRETE


    1)  Change Barrier Cost file
    2)  List data as processed (Now Off)
    3)  Abort run
    4)  Go
 WHICH >
```

If the user chooses option 1 the program will prompt the user for the name of the barrier cost file he wishes to use and then loop back to read and print the barrier type data.

Option 2 has been provided to make it easier for users to locate errors in their input data files which the program can't handle and cause it to 'blow up'. By listing the input data as it's read from the file the user is given a clue as to where to look for errors in his input file.

Option 3 provides an exit from the program and option 4 is used to proceed with processing.

Once the pre-processor program has read all of the user's input data, the program writes a 'pass' file for the FORTRAN program, prints the input data if requested, and returns to SOUNDSYS.

4.3 SOUND32

SOUND32 first reads in the input data from the 'pass' file; checks the data for illegal intersections of lanes and barriers; reads in the barrier cost data from the barrier cost file; and calculates the first results. The first results printed are the Leq's and barrier cost based on the Z barrier heights. After the first results are printed the user is presented with the SOUND32 menu.

4.3.1 <u>The Menu.</u> Once the user has reached the SOUND32 menu the user may select any of the the 9 menu options. Upon completion of any of the requested menu options (except STOP) the program will always loop back to the menu.

Example:

```
    ENTER MENU SELECTION
    (0 = PRINT MENU)
?
>0

      0).....PRINT MENU
      1).....CHANGE BARRIER HEIGHT INDEX
      2).....CHANGE BARRIER TYPES
      3).....CHANGE PEOPLE PER RECEIVER
      4).....CHANGE DESIGN NOISE LEVELS
      5).....PRINT E/C RATIOS
      6).....PRINT BARRIER HEIGHT INDEX
      7).....PRINT LEQS
      8).....STOP

   ENTER MENU SELECTION
   (0 = PRINT MENU)
```

4.3.2 <u>FORTRAN List Directed Read.</u> Any time that the user is requested to enter data from the FORTRAN progran 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 DNL 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

4.3.3 <u>Barrier Nomenclature.</u> When the user codes his 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.

4.3.4 **Barrier Heights.** To change barrier heights select menu option 1. SOUND32 will then:

a.) prompt the user for the list of barrier height index numbers for each barrier element,

b.) print the list of height indexes,

c.) print the corresponding barrier heights, and

d.) return to the menu.

Example:

```
    ENTER MENU SELECTION
    (0 = PRINT MENU)
?
>1

    ENTER BARRIER INDEX FOR EACH BARRIER ELEMENT
    (LIST DIRECTED)
?
>10*7 1

BARRIER HEIGHT INDEX FOR EACH BARRIER SECTION
 7  7  7  7  7  7  7  7  7  7  1
CORRESPONDING BARRIER HEIGHTS FOR EACH SECTION
14.14.14.14.14.14.14.14.14.14. 3.

    ENTER MENU SELECTION
    (0 = PRINT MENU)
```

4.3.5 **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.

Because of the differences in diffraction attenuations, berms may not be changed to walls and walls may not be changed to berms. Similarly, structure barriers may not be changed to non-structure barriers, and vice versa, in option 2. The user must make these changes in the input file.

Example:

```
   ENTER MENU SELECTION
   (0 = PRINT MENU)
        ?
        >2

 ENTER TYPE NUMBER FOR EACH BARRIER ELEMENT.
 (LIST DIRECTED)
?5*2 1

1        2  MASONRY
2        2  MASONRY
3        2  MASONRY
4        2  MASONRY
5        2  MASONRY
6        1  BERM

   ENTER MENU SELECTION
   (0 = PRINT MENU)
```

4.3.6 **People.** 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 and return to the menu.

4.3.7 **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.

4.3.8 **E/C Ratios.** If the user selects menu option 5 SOUND32 will display the matrix of E/C ratios.The ratios are displayed with the barrier elements running down and the barrier height index across. An asterisk is printed behind the

currently set barrier height index. After printing the E/C ratio matrix the user is returned to the menu.

4.3.9 **Barrier Height Index.** If the user selects menu option 6 SOUND32 will display the matrix of barrier heights in the same format as the E/C ratio matrix.In addition the print-out includes the barrier length and currently set barrier material. After printing the height matrix the user is returned to the menu.

4.3.10 **Leq's.** If the user selects menu option 7 SOUND32 will print the Leq(h) for each receiver based on the currently set height index number of each barrier element and the cost of each barrier material type and the total barrier cost.

If SOUND32 has encountered multiple barriers while calculating the first results, users may notice a considerable time delay before the Leq's are printed. This is because the program re-calculates any receivers when multiple barriers were encountered and the barrier height indexes have been changed.

After the Leq's and barrier cost's are printed the user is returned to the menu.

5. EFFECTIVENESS/COST RATIOS

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/C). The logarithm is used to collapse the large range of values E/C takes on and to make 10 log(E/C) act like decibels for the user's benefit. As with 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 100 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 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 sig-

nificance 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, maintaince, 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.

5.1 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 these 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.

5.2 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 per linear foot from the barrier cost file.

For those users who wish to provide their own barrier cost data, Appendix B.2 shows the format used in the barrier cost files.

5.3 POPULATION WEIGHTING

The user supplies a population weighting value for each receiver as input to SOUND32. This value is used to mulitply 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 sigificance 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 meaningfully balanced noise barrier design, he should take care to choose meaningful population weightings. The population weightings have 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 weighting. 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.

6. SOUND32 PROGRAM APPLICATIONS

6.1 BARRIER DESIGN PROCEDURES

6.1.1 Introduction. The design procedures detailed in this section are limited to the cost efficient, accoustical design of highway noise barriers. They are compatible with current Caltrans practices and policies in noise barrier design, and tailored to SOUND32.

This section gives no consideration to structural design and aesthetics; there are no provisions in SOUND32 to deal with these elements of noise barrier design.

Except for earth berms, the barrier materials do not affect the acoustical results of SOUND32. However, all materials affect barrier costs. A detailed discussion of the derivation and format of SOUND32 cost factors for various materials are found in Appendix B.

6.1.2 Data Preparation. The first questions to be considered in the barrier design are if, and where, noise mitigation is necessary along a proposed or existing highway project. In order to answer these questions the SOUND32 program needs data for the existing noise condition. It must be noted that this condition often will include existing barriers or those generated by future roadway receiver

geometrics. Typical examples are top of cuts, hinge points, ramps and structures.

If it has been determined that noise mitigation is required and noise barriers are feasible, several alternative barrier alignments and materials must be selected. Then optimum heights need to be determined for each alignment and material, and finally, the most cost efficient barrier design may be chosen.

It is important throughout the entire process to have the best available information, of the highway design, the surrounding terrain, and community layout. This requires reliable design maps showing accurate three-dimensional highway configeuations that can be tied to contour maps and layouts of the surrounding communities. Up to date aerial photographs and ground surveys are also extremely helpful in gathering the required input data for SOUND32.

Although SOUND32 has provisions for lane-by-lane traffic input, these data are usually not readily available for most projects. The SOUND3 (Caltrans version of STAMINA 1.0) program instructions (2) discussed in detail the consequences of three different methods of distributing directional traffic over an eight lane freeway. It was shown that generally maximum differences of only a few

tenths of a decibel resulted between the three 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 geometries 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.

The required SOUND32 input data and format was discussed in Chapter 3. It is recommended that these data first be entered on the input data sheets shown as Figures 6-1a, b, c, d, to allow organization of the data before entering in the computer file. The sheets generally follow the same sequence as the computer file, and therefore make it easier to input the data in correct format. Examples of use of the sheets are shown in the sample problems (Section 6.2 of this Chapter.)

FIGURE 6-1a

CALIFORNIA DEPARTMENT OF TRANSPORTATION

INPUT DATA SHEET FOR SOUND32

Caltrans Version of FHWA Level 2
Noise Prediction and Barrier Design Model
(Based on STAMINA2.0 & OPTIMA programs)

Dist._____ Co._____ Rte_____ P.M._____ Location:_____

Charge:_____ E.A./Spec.Des:_____

Data Prepared by:_____ Date:_____ Checked by:_____ Date_____

File Name & Type:_____ Account:_____ Code:_____

TITLE:

SHEET-A - TRAFFIC AND LANE DATA

TRAFFIC DATA

TRAFFIC (T) FOR LANE No.	T,	T,	T,	T,
AUTOS- VOL, SPEED	,	,	,	,
MED. TRKS- VOL, SPEED	,	,	,	,
HVY. TRKS- VOL, SPEED	,	,	,	,

LANE DATA(Max.30 lanes of 1 to 15 segments)

LANE (L) NO.	GRADE CORR. (Y or N)	COORDINATES			DESCRIPTIONS
		X	Y	Z	
L,					

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FIGURE 6-1b

CALIFORNIA DEPARTMENT OF TRANSPORTATION

INPUT DATA SHEET FOR SOUND32

Caltrans Version of FHWA Level 2
Noise Prediction and Barrier Design Model
(Based on STAMINA2.0 & OPTIMA programs)

Dist._____ Co._____ Rte_____ P.M._____ Location:_____

Charge:_____ E.A./Spec.Des:_____

Data Prepared by:_____ Date:_____ Checked by:_____ Date_____

File Name & Type:_____ Account:_____ Code:_____

TITLE:

SHEET-B - BARRIER DATA

(Max. 20 Barriers of 1 to 10 segments each)

BARR.(B) NO.	TYPE MATERIAL*	DELZ	P (MAX 3)	COORDINATES				DESCRIP. (Max. 8 CHARACTERS)
				X	Y	Zo	Z	
B,								

*Material Codes (used for Cost Factors)

1 = Earth Berms
2 = Masonry
3 = Masonry On 2.7' High Jersey Barrier (Type 27)
4 = Concrete (cast in place)
5 = Prefab Conc. Panels
6 = Steel
7 = Wood

FOR STRUCTURE BARRIERS ONLY:

Bar.No.	LANE NO.'s AFFECTED

For Structure Barriers add 90; e.g. 94 = conc. bar on Structure

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FIGURE 6-1C

CALIFORNIA DEPARTMENT OF TRANSPORTATION

INPUT DATA SHEET FOR SOUND32

Caltrans Version of FHWA Level 2
Noise Prediction and Barrier Design Model
(Based on STAMINA2.0 & OPTIMA programs)

Dist._____ Co._____ Rte_____ P.M._____ Location:_____
Charge:_____ E.A./Spec.Des:_____
Data Prepared by:_____ Date:_____ Checked by:_____ Date_____
File Name & Type:_____ Account:_____ Code:_____

TITLE:

SHEET-C - RECEIVER DATA

(Max. 40 Receivers)

RECEIVER (R), NO., DNL*, PEOPLE** COORDINATES (X, Y, Z), DESCRIPTION	RECEIVER (R), NO., DNL*, PEOPLE** COORDINATES (X, Y, Z), DESCRIPTION
R,____,____,____ ____ ____ ____ ____ ____,____,____	R,____,____,____ ____ ____ ____ ____ ____,____,____
R,____,____,____ ____ ____ ____ ____ ____,____,____	R,____,____,____ ____ ____ ____ ____ ____,____,____
R,____,____,____ ____ ____ ____ ____ ____,____,____	R,____,____,____ ____ ____ ____ ____ ____,____,____
R,____,____,____ ____ ____ ____ ____ ____,____,____	R,____,____,____ ____ ____ ____ ____ ____,____,____
R,____,____,____ ____ ____ ____ ____ ____,____,____	R,____,____,____ ____ ____ ____ ____ ____,____,____
R,____,____,____ ____ ____ ____ ____ ____,____,____	R,____,____,____ ____ ____ ____ ____ ____,____,____
R,____,____,____ ____ ____ ____ ____ ____,____,____	R,____,____,____ ____ ____ ____ ____ ____,____,____
R,____,____,____ ____ ____ ____ ____ ____,____,____	R,____,____,____ ____ ____ ____ ____ ____,____,____
R,____,____,____ ____ ____ ____ ____ ____,____,____	R,____,____,____ ____ ____ ____ ____ ____,____,____

* DNL = Design Noise Level (Leq_h, dBA)
**People= No. of People Represented by Receiver

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FIGURE 6-1d.

CALIFORNIA DEPARTMENT OF TRANSPORTATION

INPUT DATA SHEET FOR SOUND32

Caltrans Version of FHWA Level 2
Noise Prediction and Barrier Design Model
(Based on STAMINA2.0 & OPTIMA programs)

Dist._____ Co._____ Rte_____ P.M._____ Location:_____
Charge:_____ E.A./Spec.Des:_____
Data Prepared by:_____ Date:_____ Checked by:_____ Date_____
File Name & Type:_____ Account:_____ Code:_____

TITLE:

SHEET-D - DROP OFF RATES* AND ADJUSTMENT CONSTANTS & CALCULATION OPTION

DROP OFF RATES OTHER THAN 3 dBA/DOUBLE DIST.

D,(dBA)	Lane No. or All(A)	RECEIVER NO's
D,		

ADJUSTMENT CONSTANTS, (+ or-) K

K,(±dBA)	Lane No. or All(A)	RECEIVER NO's
K,		

*Drop-Off rates of 3 dBA/D.D. need not be input. (Default value = 3)

CALCULATION OPTION

☐ VC (Prints Input Data in Format, and Prints Calculated Leq's
☐ C (Prints Calculated Leq's)

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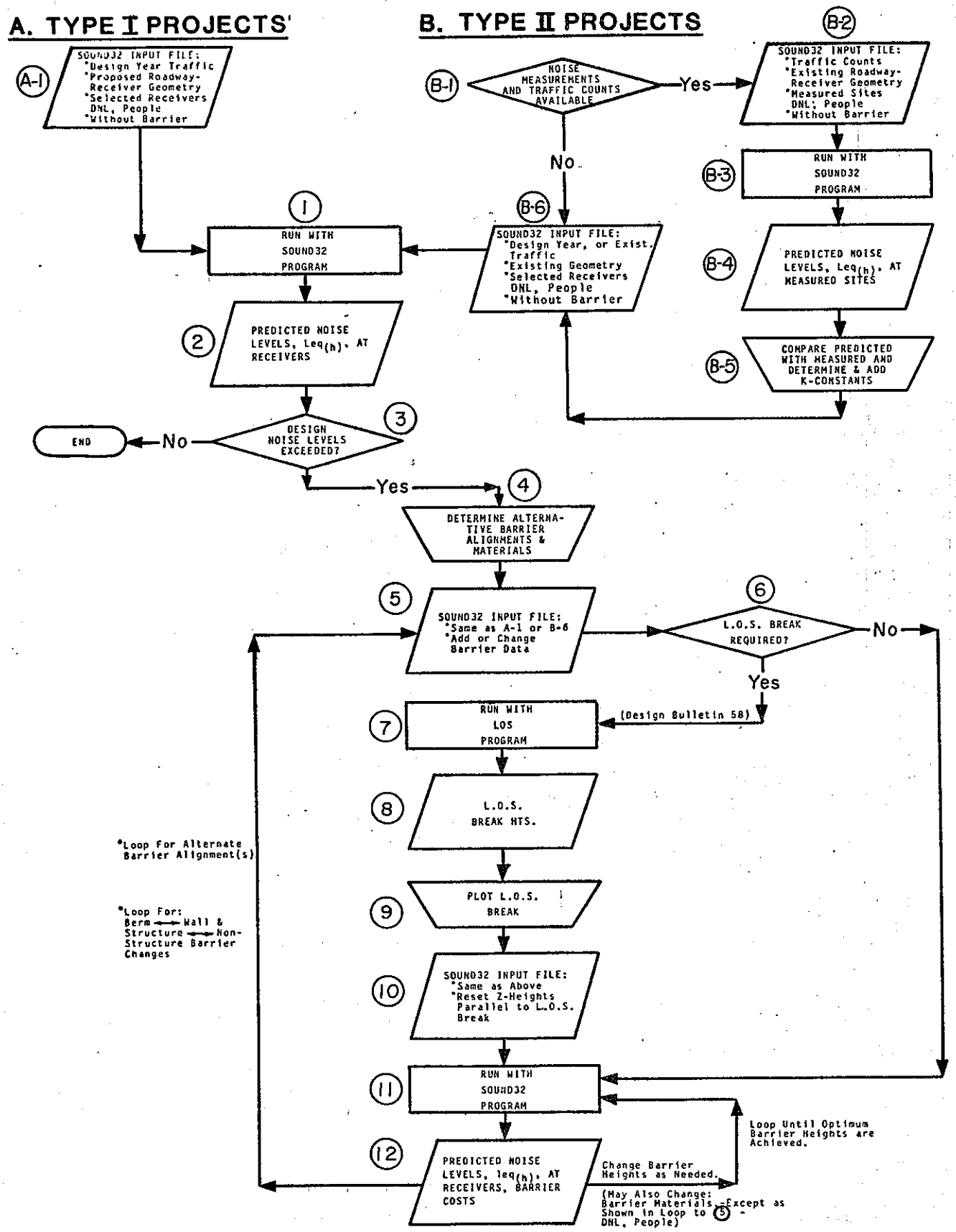
6.1.3 **Flow Diagram Design Procedures.** Figure 6-2 presents an overview of noise barrier design procedures for Type I and Type II projects defined in FHPM 7-7-3 (4). The flow diagram also shows procedures for dealing with the 11.5 ft. truck exhaust stack line of sight (L.O.S.) break required by Design Information Bulletin No. 58 (5). The L.O.S. break procedures make use of the LOS computer program (Appendix D) which accepts the SOUND32 input file.

Following is a brief discussion of the procedures outlined in Figure 6-2. The steps shown are numbered as follows: A-series for Type I projects, B-series for Type II projects and number only for both.

Briefly, Type I projects are proposed Federal or Federal-aid highway projects in new locations or improvements of existing highways that significantly change horizontal or vertical alignment or increase the number of through-lanes. Type II projects are proposed Federal or Federal-aid highway projects for noise abatement on existing highways. The principal difference between Type I and Type II design procedures is that the noise prediction portion of SOUND32 may be 'calibrated' with existing noise measurements and traffic counts for Type II projects. Except for some special cases involving the increase in number of through lanes, this calibration is

FIGURE 6-2



BARRIER DESIGN PROCEDURES WITH SOUND32 PROGRAM

obviously not possible for Type I projects on new alignments.

The following paragraphs serve as further expansions of the barrier design steps outlined in Figure 6-2. Note that depending on the type of project and path taken through the flow chart a minimum of two to four SOUND32 input files are needed. To conserve file space in the user's account and to save time, the same file can be modified or expanded and used again for subsequent steps. The information shown for each input file is not complete. Only pertinent items are discussed. For complete file structure information refer to Chapter 3.

Step A-1 (Type I projects). First, a SOUND32 file should be created to run the 'without barrier' condition. This condition should be examined to determine whether or not noise mitigation (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, cuts/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 = Z0, DELZ = 0, and P = 0)

Step B-1 (Type II projects). If existing noise measurements with simultaneous traffic counts are available, the prediction results can be calibrated to 'fit' the actual measurements. In this case go to step B-2. If no measurements are available, go to step B-6. If at all possible, noise and traffic measurements should be taken. Model calibration procedures greatly increase the accuracy of the predictions.

Step B-2. Create a SOUND32 input file including the traffic counts taken during the noise measurements (expanded to hourly volumes), existing roadway receiver geometrics, measured sites as receivers, design noise levels (DNL), and people represented by the receivers. As was the case in step A-1, <u>do not</u> include any noise barrier data, but <u>do</u> include any existing barriers (Z = Z0, DELZ = 0, P = 0)

Steps B-3 through B-5. Run the file with SOUND32 program (B-3). The results (B-4) are the noise predicted noise levels at the measurement sites, using the traffic counts. They should be compared with the measured noise values (B-5). 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).

Step B-6. If no measurements were available (i.e. coming directly from step B-1) a SOUND32 input file needs to be created with the following pertinent information:

* Design year traffic (future highway capacity) or existing peak traffic (highway already at capacity).
* Existing roadway receiver configurations. Include <u>existing</u> natural or artifical barriers (set Z = Z0, DELZ = 0, P = 0).
* Selected receivers, design noise levels (DNL) and people represented by each receiver.

If measurements were available, i.e. arriving at B-6 via steps B-2 through B-5, the same information as above would be required, plus the K-constants generated in B-5. The input file can easily be modified and expanded from the file created in step B-2. 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.

Steps 1-3. Beginning with step 1, the barrier design procedures for Type I and Type II projects are identical. At this point the user is ready to run the 'without noise barrier' condition, either with the file created in step A-1 or B-6. The resulting predicted noise levels (step 2) can then be compared 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. If it is decided to build a noise barrier, go to step 4.

Step 4. Determine alignment of barrier. The location of the barrier is governed by Caltrans guidelines in Design Information Bulletin No. 58. 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.

Step 5. 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.

Step 6. Design Information Bulletin No. 58 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 geometrics 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. For these reasons a decision point is shown in step 6.

If no L.O.S. break is required, feasible, or necessary, go to step 11.

Steps 7 - 10. The LOS program (step 7) is discussed in Appendix D, and applications are shown in Section 6.2 (sample problems). The program accepts a SOUND3 or SOUND32 file and calculates the 11.5 ft. L.O.S. break intersections for each barrier, in terms of Z coordi-

nates, heights, and distance from beginning of each barrier segment. The results (step 8) should be plotted on a profile sheet along with the Z0 height of the barrier(s) (step 9). The input file created in step 5 should be modified so that the barrier Z heights are approximately parallel to the L.O.S. break (step 10). It is also a good idea to choose the Z heights so that the lowest perturbation will be either at, or one increment (DELZ) below the L.O.S. break. Examples will be shown in the sample problems in Section 6.2 of this chapter.

Steps 11 and 12. Run SOUND32 (step 11) with either the file created in step 5 (if no L.O.S. break required), or step 10 (L.O.S. break required). The results of this run will be the noise levels in Leq(h), dB(A) for each receiver with barrier heights Z in place, and the cost of a Z-height barrier.

At this point the user has the option to change 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 looping between step 11 and 12. 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.

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 concept of E/C ratios is discussed in greater detail in Chapter 5 and Appendix A. The purpose of the E/C ratios is to allow for a 'balanced' design. To access this option see Chapter 4, Section 4.3.2. 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 use the E/C ratios as a guide toward a reasonable, cost effective barrier design.

In general, if a user chooses a design with relatively high E/C ratios, the result will be a small amount of protection at a low cost. Conversely, if the user chooses lower numbers, the barrier design will be more effective at a higher cost.

After the initial designs the user should have to 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.

For each alternate barrier system requiring different system alignments the design process must loop back to step 5.

Finally, it should be pointed out that in many cases the optimum acoustical design may have to be compromised because of the Design Information Bulletin No. 58 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.

6.2 EXAMPLE PROBLEMS

6.2.1 <u>Introduction.</u> 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.

6.2.2 **Sample Problem 1.** (Pages 6-23 through 6-48) represents a barrier proposal in conjunction with a Type I project (new highway alignment). The first page (6-24) 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 Type I projects outlined in the previous section. A table of contents is included for convenience.

6.2.3 **Problem 2 - Case Study.** Problem 2 (Pages 6-49 through 6-100) is a case study of a Caltrans Type II barrier project. The problem is presented in 4 parts: (1) Problem 2 is the without barrier case (comparison with noise measurements and K-constant included); (2) Problem 2A is the actual barrier design; (3) Problem 2B is an example design using SOUND32 procedures with the 11.5 ft. L.O.S. break constraint; and (4) Problem 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.

Page 6-50 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 omited, 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 through out 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 2.

The results would appear to indicate that the actual barrier was overdesigned. 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 2 the cost difference between actual design and SOUND32 with and without L.O.S. designs, showed savings of 33.0% and 48.3% respectively.

For user convenience a table of contents for Problem 2 is included. (Page 6-49)

SAMPLE PROBLEM 1
TABLE OF CONTENTS

Page No.(s)

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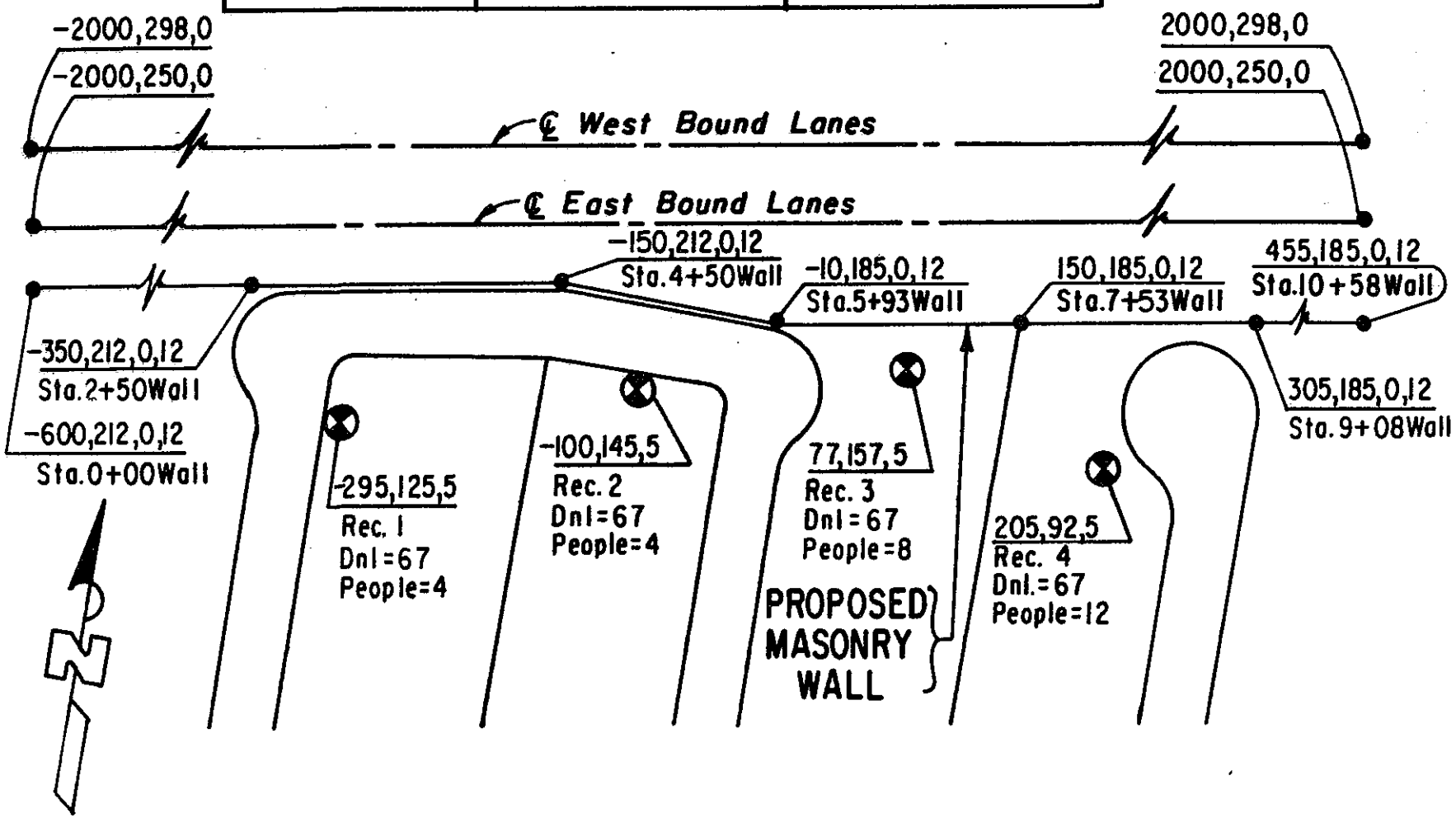
* final barrier design profile & cost per SOUND 32 6-48

SAMPLE PROBLEM I

TRAFFIC DATA

VEHICLE TYPE	EAST BOUND		WEST BOUND	
	VOLUME	SPEED	VOLUME	SPEED
AUTOS	3,060	55MPH	2,045	55 MPH
MEDIUM TRUCKS	50	55MPH	30	55 MPH
HEAVY TRUCKS	130	55MPH	85	55 MPH



Page No._____of_____

CALIFORNIA DEPARTMENT OF TRANSPORTATION

INPUT DATA SHEET FOR SOUND32

Caltrans Version of FHWA Level 2
Noise Prediction and Barrier Design Model
(Based on STAMINA2.0 & OPTIMA programs)

Dist._____ Co._____ Rte_____ P.M._____ Location:_____
Charge:_____ E.A./Spec.Des:_____
Data Prepared by:_____ Date:_____ Checked by:_____ Date_____
File Name & Type: BCR PROB3WO Account:_____ Code:_____

TITLE: SAMPLE PROBLEM 3 WITHOUT BARRIER

SHEET-A - TRAFFIC AND LANE DATA

TRAFFIC DATA

TRAFFIC (T) FOR LANE No.	T, 1	T, 2	T,	T,
AUTOS- VOL, SPEED	3060 ,55	2045,55	,	,
MED. TRKS- VOL, SPEED	50 ,55	30,55	,	,
HVY. TRKS- VOL, SPEED	130 ,55	85,55	,	,

LANE DATA(Max.30 lanes of 1 to 15 segments)

LANE (L) NO.	GRADE CORR. (Y or N)	COORDINATES X	Y	Z	DESCRIPTIONS
L,1	N	-2000	250	0	E/B LANES
		2000	250	0	
L,2	N	-2000	298	0	W/B LANES
		2000	298	0	

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CALIFORNIA DEPARTMENT OF TRANSPORTATION

INPUT DATA SHEET FOR SOUND32

Caltrans Version of FHWA Level 2
Noise Prediction and Barrier Design Model
(Based on STAMINA2.0 & OPTIMA programs)

Dist.____ Co.____ Rte____ P.M.____ Location:____
Charge:____ E.A./Spec.Des:____
Data Prepared by:____ Date:____ Checked by:____ Date____
File Name & Type: BCR PROB2WO Account:____ Code:____

TITLE: SAMPLE PROBLEM 1 WITHOUT BARRIER

SHEET-C - RECEIVER DATA

(Max. 40 Receivers)

RECEIVER (R), NO., DNL*, PEOPLE** COORDINATES (X, Y, Z), DESCRIPTION	RECEIVER (R), NO., DNL*, PEOPLE** COORDINATES (X, Y, Z), DESCRIPTION
R, 1, 67, 4	R,
-295, 125, 5, REC1	
R, 2, 67, 4	R,
-100, 145, 5, REC 2	
R, 3, 67, 8	R,
77, 157, 5, REC 3	
R, 4, 67, 12	R,
205, 92, 5, REC 4	
R,	R,
R,	R,
R,	R,
R,	R,
R,	R,
R,	R,

* DNL = Design Noise Level (L_{eq}, dBA)
**People= No. of People Represented by Receiver

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CALIFORNIA DEPARTMENT OF TRANSPORTATION

INPUT DATA SHEET FOR SOUND32

Caltrans Version of FHWA Level 2
Noise Prediction and Barrier Design Model
(Based on STAMINA2.0 & OPTIMA programs)

Dist._____ Co._____ Rte_____ P.M._____ Location:_____
Charge:_____ E.A./Spec.Des:_____
Data Prepared by:_____ Date:_____ Checked by:_____ Date_____
File Name & Type:_____ Account:_____Code:_____

TITLE:

SHEET-D - DROP OFF RATES* AND ADJUSTMENT CONSTANTS
& CALCULATION OPTION

DROP OFF RATES OTHER THAN 3 dBA/DOUBLE DIST.

D,(dBA)	Lane No. or All(A)	RECEIVER NO's
D,		

ADJUSTMENT CONSTANTS, (+ or-) K

K,(±dBA)	Lane No. or All(A)	RECEIVER NO's
K,		

*Drop-Off rates of 3 dBA/D.D. need not be input. (Default value = 3)

CALCULATION OPTION

☐ VC (Prints Input Data in Format, and Prints Calculated Leq's
☐ C (Prints Calculated Leq's)

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INPUT FILE (IN'WAR')

BCR PROB1WO

```
00010 BCR SAMPLE PROBLEM1 WITHOUT BARRIER
00020 T,1
00030 3060,55
00040 50,55
00050 130,55
00060 T,2
00070 2045,55
00080 30,55
00090 85,55
00100 L,1
00110 N,-2000,250,0,E/B LANES
00120 2000,250,0
00130 L,2
00140 N,-2000,298,0,W/B LANES
00150 2000,298,0
00160 R,1,67,4
00170 -295,125,5,REC1
00180 R,2,67,4
00190 -100,145,5,REC2
00200 R,3,67,8
00210 77,157,5,REC3
00220 R,4,67,12
00230 205,92,5,REC4
00240 C
>
```

WITHOUT BARRIER

```
RUN SOUNDSYS

     **********************
     *      SOUNDSYS      *
     *      05-04-83      *
     **********************

     (1) = RUN SOUND3
     (2) = RUN SOUND32
     (3) = RUN LOS

     WHICH ?
>2

    * * SOUND32 * *


     Enter Input FILE NAME >BCR PROB1WO

     BCR PROB1WO A Found


     Barrier Cost file = CALIF BAR$
     CALIFORNIA BARRIER COST (IN 1980 DOLLARS)
     Valid Barrier types
      1  -  91    BERM
      2  -  92    MASONRY
      3  -  93    MASONRY/JERSEY
      4  -  94    CONCRETE


     1)  Change Barrier Cost file
     2)  List data as processed (Now Off)
     3)  Abort run
     4)  Go
          WHICH >4

     RECEIVER     LEQ
     ---------------
     REC1        75.2
     REC2        75.9
     REC3        76.4
     REC4        74.2
R?
>
```

Leq RESULTS WITHOUT BARRIER

Page No._____of_____

CALIFORNIA DEPARTMENT OF TRANSPORTATION

INPUT DATA SHEET FOR SOUND32

Caltrans Version of FHWA Level 2
Noise Prediction and Barrier Design Model
(Based on STAMINA2.0 & OPTIMA programs)

Dist.____ Co.____ Rte____ P.M.____ Location:____
Charge:____ E.A./Spec.Des:____
Data Prepared by:____ Date:____ Checked by:____ Date____
File Name & Type: BCR PROBLEM Account:____ Code:____

TITLE: SAMPLE PROBLEM 1 WITH BARRIER

SHEET-B - BARRIER DATA

(Max. 20 Barriers of 1 to 10 segments each)

BARR.(B) NO.	TYPE MATERIAL*	DELZ	P (MAX 3)	COORDINATES X	Y	Zo	Z	DESCRIP. (Max. 8 CHARACTERS)
B, 1	2	1	3	-600	212	0	12	STA 0+00
				-350	212	0	12	STA 2+50
				-150	212	0	12	STA 4+50
				-10	185	0	12	STA 5+93
				150	185	0	12	STA 7+53
				305	185	0	12	STA 9+08
				455	185	0	12	STA 10+58

*Material Codes (used for Cost Factors)

1 = Earth Berms
2 = Masonry
3 = Masonry On 2.7' High Jersey Barrier (Type 27)
4 = Concrete (cast in place)
5 = Prefab Conc. Panels
6 = Steel
7 = Wood

For Structure Barriers add 90; e.g. 94 = conc. bar on Structure

FOR STRUCTURE BARRIERS ONLY:

Bar.No.	LANE NO.'s AFFECTED

RWH 4/83

INPUT FILE (IN'WAR')

BCR PROBLEM

```
 LIST
00010 BCR SAMPLE PROBLEM1 WITH BARRIER
00020 T,1
00030 3060,55
00040 50,55
00050 130,55
00060 T,2
00070 2045,55
00080 30,55
00090 85,55
00100 L,1
00110 N,-2000,250,0,E/B LANES
00120 2000,250,0
00130 L,2
00140 N,-2000,298,0,W/B LANES
00150 2000,298,0
00160 R,1,67,4
00170 -295,125,5,REC1
00180 R,2,67,4
00190 -100,145,5,REC2
00200 R,3,67,8
00210 77,157,5,REC3
00220 R,4,67,12
00230 205,92,5,REC4
00240 B,1,2,1,3
00250 -600,212,0,12,STA0+00
00260 -350,212,0,12,STA2+50
00270 -150,212,0,12,STA4+50
00280 -10,185,0,12,STA5+93
00290 150,185,0,12,STA7+53
00300 305,185,0,12,STA9+08
00310 455,185,0,12,STA10+58
00320 C
>
```

```
SOUNDSYS

     **********************
     *      SOUNDSYS      *
     *      05-04-83      *
     **********************

     (1) = RUN SOUND3
     (2) = RUN SOUND32
     (3) = RUN LOS

     WHICH ?
>3
. ***** LOS *****

      * LOS *

     File Name (or HELP) ?>BCR PROBLEM

     Is BCR PROBLEM a:
     (1)  SOUND3 input file ?
     (2) SOUND32 input file ?
     WHICH ?>2

     Lane number to use ?>1

     Barrier number ?>1

     Enter list of receivers to use
     (seperated by commas)  (max. = 40)
     >1,2,3,4

     Got data

     Enter the max. receiver to truck distance you want calculated
     >500

      18  Points calculated

     (1) = List in Barrier Order
     (2) = List in Receiver Order
     (3) = Quit
     >1

     Set paper at top of form & hit return >
```

LINE-OF-SIGHT (LOS) PROGRAM
(Calculates L.O.S. break at barrier alignment between 11.5 ft truck-stack and receivers.)

(use lane no. that will result in highest L.O.S. break.)

* 11.5' TRUCK STACK LINE-OF-SIGHT CALCULATIONS *

Page 1

Input File-BCR PROBLEM Lane No.-1 Barrier No.-1 Max. DT-500
Receiver(s)- 1 2 3 4

BCR SAMPLE PROBLEM1

X	Y	ZO	Rec	DT	LOS Z	Height	BD	Desc.
Bar. Segment 1								
-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
-600	212	0.0	1	456	9.5	9.5	0	Bar. End STA0+00
Bar. Segment 2								
-150	212 0	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
-295	212	0.0	1	125	9.5	9.5	55	Near Pt.
Bar. Segment 3								
-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
-100	202	0.0	2	105	8.6	8.6	51	Near Pt.
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	473	8.8	8.8	150	Bar. End STA10+58

DT = Distance to Truck (from Rec.)
BD = Barrier Distance (along Bar. from segment pt.)

(1) = List in Barrier Order
(2) = List in Receiver Order
(3) = Quit
>2

* 11.5' TRUCK STACK LINE-OF-SIGHT CALCULATIONS *

Page 1

Input File-BCR PROa.M Lane No.-1 Barrier No.-1 Max. DT-500
Receiver(s)- 1 2 3 4

BCR SAMPLE PROBLEM1

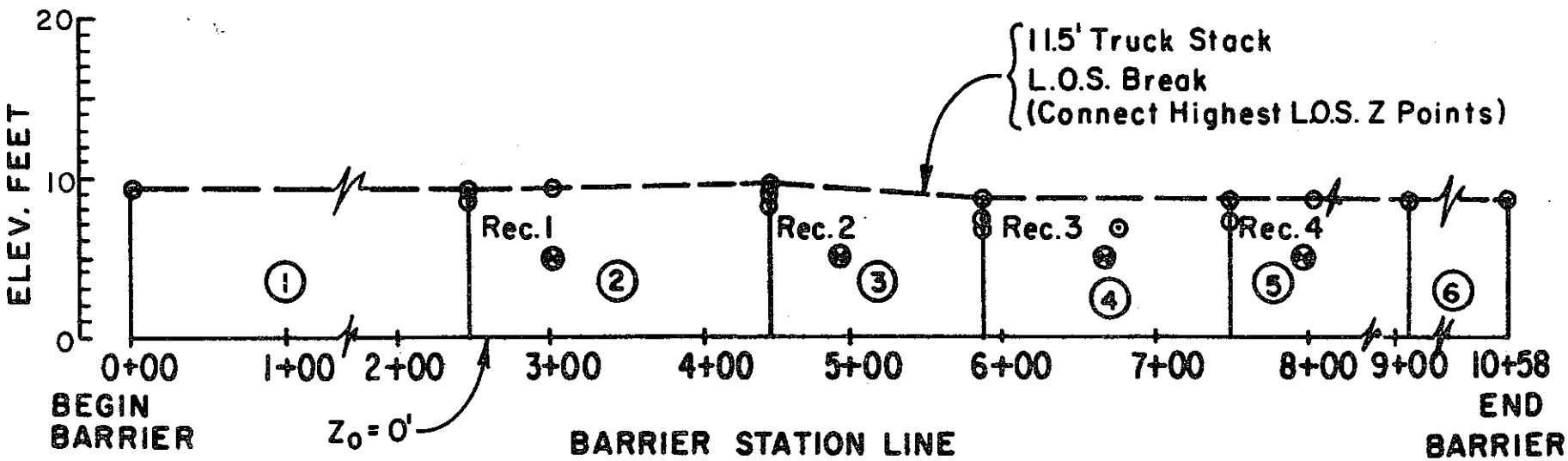
X	Y	ZO	Seg	DT	LOS Z	Height	BD	Desc.
Receiver 1								
-600	212	0.0	1	456	9.5	9.5	0	Bar. End STA0+00
-350	212	0.0	1	148	9.5	9.5	250	Bar. End STA2+50
-295	212	0.0	2	125	9.5	9.5	55	Near Pt.
-150	212	0.0	2	243	9.5	9.5	200	Bar. End STA4+50
Receiver 2								
-350	212	0.0	1	406	9.1	9.1	250	Bar. End STA2+50
-150	212	0.0	2	131	9.1	9.1	200	Bar. End STA4+50
-100	202	0.0	3	105	8.6	8.6	51	Near Pt.
-10	185	0.0	3	259	7.5	7.5	143	Bar. End STA5+93
Receiver 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	260	7.0	7.0	160	Bar. End STA7+53
Receiver 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	0.0	5	158	8.8	8.8	55	Near Pt.
305	185	0.0	5	232	8.8	8.8	155	Bar. End STA9+08
455	185	0.0	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.)

(1) = List in Barrier Order
(2) = List in Receiver Order
(3) = Quit
>3
R;
>

PROBLEM I

Sample Problem
Plotting 11.5' Truck Stack
Line-Of-Sight (L.O.S.) Break.
(Data From L.O.S. Program)



LEGEND

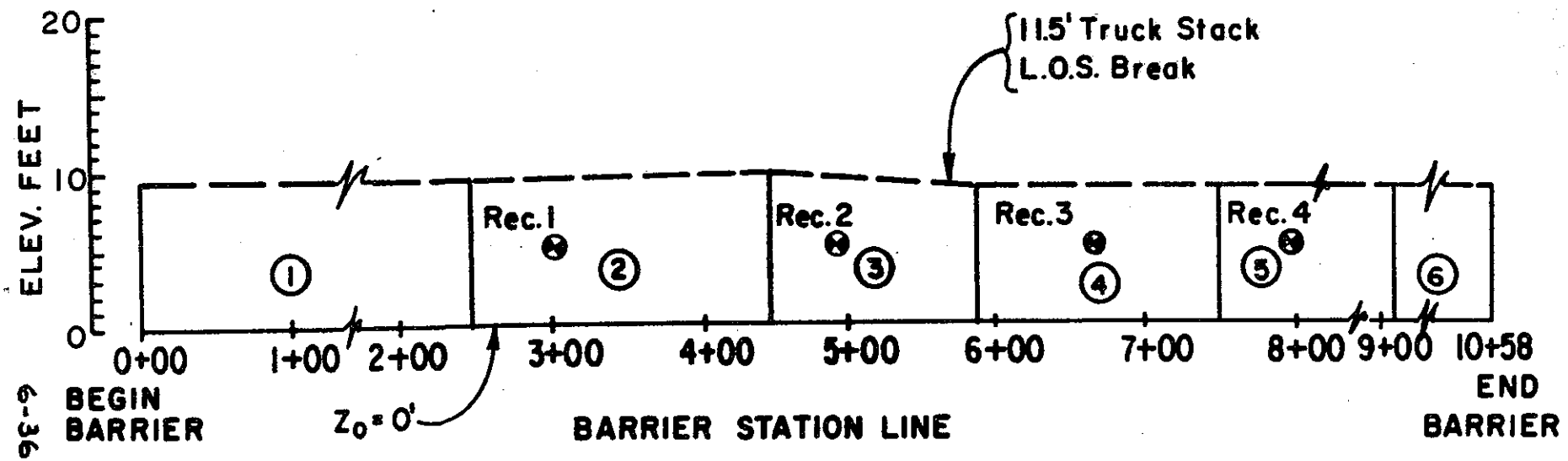
- (3) Barrier Element No.
- ⊗ Receiver Location and No.
- ⊙ L.O.S. Z per "L.O.S." Program

SCALE

Hor.: 1" = 100'
Ver.: 1" = 10'

PROBLEM I

Sample Problem
Profile Work Sheet For Barrier Design



LEGEND

③ Barrier Element No.

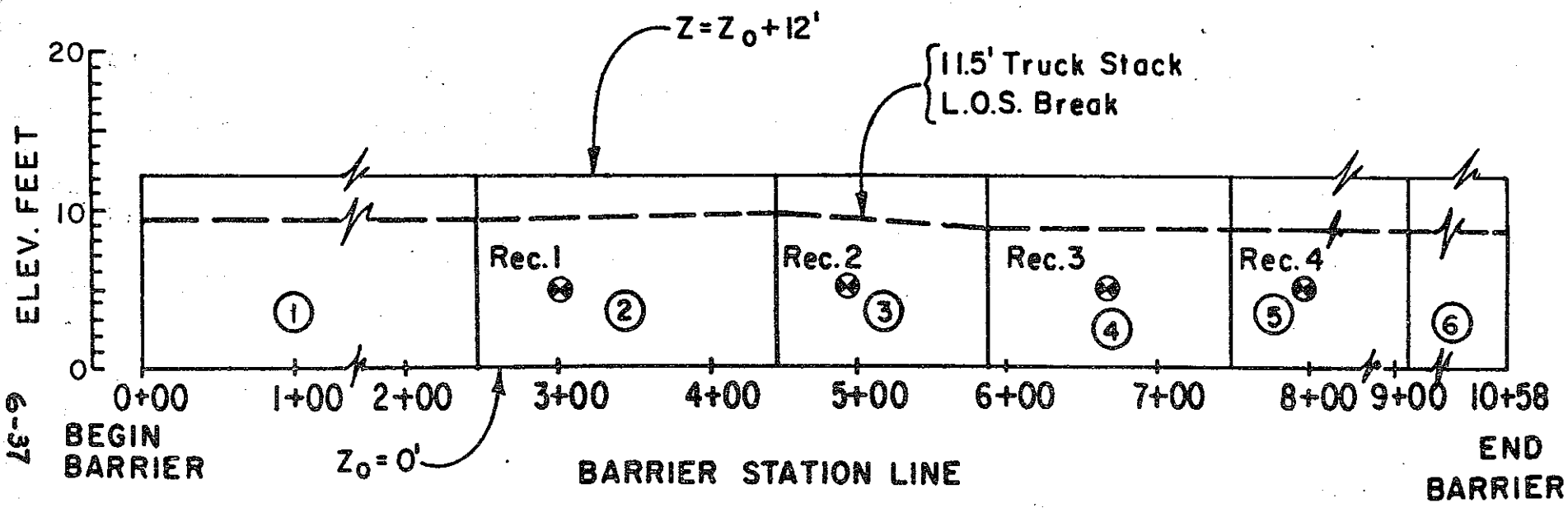
⊗ Receiver Location and No.

SCALE

Hor.: 1" = 100'
Ver.: 1" = 10'

PROBLEM I

Sample Problem
Initial Run



LEGEND

(3) Barrier Element No.

⊗ Receiver Location and No.

SCALE

Hor.: 1" = 100'
Ver.: 1" = 10'

```
RUN SOUNDSYS
                                                    WITH BARRIER

     **********************
     *      SOUNDSYS      *
     *      05-04-83      *
     **********************

     (1) = RUN SOUND3
     (2) = RUN SOUND32
     (3) = RUN LOS

     WHICH ?
>2

    * * SOUND32 * *


     Enter Input FILE NAME >BCR PROBLEM

     BCR PROBLEM A Found


     Barrier Cost file = CALIF BAR$
     CALIFORNIA BARRIER COST (IN 1980 DOLLARS)
     Valid Barrier types
      1  -  91    BERM
      2  -  92    MASONRY
      3  -  93    MASONRY/JERSEY
      4  -  94    CONCRETE


     1)  Change Barrier Cost file
     2)  List data as processed (Now Off)
     3)  Abort run
     4)  Go
          WHICH >4


R E S U L T S
***********************************

REC REC ID    DNL  PEOPLE   LEQ        OVER DNL
-----------------------------------
 1  REC1      67.      4.   67.2
 2  REC2      67.      4.   66.5   Leq RESULTS FOR 2-HEIGHT BARRIER
 3  REC3      67.      8.   65.8
 4  REC4      67.     12.   67.3
-----------------------------------   OVER DNL

BARRIER TYPE                COST
-----------------------------------
BERM                          0.
MASONRY                  111046.
MASONRY/JERSEY                0.
CONCRETE                      0.
-----------------------------------
      TOTAL COST = $     111046.   COST OF 2-HEIGHT BARRIER
***********************************


     ENTER MENU SELECTION
     (0 = PRINT MENU)
?
>0
```

```
0).....PRINT MENU
1).....CHANGE BARRIER HEIGHT INDEX
2).....CHANGE BARRIER TYPES
3).....CHANGE PEOPLE PER RECEIVER
4).....CHANGE DESIGN NOISE LEVELS
5).....PRINT E/C RATIOS
6).....PRINT BARRIER HEIGHT INDEX
7).....PRINT LEQS
8).....STOP


ENTER MENU SELECTION
(0 = PRINT MENU)
?
>5


        EFFECTIVENESS / COST RATIOS
        ***************************
```

E/C RATIOS FOR Z-HEIGHTS

BAR ELE	0	1	2	3	4	5	6	7	
1	-	30.	27.	27.	25.*	23.	22.	21.	STA0+00
2	-	36.	33.	32.	30.*	27.	26.	26.	STA2+50
3	-	37.	35.	34.	31.*	28.	27.	26.	STA4+50
4	-	42.	39.	37.	35.*	32.	30.	30.	STA5+93
5	-	38.	36.	35.	33.*	30.	29.	28.	STA7+53
6	-	32.	30.	29.	27.*	25.	24.	24.	STA9+08
	0	1	2	3	4	5	6	7	

INITIAL PATH FOR FIRST DESIGN. (NEAR EQUAL E/C RATIOS)

```
ENTER MENU SELECTION
(0 = PRINT MENU)
?
>6


        BARRIER DATA
        ************
```

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

Z-HEIGHTS

```
    ENTER MENU SELECTION
    (0 = PRINT MENU)
?
>1

    ENTER BARRIER INDEX FOR EACH BARRIER ELEMENT
    (LIST DIRECTED)
?
>6*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.

    ENTER MENU SELECTION
    (0 = PRINT MENU)
?
>7


R E S U L T S
**********************************

REC REC ID     DNL   PEOPLE    LEQ
-------------------------------------
 1  REC1       67.       4.    75.0
 2  REC2       67.       4.    75.7
 3  REC3       67.       8.    76.2
 4  REC4       67.      12.    74.1
-------------------------------------

BARRIER TYPE                   COST
-------------------------------------
BERM                             0.
MASONRY                          0.
MASONRY/JERSEY                   0.
CONCRETE                         0.
-------------------------------------
        TOTAL COST = $           0.
**********************************
```

NOTE: SETTING BARRIER HEIGHT INDEX AT ZERO WILL RESULT IN WITHOUT BARRIER Leq's

Leq RESULTS WITHOUT BARRIER (COMPARE WITH THE FIRST WITHOUT BARRIER RUN. SLIGHT DIFFERENCES (0.1-0.2dB(A)) ARE DUE TO DIFFERENCES IN ROUNDING)

```
    ENTER MENU SELECTION
    (0 = PRINT MENU)
?
>1

    ENTER BARRIER INDEX FOR EACH BARRIER ELEMENT
    (LIST DIRECTED)
?
>3,5,6,7,7,4
```

FIRST DESIGN

```
BARRIER HEIGHT INDEX FOR EACH BARRIER SECTION
  3  5  6  7  7  4
CORRESPONDING BARRIER HEIGHTS FOR EACH SECTION
11.13.14.15.15.12.
```

```
    ENTER MENU SELECTION
    (0 = PRINT MENU)
?
>7


R E S U L T S
************************************


REC REC ID     DNL  PEOPLE   LEQ
-----------------------------------
 1  REC1       67.      4.   66.9
 2  REC2       67.      4.   65.5
 3  REC3       67.      8.   64.1
 4  REC4       67.     12.   66.5
-----------------------------------
```

Leq. RESULTS FOR FIRST DESIGN

```
BARRIER TYPE                 COST
-----------------------------------
BERM                           0.
MASONRY                   136922.
MASONRY/JERSEY                 0.
CONCRETE                       0.
-----------------------------------
       TOTAL COST = $    136922.
************************************
```

COST OF FIRST DESIGN.

```
    ENTER MENU SELECTION
    (0 = PRINT MENU)
?
>5

        EFFECTIVENESS / COST RATIOS
        ***************************
BAR
ELE    0    1    2    3    4    5    6    7
```

E/C RATIOS FOR FIRST DESIGN

```
-----------------------------------------------------------------
  1     -  30.  27.  27.* 25.  23.  22.  21.   STA0+00
  2     -  36.  33.  32.  30.  27.* 26.  26.   STA2+50
  3     -  37.  35.  34.  31.  28.  27.* 26.   STA4+50
  4     -  42.  39.  37.  35.  32.  30.  30.*  STA5+93
  5     -  38.  36.  35.  33.  30.  29.  28.*  STA7+53
  6     -  32.  30.  29.  27.* 25.  24.  24.   STA9+08
-----------------------------------------------------------------
       0    1    2    3    4    5    6    7

    ENTER MENU SELECTION
    (0 = PRINT MENU)
?
>6


        BARRIER DATA
        ************
```

HEIGHTS FOR FIRST DESIGN.

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

```
    ENTER MENU SELECTION
    (0 = PRINT MENU)
?
>1

    ENTER BARRIER INDEX FOR EACH BARRIER ELEMENT
    (LIST DIRECTED)
?
>3,5,5,4,5,4

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.

    ENTER MENU SELECTION
    (0 = PRINT MENU)
?
>7


R E S U L T S

**********************************

REC REC ID    DNL  PEOPLE   LEQ
-------------------------------
 1  REC1      67.      4.   67.0
 2  REC2      67.      4.   66.0
 3  REC3      67.      8.   65.7
 4  REC4      67.     12.   67.1
-------------------------------

BARRIER TYPE                COST
-------------------------------
BERM                          0.
MASONRY                  118581.
MASONRY/JERSEY                0.
CONCRETE                      0.
-------------------------------
       TOTAL COST = $   118581.
**********************************


    ENTER MENU SELECTION
    (0 = PRINT MENU)
?
>5


         EFFECTIVENESS / COST RATIOS
         ***************************
BAR
ELE    0    1    2    3    4    5    6    7
-----------------------------------------------
  1    -   30.   27.   27.*  25.   23.   22.   21.   STA0+00
  2    -   36.   33.   32.   30.   27.*  26.   26.   STA2+50
  3    -   37.   35.   34.   31.   28.*  27.   26.   STA4+50
  4    -   42.   39.   37.   35.*  32.   30.   30.   STA5+93
  5    -   38.   36.   35.   33.   30.*  29.   28.   STA7+53
  6    -   32.   30.   29.   27.*  25.   24.   24.   STA9+08
-----------------------------------------------
       0    1    2    3    4    5    6    7
```

SECOND DESIGN
LOWER ELEMENTS 3,4,5 BY 1,3, AND 2 INCREMENTS RESPECTIVELY. BASED CHOICE ON RESULTS (LEQ) OF FIRST DESIGN.

RESULTS OF SECOND DESIGN.

COST OF SECOND DESIGN

E/C RATIOS FOR SECOND DESIGN

```
    ENTER MENU SELECTION
    (0 = PRINT MENU)
?
>6


          BARRIER DATA
          ************

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

HEIGHTS FOR SECOND DESIGN

```
    ENTER MENU SELECTION
    (0 = PRINT MENU)
?
>1

    ENTER BARRIER INDEX FOR EACH BARRIER ELEMENT
    (LIST DIRECTED) THIRD DESIGN
?
>3,5,4,4,5,4
```

LOWER ELEMENT 3 BY 1 INCREMENT (1 FT) CHOICE BASED ON Leq RESULTS OF SECOND DESIGN.

```
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.

    ENTER MENU SELECTION
    (0 = PRINT MENU)
?
>7


R E S U L T S
************************************

REC REC ID     DNL   PEOPLE    LEQ
-----------------------------------
 1  REC1       67.       4.    67.1
 2  REC2       67.       4.    66.4
 3  REC3       67.       8.    65.7
 4  REC4       67.      12.    67.1
---)-------------------------------
```

Leq RESULTS OF THIRD DESIGN.

```
BARRIER TYPE                  COST
-----------------------------------
BERM                            0.
MASONRY                    115777.
MASONRY/JERSEY                  0.
CONCRETE                        0.
-----------------------------------
        TOTAL COST = $     115777.
************************************
```

COST OF THIRD DESIGN

```
ENTER MENU SELECTION
(0 = PRINT MENU)

?
>5

        EFFECTIVENESS / COST RATIOS
        ***************************
BAR                                                    E/C RATIOS FOR THIRD DESIGN.
ELE    0    1    2    3    4    5    6    7
-----------------------------------------------------------------
  1    -   30.   27.   27.*  25.   23.   22.   21.    STA0+00
  2    -   36.   33.   32.   30.   27.*  26.   26.    STA2+50
  3    -   37.   35.   34.   31.*  28.   27.   26.    STA4+50
  4    -   42.   39.   37.   35.*  32.   30.   30.    STA5+93
  5    -   38.   36.   35.   33.   30.*  29.   28.    STA7+53
  6    -   32.   30.   29.   27.*  25.   24.   24.    STA9+08
-----------------------------------------------------------------
       0    1    2    3    4    5    6    7

ENTER MENU SELECTION
(0 = PRINT MENU)
?
>6

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

ENTER MENU SELECTION
(0 = PRINT MENU)
?
>1

ENTER BARRIER INDEX FOR EACH BARRIER ELEMENT
(LIST DIRECTED) FOURTH DESIGN.
?                LOWER ELEMENT 3 BY 1 MORE INCREMENT. CHOICE BASED
>3,5,3,4,5,4                                  ON Leq RESULTS OF
                                              THIRD DESIGN.

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.
```

```
    ENTER MENU SELECTION
    (0 = PRINT MENU)
?
>7

R E S U L T S
************************************

REC REC ID     DNL   PEOPLE    LEQ
-----------------------------------
 1  REC1       67.       4.   67.2
 2  REC2       67.       4.   66.8
 3  REC3       67.       8.   65.7
 4  REC4       67.      12.   67.1
-----------------------------------

BARRIER TYPE                  COST
-----------------------------------
BERM                            0.
MASONRY                    114494.
MASONRY/JERSEY                  0.
CONCRETE                        0.
-----------------------------------
       TOTAL COST = $     114494.
************************************

    ENTER MENU SELECTION
    (0 = PRINT MENU)
?
>5

         EFFECTIVENESS / COST RATIOS
         ***************************
BAR
ELE     0    1    2    3    4    5    6    7
-----------------------------------------------------------
  1     -  30.  27.  27.*  25.  23.  22.  21.   STA0+00
  2     -  36.  33.  32.   30.  27.*  26.  26.   STA2+50
  3     -  37.  35.  34.*  31.  28.  27.  26.   STA4+50
  4     -  42.  39.  37.   35.*  32.  30.  30.   STA5+93
  5     -  38.  36.  35.   33.  30.*  29.  28.   STA7+53
  6     -  32.  30.  29.   27.*  25.  24.  24.   STA9+08
-----------------------------------------------------------
        0    1    2    3    4    5    6    7

    ENTER MENU SELECTION
    (0 = PRINT MENU)
?
>6

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

OVER DNL

Leq. RESULTS FOR FOURTH DESIGN.

COST OF FOURTH DESIGN.

E/C RATIOS FOR FOURTH DESIGN

HEIGHTS FOR FOURTH DESIGN

```
    ENTER MENU SELECTION
    (0 = PRINT MENU)
?
>1

    ENTER BARRIER INDEX FOR EACH BARRIER ELEMENT
    (LIST DIRECTED)  FIFTH DESIGN
?                    INCREASE ELEMENT 3 BY 1 INCREMENT
>3,5,4,3,5,4         LOWER ELEMENT 4 BY 1 INCREMENT.

BARRIER HEIGHT INDEX FOR EACH BARRIER SECTION
  3  5  4  3  5  4
CORRESPONDING BARRIER HEIGHTS FOR EACH SECTION
11.13.12.11.13.12.

    ENTER MENU SELECTION
    (0 = PRINT MENU)
?
>7
```

CHOICE BASED ON Leq RESULTS OF FOURTH DESIGN.

```
R E S U L T S
************************************

REC REC ID     DNL  PEOPLE   LEQ
-----------------------------------
 1  REC1       67.      4.   67.1
 2  REC2       67.      4.   66.5
 3  REC3       67.      8.   66.4
 4  REC4       67.     12.   67.2
-----------------------------------
```

Leq RESULTS OF FIFTH DESIGN

OVER DNL

```
BARRIER TYPE                COST
-----------------------------------
BERM                          0.
MASONRY                  114337.
MASONRY/JERSEY                0.
CONCRETE                      0.
-----------------------------------
      TOTAL COST = $   114337.
************************************
```

COST OF FIFTH DESIGN

```
    ENTER MENU SELECTION
    (0 = PRINT MENU)
?
>5

        EFFECTIVENESS / COST RATIOS
        ***************************
```

E/C RATIOS FOR FIFTH DESIGN

BAR ELE	0	1	2	3	4	5	6	7	
1	-	30.	27.	27.*	25.	23.	22.	21.	STA0+00
2	-	36.	33.	32.	30.	27.*	26.	26.	STA2+50
3	-	37.	35.	34.	31.*	28.	27.	26.	STA4+50
4	-	42.	39.	37.*	35.	32.	30.	30.	STA5+93
5	-	38.	36.	35.	33.	30.*	29.	28.	STA7+53
6	-	32.	30.	29.	27.*	25.	24.	24.	STA9+08
	0	1	2	3	4	5	6	7	

```
    ENTER MENU SELECTION
    (0 = PRINT MENU)
?
>6


        BARRIER DATA
        ************
```

HEIGHTS FOR FIFTH DESIGN

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

```
    ENTER MENU SELECTION
    (0 = PRINT MENU)
?
>1

    ENTER BARRIER INDEX FOR EACH BARRIER ELEMENT
    (LIST DIRECTED)
?
>3,5,4,3,5,5
```

INCREASE ELEMENT 6 BY 1 INCREMENT (SIXTH DESIGN)

```
BARRIER HEIGHT INDEX FOR EACH BARRIER SECTION
  3  5  4  3  5  5
CORRESPONDING BARRIER HEIGHTS FOR EACH SECTION
11.13.12.11.13.13.

    ENTER MENU SELECTION
    (0 = PRINT MENU)
?
>7


R E S U L T S
*********************************
```

REC	REC ID	DNL	PEOPLE	LEQ
1	REC1	67.	4.	67.1
2	REC2	67.	4.	66.5
3	REC3	67.	8.	66.4
4	REC4	67.	12.	67.1

Leq RESULTS FOR SIXTH DESIGN.

BARRIER TYPE	COST
BERM	0.
MASONRY	117287.
MASONRY/JERSEY	0.
CONCRETE	0.

```
        TOTAL COST = $   117287.
*********************************
```

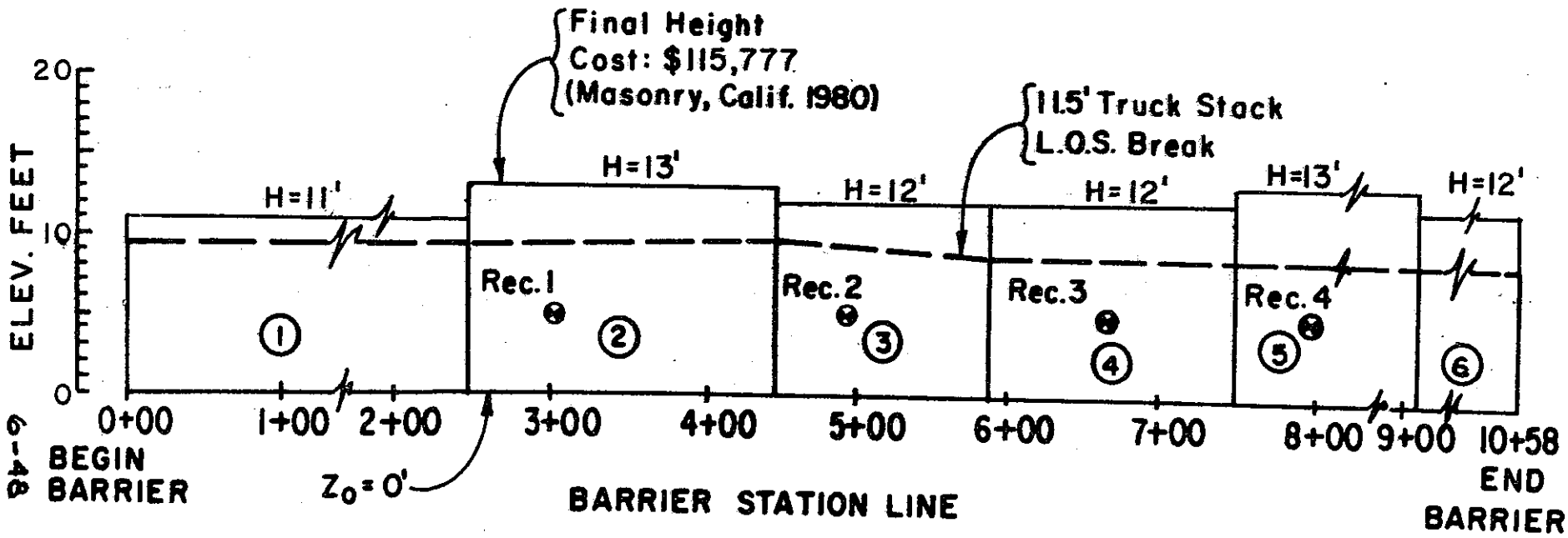
COST OF SIXTH DESIGN.

NOTE: CHOOSE THIRD DESIGN. ADEQUATE PROTECTION FOR MINIMUM COST.

```
    ENTER MENU SELECTION
    (0 = PRINT MENU)
?
>8
R:
```

PROBLEM I

Sample Problem
Final Barrier Design



LEGEND

(3) Barrier Element No.

⊗ Receiver Location and No.

SCALE

Hor.: 1" = 100'
Ver.: 1" = 10'

PROBLEM 2 - CASE STUDY
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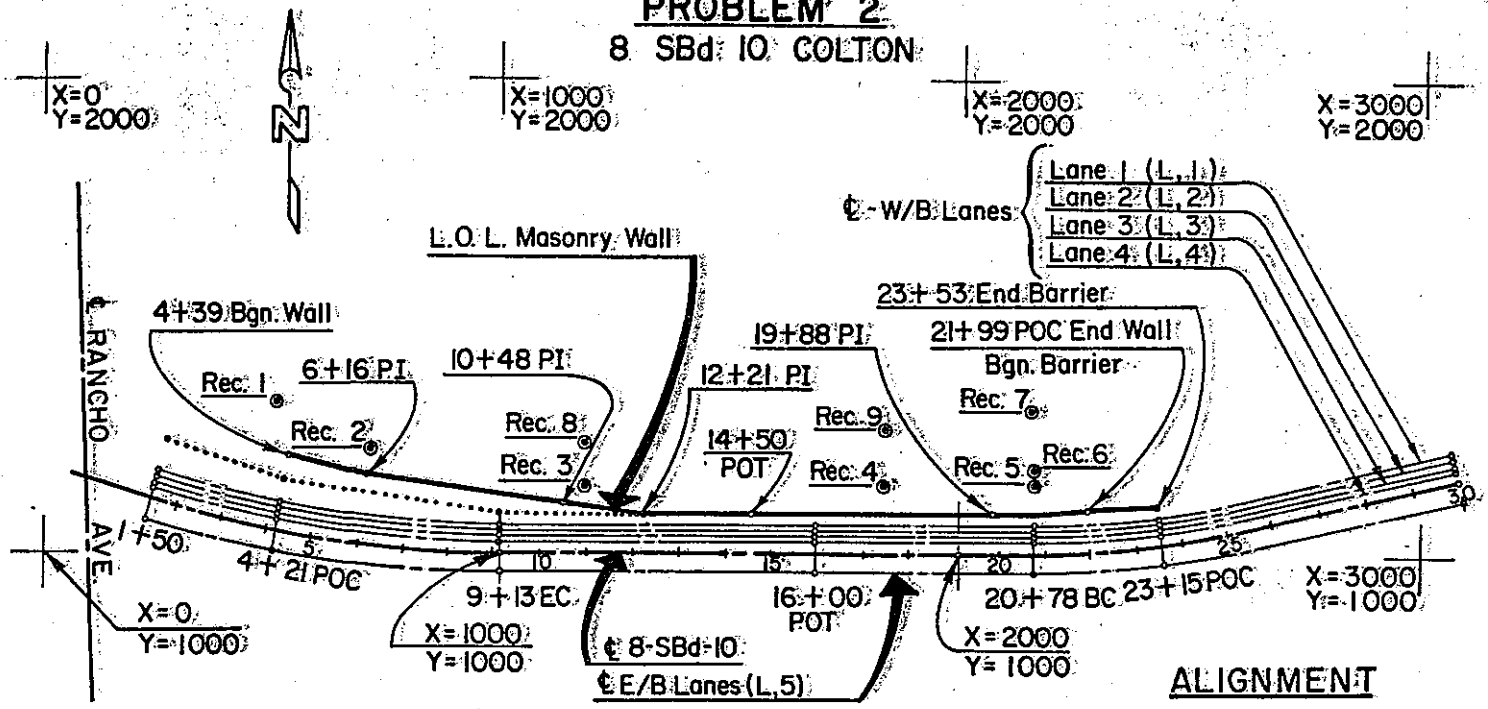
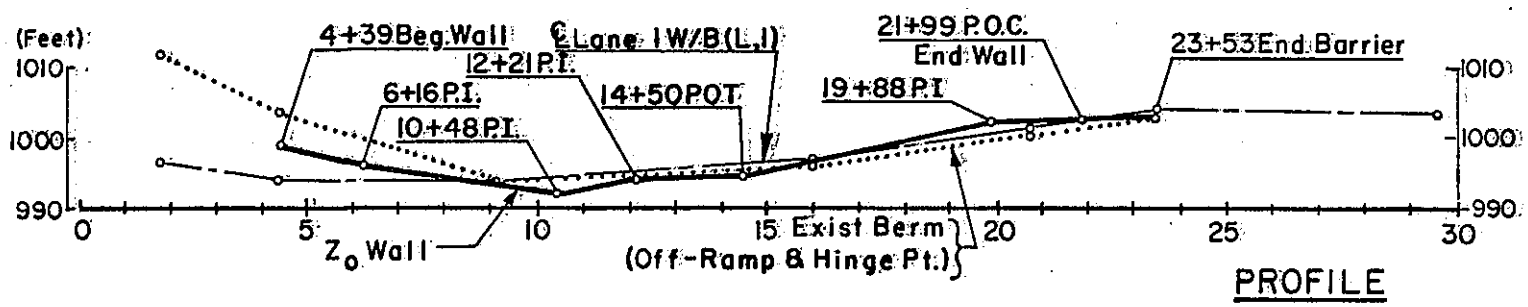
PROBLEM 2

8 SBd 10 COLTON





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CALIFORNIA DEPARTMENT OF TRANSPORTATION

INPUT DATA SHEET FOR SOUND32

Caltrans Version of FHWA Level 2
Noise Prediction and Barrier Design Model
(Based on STAMINA2.0 & OPTIMA programs)

Dist._____ Co._____ Rte_____ P.M._____ Location:_____
Charge:_____ E.A./Spec.Des:_____
Data Prepared by:_____ Date:_____ Checked by:_____ Date_____
File Name & Type: BCR PROB2 Account:_____ Code:_____

TITLE: PROBLEM 2 WITHOUT BARRIER

SHEET-A - TRAFFIC AND LANE DATA

TRAFFIC DATA

TRAFFIC (T) FOR LANE No.	T,1	T,2	T,	T,
AUTOS- VOL, SPEED	940,50	1042,55	,	,
MED. TRKS- VOL, SPEED	111,50	79,55	,	,
HVY. TRKS- VOL, SPEED	158,50	88,55	,	,

LANE DATA(Max.30 lanes of 1 to 15 segments)

LANE (L) NO.	GRADE CORR. (Y or N)	COORDINATES X	Y	Z	DESCRIPTIONS
L,1	N	260.5	1154.5	997.3	1+50 LANE 1
	N	520.3	1099.3	994.9	4+21 POC
	N	1000.0	1060.0	994.6	9+13 EC
	N	1687.2	1060.0	997.7	16+00 POT
	N	2165.3	1060.0	1002.3	20+78 BC
	N	2442.3	1080.0	1004.9	23+65 POC
		3059.9	1209.2	1004.1	30+00 LANE 1
L,2	N	257.5	1143.0	997.5	1+50 LANE2
	N	518.3	1087.5	995.4	4+21 POC
	N	1000.0	1048.0	994.8	9+13 EC
	N	1687.2	1048.0	997.9	16+00 POT
	N	2165.3	1048.0	1002.9	20+78 BC
	N	2444.0	1068.1	1005.9	23+65 POC
		3062.4	1197.5	1004.4	30+00 LANE2

RWH 4/83

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CALIFORNIA DEPARTMENT OF TRANSPORTATION

INPUT DATA SHEET FOR SOUND32

Caltrans Version of FHWA Level 2
Noise Prediction and Barrier Design Model
(Based on STAMINA2.0 & OPTIMA programs)

Dist.____ Co.____ Rte____ P.M.____ Location:____
Charge:____ E.A./Spec.Des:____
Data Prepared by:____ Date:____ Checked by:____ Date____
File Name & Type: BCR PROB2 Account:____ Code:____

TITLE: PROBLEM 2 WITHOUT BARRIER

SHEET-A - TRAFFIC AND LANE DATA

TRAFFIC DATA

TRAFFIC (T) FOR LANE No.	T,3	T,4	T,	T,
AUTOS- VOL, SPEED	1025,55	429,55	,	,
MED. TRKS- VOL, SPEED	28,55	0,55	,	,
HVY. TRKS- VOL, SPEED	0,55	0,55	,	,

LANE DATA(Max.30 lanes of 1 to 15 segments)

LANE (L) NO.	GRADE CORR. (Y or N)	COORDINATES X	Y	Z	DESCRIPTIONS
L,3	N	254.5	1131.5	997.7	1+50 LANE 3
	N	516.4	1075.7	995.9	4+21 POC
	N	1000.0	1036.0	994.9	9+13 EC
	N	1687.2	1036.0	998.9	16+00 POT
	N	2165.3	1036.0	1003.7	20+78 BC
	N	2445.7	1056.2	1006.9	23+65 POC
		3065.0	1185.8	1004.6	30+00 LANE 3
L,4	N	251.5	1120.0	997.9	1+50 LANE 4
	N	514.4	1063.9	996.4	4+21 POC
	N	1000.0	1024.0	995.1	9+13 EC
	N	1687.2	1024.0	998.2	16+00 POT
	N	2165.3	1024.0	1004.4	20+78 BC
	N	2447.4	1044.3	1007.8	23+65 POC
		3067.5	1174.1	1004.9	30+00 LANE 4

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CALIFORNIA DEPARTMENT OF TRANSPORTATION

INPUT DATA SHEET FOR SOUND32

Caltrans Version of FHWA Level 2
Noise Prediction and Barrier Design Model
(Based on STAMINA2.0 & OPTIMA programs)

Dist.____ Co.____ Rte____ P.M.____ Location:____
Charge:____ E.A./Spec.Des:____
Data Prepared by:____ Date:____ Checked by:____ Date____
File Name & Type: BCR PROB2 Account:____ Code:____

TITLE: PROBLEM 2 WITHOUT BARRIER

SHEET-A - TRAFFIC AND LANE DATA

TRAFFIC DATA

TRAFFIC (T) FOR LANE No.	T, 5	T,	T,	T,
AUTOS- VOL, SPEED	1850, 55	,	,	,
MED. TRKS- VOL, SPEED	118, 55	,	,	,
HVY. TRKS- VOL, SPEED	132, 55	,	,	,

LANE DATA(Max.30 lanes of 1 to 15 segments)

LANE (L) NO.	GRADE CORR. (Y or N)	COORDINATES X	Y	Z	DESCRIPTIONS
L, 5	N	235.0	1036.0	997.6	1+50 CL E/B LANES
	N	503.6	998.8	997.1	4+21 POC
	N	1000.0	958.0	995.1	9+13 EC
	N	1687.2	958.0	998.3	16+00 POT
	N	2165.3	958.0	1006.6	20+78 BC
	N	2456.8	978.9	1013.0	23+65 POC
		3081.5	1109.6	1004.5	30+00 CL E/B LANES

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CALIFORNIA DEPARTMENT OF TRANSPORTATION

INPUT DATA SHEET FOR SOUND32

Caltrans Version of FHWA Level 2
Noise Prediction and Barrier Design Model
(Based on STAMINA2.0 & OPTIMA programs)

Dist._____ Co._____ Rte_____ P.M._____ Location:_____
Charge:_____ E.A./Spec.Des:_____
Data Prepared by:_____ Date:_____ Checked by:_____ Date_____
File Name & Type: BGR PROB2 Account:_____ Code:_____

TITLE: WITHOUT BARRIER

SHEET-B - BARRIER DATA

(Max. 20 Barriers of 1 to 10 segments each)

BARR.(B) NO.	TYPE MATERIAL*	DELZ	P (MAX 3)	COORDINATES X	Y	Zo	Z	DESCRIP. (Max. 8 CHARACTERS)
B,1	1	0	0	281	1232	1012	1012	OR1+50
				529	1152	1004	1004	OR4+21
				1000	1080	994	994	OR9+13
				1687	1079	996.5	996.5	HP 16+00
				2165	1079	1001	1001	HP 20+78
				2440	1099	1003	1003	HP 23+65

*Material Codes (used for Cost Factors)

1 = Earth Berms
2 = Masonry
3 = Masonry On 2.7' High Jersey Barrier (Type 27)
4 = Concrete (cast in place)
5 = Prefab Conc. Panels
6 = Steel
7 = Wood

FOR STRUCTURE BARRIERS ONLY:

Bar.No.	LANE NO.'s AFFECTED

For Structure Barriers add 90; e.g. 94 = conc. bar on Structure

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CALIFORNIA DEPARTMENT OF TRANSPORTATION

INPUT DATA SHEET FOR SOUND32

Caltrans Version of FHWA Level 2
Noise Prediction and Barrier Design Model
(Based on STAMINA2.0 & OPTIMA programs)

Dist.____ Co.____ Rte____ P.M.____ Location:____
Charge:____ E.A./Spec.Des:____
Data Prepared by:____ Date:____ Checked by:____ Date____
File Name & Type: BCR PROB2 Account:____ Code:____

TITLE: PROBLEM 2 WITHOUT BARRIER

SHEET-C - RECEIVER DATA

(Max. 40 Receivers)

RECEIVER (R), NO., DNL*, PEOPLE** COORDINATES (X, Y, Z), DESCRIPTION	RECEIVER (R), NO., DNL*, PEOPLE** COORDINATES (X, Y, Z), DESCRIPTION
R, 1, 67, 4	R, , ,
515, 1314, 1005, REC1	, , ,
R, 2, 67, 20	R, , ,
726, 1214, 1001, REC2	, , ,
R, 3, 67, 12	R, , ,
1182, 1140, 995.5 REC 3	, , ,
R, 4, 67, 16	R, , ,
1831, 1142, 985, REC 4	, , ,
R, 5, 67, 4	R, , ,
2135, 1148, 978, REC 5	, , ,
R, 6, 67, 8	R, , ,
2153, 1186, 978, REC 6	, , ,
R, 7, 67, 8	R, , ,
2147, 1304, 978, REC 7	, , ,
R, 8, 67, 12	R, , ,
1182, 1235, 995.5, REC 8	, , ,
R, 9, 67, 20	R, , ,
1831, 1253, 985, REC 9	, , ,
R, , ,	R, , ,
, , ,	, , ,

* DNL = Design Noise Level (Leq_h, dBA)
**People= No. of People Represented by Receiver

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CALIFORNIA DEPARTMENT OF TRANSPORTATION

INPUT DATA SHEET FOR SOUND32

Caltrans Version of FHWA Level 2
Noise Prediction and Barrier Design Model
(Based on STAMINA2.0 & OPTIMA programs)

Dist.____ Co.____ Rte____ P.M.____ Location:____
Charge:____ E.A./Spec.Des:____
Data Prepared by:____ Date:____ Checked by:____ Date____
File Name & Type: BCR PROB2 Account:____ Code:____

TITLE:

SHEET-D - DROP OFF RATES* AND ADJUSTMENT CONSTANTS & CALCULATION OPTION

DROP OFF RATES OTHER THAN 3 dBA/DOUBLE DIST.

D,(dBA)	Lane No. or All(A)	RECEIVER NO's
D, 4.5	A	1,2

ADJUSTMENT CONSTANTS, (+ or-) K

K,(±dBA)	Lane No. or All(A)	RECEIVER NO's
K,		

*Drop-Off rates of 3 dBA/D.D. need not be input. (Default value = 3)

CALCULATION OPTION

☑ VC (Prints Input Data in Format, and Prints Calculated Leq's
☐ C (Prints Calculated Leq's)

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INPUT FILE (IN 'WAR')
BCR PROB2

```
00010 CASE STUDY- BEFORE BARRIER
00020 T,1
00030 940,50,111,50,158,50
00040 T,2
00050 1042,55,79,55,88,55
00060 T,3
00070 1025,55,28,55,0,55
00080 T,4
00090 429,55,0,55,0,55
00100 T,5
00110 1850,55,118,55,132,55
00120 L,1
00130 N,260.5,1154.5,997.3,STA 1+50 W/B LANE 1(SLOW)
00140 N,520.3,1099.3,994.9,STA 4+21POC
00150 N,1000.0,1060.0,994.6,STA 9+13EC
00160 N,1687.2,1060.0,997.7,STA 16+00POT
00170 N,2165.3,1060.0,1002.3,STA 20+78BC
00180 N,2442.3,1080.0,1004.9,STA 23+65POC
00190 3059.9,1209.2,1004.1,STA 30+00 W/B LANE 1(SLOW)
00200 L,2
00210 N,257.5,1143.0,997.5,STA 1+50 W/B LANE 2
00220 N,518.3,1087.5,995.4,STA 4+21POC
00230 N,1000.0,1048.0,994.8,STA 9+13EC
00240 N,1687.2,1048.0,997.9,STA 16+00POT
00250 N,2165.3,1048.0,1002.9,STA20+78BC
00260 N,2444.0,1068.1,1005.9,STA23+65POC
00270 3062.4,1197.5,1004.4,STA 30+00 W/B LANE 2
00280 L,3
00290 N,254.5,1131.5,997.7,STA 1+50 W/B LANE 3
00300 N,516.4,1075.7,995.9,STA 4+21POC
00310 N,1000.0,1036.0,994.9,9+13EC
00320 N,1687.2,1036.0,998.0,STA 16+00POT
00330 N,2165.3,1036.0,1003.7,STA 20+78BC
00340 N,2445.7,1056.2,1006.9,STA 23+65POC
00350 3065.0,1185.8,1004.6,STA 30+00 W/B LANE 3
00360 L,4
00370 N,251.5,1120.0,997.9,STA 1+50 W/B LANE 4
00380 N,514.4,1063.9,996.4,STA 4+21POC
00390 N,1000.0,1024.0,995.1,STA 9+13EC
00400 N,1687.2,1024.00,998.2,STA 16+00POT
00410 N,2165.3,1024.0,1004.4,STA 20+78BC
00420 N,2447.4,1044.3,1007.8,STA 23+65POC
00430 3067.5,1174.1,1004.9,STA 30+00 W/B LANE 4
00440 L,5
00450 N,235.0,1036.0,997.6,STA 1+50 CL E/B LANES (LANE 5)
00460 N,503.6,998.8,997.1,STA 4+21POC
00470 N,1000.0,958.0,995.1,STA 9+13EC
00480 N,1687.2,958.0,998.3,STA 16+00POT
00490 N,2165.3,958.0,1006.6,STA 20+78BC
00500 N,2456.8,978.9,1013.0,STA 23+65POC
00510 3081.5,1109.6,1004.5,STA 30+00 CL E/B LANES (LANE 5)
00520 B,1,1,0,0
00530 281,1232,1012,1012,OR1+50
00540 529,1152,1004,1004,OR4+21
00550 1000,1080,994,994,OR9+13
00560 1687,1079,996.5,996.5,HP16+00
00570 2165,1079,1001,1001,HP20+78
00580 2440,1099,1003,1003,HP23+65
00590 R,1,67,4
00600 515,1314,1005,REC 1
00610 R,2,67,20
00620 726,1214,1001,REC 2
00630 R,3,67,12
00640 1182,1140,995.5,REC 3
00650 R,4,67,16
00660 1831,1142,985,REC 4
00670 R,5,67,4
00680 2135,1148,978,REC 5
00690 R,6,67,8
00700 2153,1186,978,REC 6
00710 R,7,67,8
00720 2147,1304,978,REC 7
00730 R,8,67,12
00740 1182,1235,995.5,REC 8
00750 R,9,67,20
00760 1831,1253,985,REC 9
00770 D,4.5
00780 A,1,2
00790 VC
>
```

BEFORE BARRIER

```
RUN SOUNDSYS

      **********************
      *      SOUNDSYS      *
      *      05-04-83      *
      **********************

      (1) = RUN SOUND3
      (2) = RUN SOUND32
      (3) = RUN LOS

      WHICH ?
>2

    * * SOUND32 * *


      Enter Input FILE NAME >BCR PROB2

      BCR PROB2 A Found


      Barrier Cost file = CALIF BAR$
      CALIFORNIA BARRIER COST (IN 1980 DOLLARS)
      Valid Barrier types
       1  -  91    BERM
       2  -  92    MASONRY
       3  -  93    MASONRY/JERSEY
       4  -  94    CONCRETE


      1)  Change Barrier Cost file
      2)  List data as processed (Now Off)
      3)  Abort run
      4)  Go
          WHICH >4

      Set paper at top of form & hit RETURN>
```

```
            * * SOUND32 (Caltrans version of STAMINA2/OPTIMA) * *

      Input Data file    : (TMLNOISE) BCR PROB2 A
      Barrier Cost file  : CALIF BAR$
      Date               : 06/21/83 07:20:17 TUE

      CASE STUDY- BEFORE BARRIER
      ==========================================================================
      TRAFFIC DATA
      ------------
      Lane          Auto        Medium Trks      Heavy Trks
       No.        VPH  MPH        VPH  MPH         VPH  MPH
      ---------------------------------------------------------
        1         940   50        111   50         158   50
        2        1042   55         79   55          88   55
        3        1025   55         28   55           0   55
        4         429   55          0   55           0   55
        5        1850   55        118   55         132   55
      ==========================================================================
```

LANE DATA

Lane No.	Seg.	Grade Cor.	X	Y	Z	
1	1	NO	260.5	1154.5	997.3	STA 1+50 W/B LANE 1(SLOW)
	2	NO	520.3	1099.3	994.9	STA 4+21POC
	3	NO	1000.0	1060.0	994.6	STA 9+13EC
	4	NO	1687.2	1060.0	997.7	STA 16+00POT
	5	NO	2165.3	1060.0	1002.3	STA 20+78BC
	6	NO	2442.3	1080.0	1004.9	STA 23+65POC
			3059.9	1209.2	1004.1	STA 30+00 W/B LANE 1(SLOW)
2	1	NO	257.5	1143.0	997.5	STA 1+50 W/B LANE 2
	2	NO	518.3	1087.5	995.4	STA 4+21POC
	3	NO	1000.0	1048.0	994.8	STA 9+13EC
	4	NO	1687.2	1048.0	997.9	STA 16+00POT
	5	NO	2165.3	1048.0	1002.9	STA20+78BC
	6	NO	2444.0	1068.1	1005.9	STA23+65POC
			3062.4	1197.5	1004.4	STA 30+00 W/B LANE 2
3	1	NO	254.5	1131.5	997.7	STA 1+50 W/B LANE 3
	2	NO	516.4	1075.7	995.9	STA 4+21POC
	3	NO	1000.0	1036.0	994.9	9+13EC
	4	NO	1687.2	1036.0	998.0	STA 16+00POT
	5	NO	2165.3	1036.0	1003.7	STA 20+78BC
	6	NO	2445.7	1056.2	1006.9	STA 23+65POC
			3065.0	1185.8	1004.6	STA 30+00 W/B LANE 3
4	1	NO	251.5	1120.0	997.9	STA 1+50 W/B LANE 4
	2	NO	514.4	1063.9	996.4	STA 4+21POC
	3	NO	1000.0	1024.0	995.1	STA 9+13EC
	4	NO	1687.2	1024.0	998.2	STA 16+00POT
	5	NO	2165.3	1024.0	1004.4	STA 20+78BC
	6	NO	2447.4	1044.3	1007.8	STA 23+65POC
			3067.5	1174.1	1004.9	STA 30+00 W/B LANE 4
5	1	NO	235.0	1036.0	997.6	STA 1+50 CL E/B LANES (LANE
	2	NO	503.6	998.8	997.1	STA 4+21POC
	3	NO	1000.0	958.0	995.1	STA 9+13EC
	4	NO	1687.2	958.0	998.3	STA 16+00POT
	5	NO	2165.3	958.0	1006.6	STA 20+78BC
	6	NO	2456.8	978.9	1013.0	STA 23+65POC
			3081.5	1109.6	1004.5	STA 30+00 CL E/B LANES (LAN

BARRIER DATA

Barrier No. 1 Type - (1)BERM
Height Increment (DELZ)= 0.0 No. Height Changes (P)=0

Seg.	X	Y	Ground (ZO)	Top (Z)		Barrier Heights at Ends
1	281.0	1232.0	1012.0	1012.0	* OR1+50	* 0
2	529.0	1152.0	1004.0	1004.0	* OR4+21	* 0
3	1000.0	1080.0	994.0	994.0	* OR9+13	* 0
4	1687.0	1079.0	996.5	996.5	* HP16+00	* 0
5	2165.0	1079.0	1001.0	1001.0	* HP20+78	* 0
	2440.0	1099.0	1003.0	1003.0	* HP23+65	* 0

RECEIVER DATA

Rec. No.	X	Y	Z	DNL	People	ID
1	515.0	1314.0	1005.0	67	4	REC 1
2	726.0	1214.0	1001.0	67	20	REC 2
3	1182.0	1140.0	995.5	67	12	REC 3
4	1831.0	1142.0	985.0	67	16	REC 4
5	2135.0	1148.0	978.0	67	4	REC 5
6	2153.0	1186.0	978.0	67	8	REC 6
7	2147.0	1304.0	978.0	67	8	REC 7
8	1182.0	1235.0	995.5	67	12	REC 8
9	1831.0	1253.0	985.0	67	20	REC 9

DROP-OFF RATES

LANE No.+	Receiver 1	2	3	4	5	6	7	8	9
1 !	4.5	4.5	3.0	3.0	3.0	3.0	3.0	3.0	3.0
2 !	4.5	4.5	3.0	3.0	3.0	3.0	3.0	3.0	3.0
3 !	4.5	4.5	3.0	3.0	3.0	3.0	3.0	3.0	3.0
4 !	4.5	4.5	3.0	3.0	3.0	3.0	3.0	3.0	3.0
5 !	4.5	4.5	3.0	3.0	3.0	3.0	3.0	3.0	3.0

K - CONSTANTS

All Lane Receiver/Pairs = 0.0 dBA

MODEL CALIBRATION WITH MEASUREMENTS

R E S U L T S

REC	REC ID	DNL	PEOPLE	LEQ	MEASURED LEQ(h), dB(A)	K-CONSTANTS, dB(A) (ROUNDED OFF)
1	REC 1	67.	4.	64.9	64	-1
2	REC 2	67.	20.	69.0	66	-3
3	REC 3	67.	12.	75.6	72	-4
4	REC 4	67.	16.	73.5	69	-4
5	REC 5	67.	4.	70.2	—	-7*
6	REC 6	67.	8.	72.3	65	-7
7	REC 7	67.	8.	71.0	—	-7*
8	REC 8	67.	12.	72.3	—	-4*
9	REC 9	67.	20.	71.6	—	-4*

* ESTIMATED K-CONSTANTS BASED ON K-CONSTANTS OF NEARBY OR SIMILAR RECEIVERS

BARRIER TYPE	COST
BERM	0.
MASONRY	0.
MASONRY/JERSEY	0.
CONCRETE	0.
TOTAL COST = $	0.

ADJUSTED RESULTS: (AFTER APPLYING K-CONST.'S)

	Leq(h), dB(A)
REC 1	63.9
REC 2	66.0
REC 3	71.6
REC 4	69.5
REC 5	63.2
REC 6	65.3
REC 7	64.0
REC 8	68.3
REC 9	67.6

NOTE: REC. 3,4,8,9 ARE ABOVE DESIGN NOISE LEVEL OF 67 dB(A), Leq(h).

A BARRIER IS NEEDED TO PROTECT THESE RECEIVERS.

```
ENTER MENU SELECTION
(0 = PRINT MENU)
?
>0

 0).....PRINT MENU
 1).....CHANGE BARRIER HEIGHT INDEX
 2).....CHANGE BARRIER TYPES
 3).....CHANGE PEOPLE PER RECEIVER
 4).....CHANGE DESIGN NOISE LEVELS
 5).....PRINT E/C RATIOS
 6).....PRINT BARRIER HEIGHT INDEX
 7).....PRINT LEQS
 8).....STOP

ENTER MENU SELECTION
(0 = PRINT MENU)
?
>8
R!
```

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CALIFORNIA DEPARTMENT OF TRANSPORTATION

INPUT DATA SHEET FOR SOUND32

Caltrans Version of FHWA Level 2
Noise Prediction and Barrier Design Model
(Based on STAMINA2.0 & OPTIMA programs)

Dist.____ Co.____ Rte____ P.M.____ Location:____
Charge:____ E.A./Spec.Des:____
Data Prepared by:____ Date:____ Checked by:____ Date____
File Name & Type: BCR PROB2A Account:____ Code:____

TITLE: ACTUAL DESIGN

SHEET-B - BARRIER DATA

(Max. 20 Barriers of 1 to 10 segments each)

BARR.(B) NO.	TYPE MATERIAL*	DELZ	P (MAX 3)	COORDINATES X	Y	Zo	Z	DESCRIP. (Max. 8 CHARACTERS)
B, 1	1	0	0	281	1232	1012	1012	OR 1+50
				529	1152	1004	1004	OR 4+21
				1000	1080	994	994	OR 9+13
				1687	1079	996.5	996.5	HP 16+00
				2165	1079	1001	1001	HP 20+78
				2440	1099	1003	1003	HP 23+65
B, 2	2	0	0	537.8	1206.1	999.2	1006.5	4+39 WALL
				707.9	1158.4	996.5	1006.5	6+16 WALL
				1137.0	1107.0	992.1	1006.1	10+98 WALL
				1308.6	1081.8	994.2	1006.2	12+21 WALL
B, 3	3	0	0	1308.6	1081.8	994.2	1006.2	12+21 WALL
				1537.2	1081.8	994.6	1005.9	14+50 WALL
				2074.8	1081.8	1002.3	1011.0	19+88 WALL
				2286.1	1090.0	1002.9	1011.6	21+99 WALL
B, 4	3	0	0	2286.1	1090.0	1002.9	1005.6	21+99 BAR
				2438.7	1104.7	1003.3	1006.0	23+53 BAR

*Material Codes (used for Cost Factors)

1 = Earth Berms
2 = Masonry
3 = Masonry On 2.7' High Jersey Barrier (Type 27)
4 = Concrete (cast in place)
5 = Prefab Conc. Panels
6 = Steel
7 = Wood

FOR STRUCTURE BARRIERS ONLY:

Bar.No.	LANE NO.'s AFFECTED

For Structure Barriers add 90; e.g. 94 = conc. bar on Structure

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CALIFORNIA DEPARTMENT OF TRANSPORTATION

INPUT DATA SHEET FOR SOUND32

Caltrans Version of FHWA Level 2
Noise Prediction and Barrier Design Model
(Based on STAMINA2.0 & OPTIMA programs)

Dist._____ Co._____ Rte_____ P.M._____ Location:_____
Charge:_____ E.A./Spec.Des:_____
Data Prepared by:_____ Date:_____ Checked by:_____ Date_____
File Name & Type: BCR PROB2A Account:_____ Code:_____

TITLE: ACTUAL DESIGN

SHEET-D - DROP OFF RATES* AND ADJUSTMENT CONSTANTS & CALCULATION OPTION

DROP OFF RATES OTHER THAN 3 dBA/DOUBLE DIST.

D,(dBA)	Lane No. or All(A)	RECEIVER NO's
D, 4.5	A	1,2

ADJUSTMENT CONSTANTS, (+ or-) K

K,(±dBA)	Lane No. or All(A)	RECEIVER NO's
K, -1	A	1
K, -3	A	2
K, -4	A	3, 4, 8, 9
K, -7	A	5, 6, 7.

*Drop-Off rates of 3 dBA/D.D. need not be input. (Default value = 3)

CALCULATION OPTION

☑ VC (Prints Input Data in Format, and Prints Calculated Leq's
☐ C (Prints Calculated Leq's)

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INPUT FILE (IN'WAR')
BCR PROB2A

```
00010 CASE STUDY- ACTUAL DESIGN
00020 T,1
00030 940,50,111,50,158,50
00040 T,2
00050 1042,55,79,55,88,55
00060 T,3
00070 1025,55,28,55,0,55
00080 T,4
00090 429,55,0,55,0,55
00100 T,5
00110 1850,55,118,55,132,55
00120 L,1
00130 N,260.5,1154.5,997.3,STA 1+50 W/B LANE 1(SLOW)
00140 N,520.3,1099.3,994.9,STA 4+21POC
00150 N,1000.0,1060.0,994.6,STA 9+13EC
00160 N,1687.2,1060.0,997.7,STA 16+00POT
00170 N,2165.3,1060.0,1002.3,STA 20+78BC
00180 N,2442.3,1080.0,1004.9,STA 23+65POC
00190 3059.9,1209.2,1004.1,STA 30+00 W/B LANE 1(SLOW)
00200 L,2
00210 N,257.5,1143.0,997.5,STA 1+50 W/B LANE 2
00220 N,518.3,1087.5,995.4,STA 4+21POC
00230 N,1000.0,1048.0,994.8,STA 9+13EC
00240 N,1687.2,1048.0,997.9,STA 16+00POT
00250 N,2165.3,1048.0,1002.9,STA20+78BC
00260 N,2444.0,1068.1,1005.9,STA23+65POC
00270 3062.4,1197.5,1004.4,STA 30+00 W/B LANE 2
00280 L,3
00290 N,254.5,1131.5,997.7,STA 1+50 W/B LANE 3
00300 N,516.4,1075.7,995.9,STA 4+21POC
00310 N,1000.0,1036.0,994.9,9+13EC
00320 N,1687.2,1036.0,998.0,STA 16+00POT
00330 N,2165.3,1036.0,1003.7,STA 20+78BC
00340 N,2445.7,1056.2,1006.9,STA 23+65POC
00350 3065.0,1185.8,1004.6,STA 30+00 W/B LANE 3
00360 L,4
00370 N,251.5,1120.0,997.9,STA 1+50 W/B LANE 4
00380 N,514.4,1063.9,996.4,STA 4+21POC
00390 N,1000.0,1024.0,995.1,STA 9+13EC
00400 N,1687.2,1024.00,998.2,STA 16+00POT
00410 N,2165.3,1024.0,1004.4,STA 20+78BC
00420 N,2447.4,1044.3,1007.8,STA 23+65POC
00430 3067.5,1174.1,1004.9,STA 30+00 W/B LANE 4
00440 L,5
00450 N,235.0,1036.0,997.6,STA 1+50 CL E/B LANES (LANE 5)
00460 N,503.6,998.8,997.1,STA 4+21POC
00470 N,1000.0,958.0,995.1,STA 9+13EC
00480 N,1687.2,958.0,998.3,STA 16+00POT
00490 N,2165.3,958.0,1006.6,STA 20+78BC
00500 N,2456.8,978.9,1013.0,STA 23+65POC
00510 3081.5,1109.6,1004.5,STA 30+00 CL E/B LANES (LANE 5)
00520 B,1,1,0,0
00530 281,1232,1012,1012,OR1+50
00540 529,1152,1004,1004,OR4+21
00550 1000,1080,994,994,OR9+13
00560 1687,1079,996.5,996.5,HP16+00
00570 2165,1079,1001,1001,HP20+78
00580 2440,1099,1003,1003,HP23+65
00590 R,1,67,4
00600 515,1314,1005,REC 1
00610 R,2,67,20
00620 726,1214,1001,REC 2
00630 R,3,67,12
00640 1182,1140,995.5,REC 3
00650 R,4,67,16
00660 1831,1142,985,REC 4
00670 R,5,67,4
00680 2135,1148,978,REC 5
00690 R,6,67,8
00700 2153,1186,978,REC 6
00710 R,7,67,8
00720 2147,1304,978,REC 7
```

```
00730 R,8,67,12
00740 1182,1235,995.5,REC 8
00750 R,9,67,20
00760 1831,1253,985,REC 9
00770 D,4,5
00780 A,1,2
00790 B,2,2,0,0
00800 537.8,1206.1,999.2,1006.5,4+39WALL
00810 707.9,1158.4,996.5,1006.5,6+16WALL
00820 1137.0,1107.0,992.1,1006.1,10+48WLL
00830 1308.6,1081.8,994.2,1006.2,12+21WLL
00840 B,3,3,0,0
00850 1308.6,1081.8,994.2,1006.2,12+21WLL
00860 1537.2,1081.8,994.6,1005.9,14+50WLL
00870 2074.8,1081.8,1002.3,1011.0,19+88WLL
00880 2286.1,1090.0,1002.9,1011.6,21+99WLL
00890 B,4,3,0,0
00900 2286.1,1090.0,1002.9,1005.6,21+99BAR
00910 2438.7,1104.7,1003.3,1006.0,23+53BAR
00920 K,-1
00930 A,1
00940 K,-3
00950 A,2
00960 K,-4
00970 A,3,4,8,9
00980 K,-7
00990 A,5,6,7
01000 VC
>
```

```
RUN SOUNDSYS 2

                                        ACTUAL DESIGN

     **********************
     *      SOUNDSYS      *
     *      05-04-83      *
     **********************

    * * SOUND32 * *


     Enter Input FILE NAME >BCR PROB2A

     BCR PROB2A A Found


     Barrier Cost file = CALIF BAR$
     CALIFORNIA BARRIER COST (IN 1980 DOLLARS)
     Valid Barrier types
      1  -  91    BERM
      2  -  92    MASONRY
      3  -  93    MASONRY/JERSEY
      4  -  94    CONCRETE


     1)  Change Barrier Cost file
     2)  List data as processed (Now Off)
     3)  Abort run
     4)  Go
          WHICH >4

     Set paper at top of form & hit RETURN>
```

```
          * * SOUND32 (Caltrans version of STAMINA2/OPTIMA) * *

Input Data file    : (TMLNOISE) BCR PROB2A A
Barrier Cost file  : CALIF BAR$
Date               : 06/03/83 08:40:49 FRI

CASE STUDY- ACTUAL DESIGN
```

TRAFFIC DATA

Lane No.	Auto VPH	Auto MPH	Medium Trks VPH	Medium Trks MPH	Heavy Trks VPH	Heavy Trks MPH
1	940	50	111	50	158	50
2	1042	55	79	55	88	55
3	1025	55	28	55	0	55
4	429	55	0	55	0	55
5	1850	55	118	55	132	55

LANE DATA

Lane No.	Ses.	Grade Cor.	X	Y	Z	
1	1	NO	260.5	1154.5	997.3	STA 1+50 W/B LANE 1(SLOW)
	2	NO	520.3	1099.3	994.9	STA 4+21POC
	3	NO	1000.0	1060.0	994.6	STA 9+13EC
	4	NO	1687.2	1060.0	997.7	STA 16+00POT
	5	NO	2165.3	1060.0	1002.3	STA 20+78BC
	6	NO	2442.3	1080.0	1004.9	STA 23+65POC
			3059.9	1209.2	1004.1	STA 30+00 W/B LANE 1(SLOW)
2	1	NO	257.5	1143.0	997.5	STA 1+50 W/B LANE 2
	2	NO	518.3	1087.5	995.4	STA 4+21POC
	3	NO	1000.0	1048.0	994.8	STA 9+13EC
	4	NO	1687.2	1048.0	997.9	STA 16+00POT
	5	NO	2165.3	1048.0	1002.9	STA20+78BC
	6	NO	2444.0	1068.1	1005.9	STA23+65POC
			3062.4	1197.5	1004.4	STA 30+00 W/B LANE 2
3	1	NO	254.5	1131.5	997.7	STA 1+50 W/B LANE 3
	2	NO	516.4	1075.7	995.9	STA 4+21POC
	3	NO	1000.0	1036.0	994.9	9+13EC
	4	NO	1687.2	1036.0	998.0	STA 16+00POT
	5	NO	2165.3	1036.0	1003.7	STA 20+78BC
	6	NO	2445.7	1056.2	1006.9	STA 23+65POC
			3065.0	1185.8	1004.6	STA 30+00 W/B LANE 3
4	1	NO	251.5	1120.0	997.9	STA 1+50 W/B LANE 4
	2	NO	514.4	1063.9	996.4	STA 4+21POC
	3	NO	1000.0	1024.0	995.1	STA 9+13EC
	4	NO	1687.2	1024.0	998.2	STA 16+00POT
	5	NO	2165.3	1024.0	1004.4	STA 20+78BC
	6	NO	2447.4	1044.3	1007.8	STA 23+65POC
			3067.5	1174.1	1004.9	STA 30+00 W/B LANE 4
5	1	NO	235.0	1036.0	997.6	STA 1+50 CL E/B LANES (LANE
	2	NO	503.6	998.8	997.1	STA 4+21POC
	3	NO	1000.0	958.0	995.1	STA 9+13EC
	4	NO	1687.2	958.0	998.3	STA 16+00POT
	5	NO	2165.3	958.0	1006.6	STA 20+78BC
	6	NO	2456.8	978.9	1013.0	STA 23+65POC
			3081.5	1109.6	1004.5	STA 30+00 CL E/B LANES (LAN

BARRIER DATA

Barrier No. 1 Type - (1)BERM
Height Increment (DELZ)= 0.0 No. Height Changes (P)=0

Seg.	X	Y	Ground (Z0)	Top (Z)		Barrier Heights at Ends
1	281.0	1232.0	1012.0	1012.0	* OR1+50 *	0
2	529.0	1152.0	1004.0	1004.0	* OR4+21 *	0
3	1000.0	1080.0	994.0	994.0	* OR9+13 *	0
4	1687.0	1079.0	996.5	996.5	* HP16+00 *	0
5	2165.0	1079.0	1001.0	1001.0	* HP20+78 *	0
	2440.0	1099.0	1003.0	1003.0	* HP23+65 *	0

Barrier No. 2 Type - (2)MASONRY
Height Increment (DELZ)= 0.0 No. Height Changes (P)=0

Seg.	X	Y	Ground (Z0)	Top (Z)		Barrier Heights at Ends
1	537.8	1206.1	999.2	1006.5	* 4+39WALL*	7
2	707.9	1158.4	996.5	1006.5	* 6+16WALL*	10
3	1137.0	1107.0	992.1	1006.1	* 10+48WLL*	14
	1308.6	1081.8	994.2	1006.2	* 12+21WLL*	12

Barrier No. 3 Type - (3)MASONRY/JERSEY
Height Increment (DELZ)= 0.0 No. Height Changes (P)=0

Seg.	X	Y	Ground (Z0)	Top (Z)		Barrier Heights at Ends
1	1308.6	1081.8	994.2	1006.2	* 12+21WLL*	12
2	1537.2	1081.8	994.6	1005.9	* 14+50WLL*	11
3	2074.8	1081.8	1002.3	1011.0	* 19+88WLL*	9
	2286.1	1090.0	1002.9	1011.6	* 21+99WLL*	9

Barrier No. 4 Type - (3)MASONRY/JERSEY
Height Increment (DELZ)= 0.0 No. Height Changes (P)=0

Seg.	X	Y	Ground (Z0)	Top (Z)		Barrier Heights at Ends
1	2286.1	1090.0	1002.9	1005.6	* 21+99BAR*	3
	2438.7	1104.7	1003.3	1006.0	* 23+53BAR*	3

RECEIVER DATA

Rec. No.	X	Y	Z	DNL	People	ID
1	515.0	1314.0	1005.0	67	4	REC 1
2	726.0	1214.0	1001.0	67	20	REC 2
3	1182.0	1140.0	995.5	67	12	REC 3
4	1831.0	1142.0	985.0	67	16	REC 4
5	2135.0	1148.0	978.0	67	4	REC 5
6	2153.0	1186.0	978.0	67	8	REC 6
7	2147.0	1304.0	978.0	67	8	REC 7
8	1182.0	1235.0	995.5	67	12	REC 8
9	1831.0	1253.0	985.0	67	20	REC 9

DROP-OFF RATES

LANE No.+	Receiver 1	2	3	4	5	6	7	8	9
1	4.5	4.5	3.0	3.0	3.0	3.0	3.0	3.0	3.0
2	4.5	4.5	3.0	3.0	3.0	3.0	3.0	3.0	3.0
3	4.5	4.5	3.0	3.0	3.0	3.0	3.0	3.0	3.0
4	4.5	4.5	3.0	3.0	3.0	3.0	3.0	3.0	3.0
5	4.5	4.5	3.0	3.0	3.0	3.0	3.0	3.0	3.0

K - CONSTANTS

LANE No.+	Receiver 1	2	3	4	5	6	7	8	9
1 :	-1.0	-3.0	-4.0	-4.0	-7.0	-7.0	-7.0	-4.0	-4.0
2 :	-1.0	-3.0	-4.0	-4.0	-7.0	-7.0	-7.0	-4.0	-4.0
3 :	-1.0	-3.0	-4.0	-4.0	-7.0	-7.0	-7.0	-4.0	-4.0
4 :	-1.0	-3.0	-4.0	-4.0	-7.0	-7.0	-7.0	-4.0	-4.0
5 :	-1.0	-3.0	-4.0	-4.0	-7.0	-7.0	-7.0	-4.0	-4.0

R E S U L T S
****

REC	REC ID	DNL	PEOPLE	LEQ
1	REC 1	67.	4.	63.8
2	REC 2	67.	20.	64.4
3	REC 3	67.	12.	62.7
4	REC 4	67.	16.	61.4
5	REC 5	67.	4.	59.3
6	REC 6	67.	8.	60.3
7	REC 7	67.	8.	60.8
8	REC 8	67.	12.	62.4
9	REC 9	67.	20.	62.1

BARRIER TYPE	COST
BERM	0.
MASONRY	80318.
MASONRY/JERSEY	134387.
CONCRETE	0.
TOTAL COST = $	214705.

****

ENTER MENU SELECTION
(0 = PRINT MENU)
?
>5

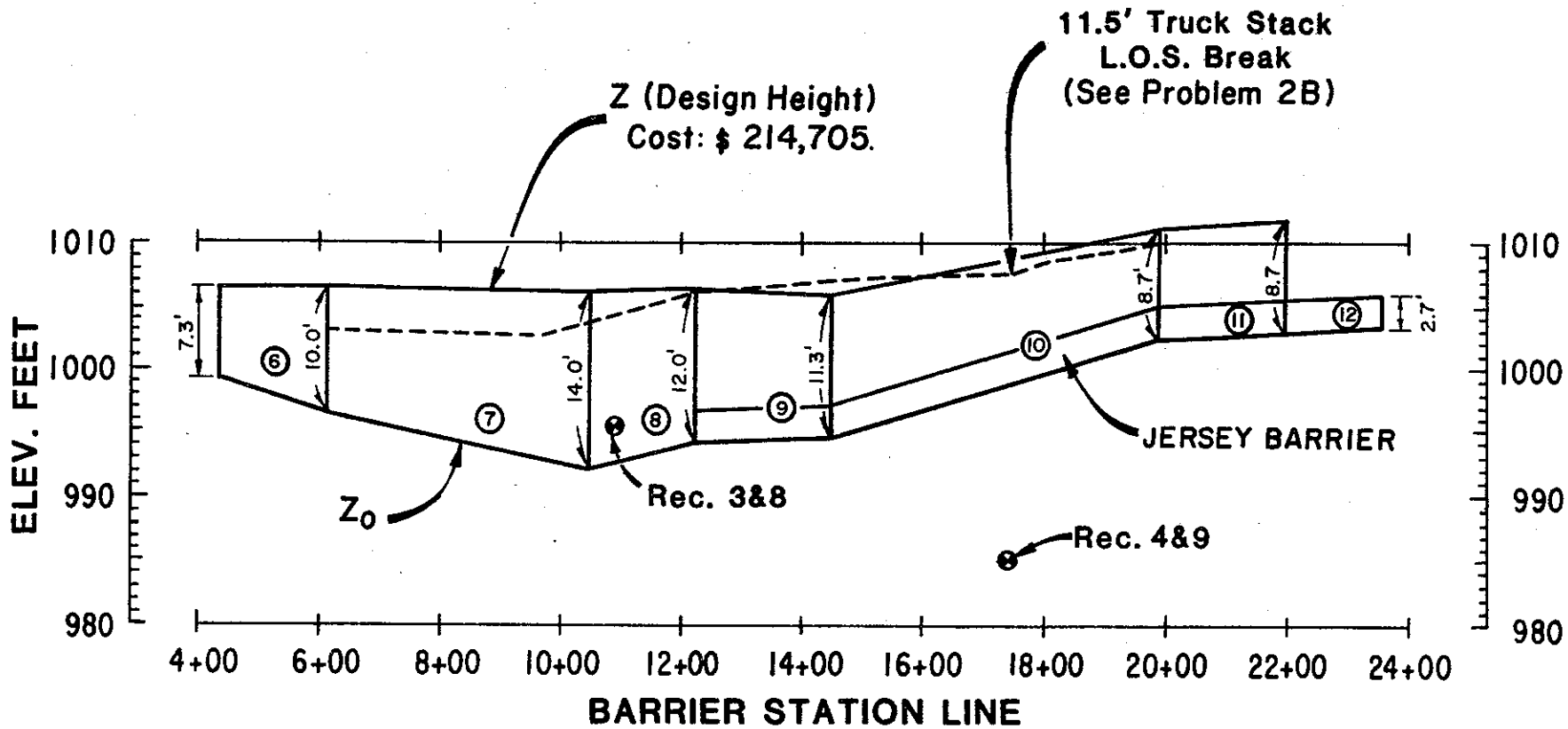
EFFECTIVENESS / COST RATIOS
****

BAR ELE	0	1	2	3	4	5	6	7	
1	-	0.*							OR1+50
2	-	0.*							OR4+21
3	-	0.*							OR9+13
4	-	0.*							HP16+00
5	-	0.*							HP20+78
6	-	0.*							4+39WALL
7	-	0.*							6+16WALL
8	-	0.*							10+48WLL
9	-	0.*							12+21WLL
10	-	0.*							14+50WLL
11	-	0.*							19+88WLL
12	-	0.*							21+99BAR
	0	1	2	3	4	5	6	7	

```
ENTER MENU SELECTION
(0 = PRINT MENU)
?
>0

 0).....PRINT MENU
 1).....CHANGE BARRIER HEIGHT INDEX
 2).....CHANGE BARRIER TYPES
 3).....CHANGE PEOPLE PER RECEIVER
 4).....CHANGE DESIGN NOISE LEVELS
 5).....PRINT E/C RATIOS
 6).....PRINT BARRIER HEIGHT INDEX
 7).....PRINT LEQS
 8).....STOP

ENTER MENU SELECTION
(0 = PRINT MENU)
?
>6

        BARRIER DATA
        ************

BAR                BARRIER HEIGHTS                  BAR
ELE    0    1    2    3    4    5    6    7        ID        LENGTH  TYPE
-----------------------------------------------------------------------------
 1     -   0.*                                     OR1+50     260.7   BERM
 2     -   0.*                                     OR4+21     476.6   BERM
 3     -   0.*                                     OR9+13     687.0   BERM
 4     -   0.*                                     HP16+00    478.0   BERM
 5     -   0.*                                     HP20+78    275.7   BERM
                                                                       BARRIER HEIGHTS
 6     -   9.*                                     4+39WALL   176.7   MASONRY
 7     -  12.*                                     6+16WALL   432.2   MASONRY
 8     -  13.*                                     10+48WLL   173.4   MASONRY
                                                                       OF ACTUAL DESIGN
 9     -  12.*                                     12+21WLL   228.6   MASONRY/JERSEY
10     -  10.*                                     14+50WLL   537.6   MASONRY/JERSEY
11     -   9.*                                     19+88WLL   211.5   MASONRY/JERSEY
12     -   3.*                                     21+99BAR   153.3   MASONRY/JERSEY
-----------------------------------------------------------------------------
       0    1    2    3    4    5    6    7

ENTER MENU SELECTION
(0 = PRINT MENU)
?
>8
R$

>
```

PROBLEM 2A

Case Study ~ Actual Design



LEGEND

⑧ Barrier Element No.

⊗ Receiver Location and No.

SCALE

Hor.: 100'

Vert.: 10'

Page No._____of_____

CALIFORNIA DEPARTMENT OF TRANSPORTATION

INPUT DATA SHEET FOR SOUND32

Caltrans Version of FHWA Level 2
Noise Prediction and Barrier Design Model
(Based on STAMINA2.0 & OPTIMA programs)

Dist._____ Co._____ Rte_____ P.M._____ Location:_____
Charge:_____ E.A./Spec.Des:_____
Data Prepared by:_____ Date:_____ Checked by:_____ Date_____
File Name & Type: BCR PROB2B Account:_____ Code:_____

TITLE: TRANSLAB DESIGN 1 - 11.5' L.O.S. BREAK

SHEET-B - BARRIER DATA

(Max. 20 Barriers of 1 to 10 segments each)

BARR.(B) NO.	TYPE MATERIAL*	DELZ	P (MAX 3)	COORDINATES X	Y	Zo	Z	DESCRIP. (Max. 8 CHARACTERS)
B,1	1	0	0	281	1232	1012	1012	OR1+50
				529	1152	1004	1004	OR4+21
				1000	1080	994	994	OR9+13
				1687	1079	996.5	996.5	HP16+00
				2165	1079	1001	1001	HP20+78
				2440	1099	1003	1003	HP23+65
B,2	2	1	3	707.9	1158.4	996.5	1004.0	6+16 WALL
				1137.0	1107.0	992.1	1004.6	10+48 WLL
				1308.6	1081.8	994.2	1007.2	12+21 WLL
B,3	3	1	3	1308.6	1081.8	994.2	1007.2	12+21 WLL
				1537.2	1081.8	994.2	1008.1	14+50 WLL
				2074.8	1081.8	1002.3	1010.8	19+88WLL
B,4	3	0	0	2074.8	1081.8	1002.3	1005.0	19+88 BAR
				2286.1	1090.0	1002.9	1005.6	21+99 BAR
				2438.7	1104.7	1003.3	1006.0	23+53 BAR

*Material Codes (used for Cost Factors)

1 = Earth Berms
2 = Masonry
3 = Masonry On 2.7' High Jersey Barrier (Type 27)
4 = Concrete (cast in place)
5 = Prefab Conc. Panels
6 = Steel
7 = Wood

FOR STRUCTURE BARRIERS ONLY:

Bar.No.	LANE NO.'s AFFECTED

For Structure Barriers add 90; e.g. 94 = conc. bar on Structure

RWH 4/83

INPUT FILE (IN'WAR')
BCR PROB2B

```
00010 TRANSLAB DESIGN 1 - WITH 11.5 FT L.O.S. BREAK CONSTRAINT.
00020 T,1
00030 940,50,111,50,158,50
00040 T,2
00050 1042,55,79,55,88,55
00060 T,3
00070 1025,55,28,55,0,55
00080 T,4
00090 429,55,0,55,0,55
00100 T,5
00110 1850,55,118,55,132,55
00120 L,1
00130 N,260.5,1154.5,997.3,STA 1+50 W/B LANE 1(SLOW)
00140 N,520.3,1099.3,994.9,STA 4+21POC
00150 N,1000.0,1060.0,994.6,STA 9+13EC
00160 N,1687.2,1060.0,997.7,STA 16+00POT
00170 N,2165.3,1060.0,1002.3,STA 20+78BC
00180 N,2442.3,1080.0,1004.9,STA 23+65POC
00190 3059.9,1209.2,1004.1,STA 30+00 W/B LANE 1(SLOW)
00200 L,2
00210 N,257.5,1143.0,997.5,STA 1+50 W/B LANE 2
00220 N,518.3,1087.5,995.4,STA 4+21POC
00230 N,1000.0,1048.0,994.8,STA 9+13EC
00240 N,1687.2,1048.0,997.9,STA 16+00POT
00250 N,2165.3,1048.0,1002.9,STA20+78BC
00260 N,2444.0,1068.1,1005.9,STA23+65POC
00270 3062.4,1197.5,1004.4,STA 30+00 W/B LANE 2
00280 L,3
00290 N,254.5,1131.5,997.7,STA 1+50 W/B LANE 3
00300 N,516.4,1075.7,995.9,STA 4+21POC
00310 N,1000.0,1036.0,994.9,9+13EC
00320 N,1687.2,1036.0,998.0,STA 16+00POT
00330 N,2165.3,1036.0,1003.7,STA 20+78BC
00340 N,2445.7,1056.2,1006.9,STA 23+65POC
00350 3065.0,1185.8,1004.6,STA 30+00 W/B LANE 3
00360 L,4
00370 N,251.5,1120.0,997.9,STA 1+50 W/B LANE 4
00380 N,514.4,1063.9,996.4,STA 4+21POC
00390 N,1000.0,1024.0,995.1,STA 9+13EC
00400 N,1687.2,1024.00,998.2,STA 16+00POT
00410 N,2165.3,1024.0,1004.4,STA 20+78BC
00420 N,2447.4,1044.3,1007.8,STA 23+65POC
00430 3067.5,1174.1,1004.9,STA 30+00 W/B LANE 4
00440 L,5
00450 N,235.0,1036.0,997.6,STA 1+50 CL E/B LANES (LANE 5)
00460 N,503.6,998.8,997.1,STA 4+21POC
00470 N,1000.0,958.0,995.1,STA 9+13EC
00480 N,1687.2,958.0,998.3,STA 16+00POT
00490 N,2165.3,958.0,1006.6,STA 20+78BC
00500 N,2456.8,978.9,1013.0,STA 23+65POC
00510 3081.5,1109.6,1004.5,STA 30+00 CL E/B LANES (LANE 5)
00520 B,1,1,0,0
00530 281,1232,1012,1012,OR1+50
00540 529,1152,1004,1004,OR4+21
00550 1000,1080,994,994,OR9+13
00560 1687,1079,996.5,996.5,HP16+00
00570 2165,1079,1001,1001,HP20+78
00580 2440,1099,1003,1003,HP23+65
00590 R,1,67,4
00600 515,1314,1005,REC 1
00610 R,2,67,20
00620 726,1214,1001,REC 2
00630 R,3,67,12
00640 1182,1140,995.5,REC 3
00650 R,4,67,16
00660 1831,1142,985,REC 4
00670 R,5,67,4
00680 2135,1148,978,REC 5
00690 R,6,67,8
00700 2153,1186,978,REC 6
00710 R,7,67,8
00720 2147,1304,978,REC 7
```

```
00730 R,8,67,12
00740 1182,1235,995.5,REC 8
00750 R,9,67,20
00760 1831,1253,985,REC 9
00770 D,4,5
00780 A,A
00790 B,2,2,1,3
00800 707.9,1158.4,996.5,1004.0,6+16WALL
00810 1137.0,1107.0,992.1,1004.6,10+48WLL
00820 1308.6,1081.8,994.2,1007.2,12+21WLL
00830 B,3,3,1,3
00840 1308.6,1081.8,994.2,1007.2,12+21WLL
00850 1537.2,1081.8,994.6,1008.1,14+50WLL
00860 2074.8,1081.8,1002.3,1010.8,19+88WLL
00870 B,4,3,0,0
00880 2074.8,1081.8,1002.3,1005.0,19+88BAR
00890 2286.1,1090.0,1002.9,1005.6,21+99BAR
00900 2438.7,1104.7,1003.3,1006.0,23+53BAR
00910 K,-1
00920 A,1
00930 K,-3
00940 A,2
00950 K,-4
00960 A,3,4,8,9
00970 K,-7
00980 A,5,6,7
00990 C
>
```

```
SOUNDSYS 3

11.5' L.O.S. BREAK - BARRIER 2

***** LOS *****

      * LOS *

     File Name (or HELP) ?>BCR PROB2B

     Is BCR PROB2B a:
     (1)  SOUND3 input file ?
     (2) SOUND32 input file ?
     WHICH ?>2

     Lane number to use ?>1

     Barrier number ?>2

     Enter list of receivers to use
     (seperated by commas)  (max. = 40)
     >3,4,8,9

     Got data

     Enter the max. receiver to truck distance you want calculated
     >1000

      17  Points calculated

     (1) = List in Barrier Order
     (2) = List in Receiver Order
     (3) = Quit
     >1

     Set paper at top of form & hit return >
```

* 11.5' TRUCK STACK LINE-OF-SIGHT CALCULATIONS *

Page 1

Input File-BCR PROB2B Lane No.-1 Barrier No.-2 Max. DT-1000
Receiver(s)- 3 4 8 9

TRANSLAB DESIGN 1 - WITH 11.5 FT L.O.S. BREAK CONSTRAINT.

X	Y	ZO	Rec	DT	LOS Z	Height	BD	Desc.
Bar. Segment 1								
708	1158	996.5	8	748	1003.0	6.5	0	Bar. End 6+16WALL
771	1151	995.8	8	676	1002.3	6.5	64	Lane End
813	1146	995.4	3	922	1000.8	5.4	106	Lane End
970	1127	993.8	3	663	999.0	5.2	264	Lane End
1059	1116	992.9	8	253	1002.7	9.8	353	Lane End
1113	1110	992.3	3	199	999.5	7.2	408	Lane End
1137	1107	992.1	3	135	1000.0	7.9	432	Bar. End 6+16WALL
1137	1107	992.1	9	913	1001.4	9.3	432	Bar. End 6+16WALL
1137	1107	992.1	8	186	1003.7	11.6	432	Bar. End 6+16WALL
Bar. Segment 2								
1177	1101	992.6	9	853	1001.6	9.0	41	Lane End
1182	1100	992.7	3	80	1001.2	8.5	46	Near Pt.
1182	1100	992.7	8	175	1004.3	11.6	45	Near Pt.
1273	1087	993.8	4	835	999.2	5.4	138	Lane End
1309	1082	994.2	4	716	1000.9	6.7	173	Bar. End 10+48WLL
1309	1082	994.2	3	192	1004.4	10.2	173	Bar. End 12+21WLL
1309	1082	994.2	9	620	1004.7	10.5	173	Bar. End 10+48WLL
1309	1082	994.2	8	227	1006.1	11.9	173	Bar. End 12+21WLL

DT = Distance to Truck (from Rec.)
BD = Barrier Distance (along Bar. from segment pt.)

(1) = List in Barrier Order
(2) = List in Receiver Order
(3) = Quit
>2

* 11.5' TRUCK STACK LINE-OF-SIGHT CALCULATIONS *

Page 1

Input File-BCR PROB2B Lane No.-1 Barrier No.-2 Max. DT-1000
Receiver(s)- 3 4 8 9

TRANSLAB DESIGN 1 - WITH 11.5 FT L.O.S. BREAK CONSTRAINT.

X	Y	ZO	Seg	DT	LOS Z	Height	BD	Desc.
Receiver 3								
813	1146	995.4	1	922	1000.8	5.4	106	Lane End
970	1127	993.8	1	663	999.0	5.2	264	Lane End
1113	1110	992.3	1	199	999.5	7.2	408	Lane End
1137	1107	992.1	1	135	1000.0	7.9	432	Bar. End 6+16WALL
1182	1100	992.7	2	80	1001.2	8.5	46	Near Pt.
1309	1082	994.2	2	192	1004.4	10.2	173	Bar. End 12+21WLL
Receiver 4								
1273	1087	993.8	2	835	999.2	5.4	138	Lane End
1309	1082	994.2	2	716	1000.9	6.7	173	Bar. End 10+48WLL
Receiver 8								
708	1158	996.5	1	748	1003.0	6.5	0	Bar. End 6+16WALL
771	1151	995.8	1	676	1002.3	6.5	64	Lane End
1059	1116	992.9	1	253	1002.7	9.8	353	Lane End
1137	1107	992.1	1	186	1003.7	11.6	432	Bar. End 6+16WALL
1182	1100	992.7	2	175	1004.3	11.6	45	Near Pt.
1309	1082	994.2	2	227	1006.1	11.9	173	Bar. End 12+21WLL
Receiver 9								
1137	1107	992.1	1	913	1001.4	9.3	432	Bar. End 6+16WALL
1177	1101	992.6	2	853	1001.6	9.0	41	Lane End
1309	1082	994.2	2	620	1004.7	10.5	173	Bar. End 10+48WLL

DT = Distance to Truck (from Rec.)
BD = Barrier Distance (along Bar. from segment pt.)

```
SOUNDSYS 3
                                                    11.5' L.O.S. BREAK-BARRIER3

***** LOS *****

     * LOS *

    File Name (or HELP) ?>BCR PROB2B

    Is BCR PROB2B a:
    (1)  SOUND3 input file ?
    (2) SOUND32 input file ?
    WHICH ?>2

    Lane number to use ?>1

    Barrier number ?>3

    Enter list of receivers to use
    (seperated by commas)  (max. = 40)
    >3,4,8,9

    Got data

    Enter the max. receiver to truck distance you want calculated
    >1000

     18  Points calculated

    (1) = List in Barrier Order
    (2) = List in Receiver Order
    (3) = Quit
    >1

    Set paper at top of form & hit return >
```

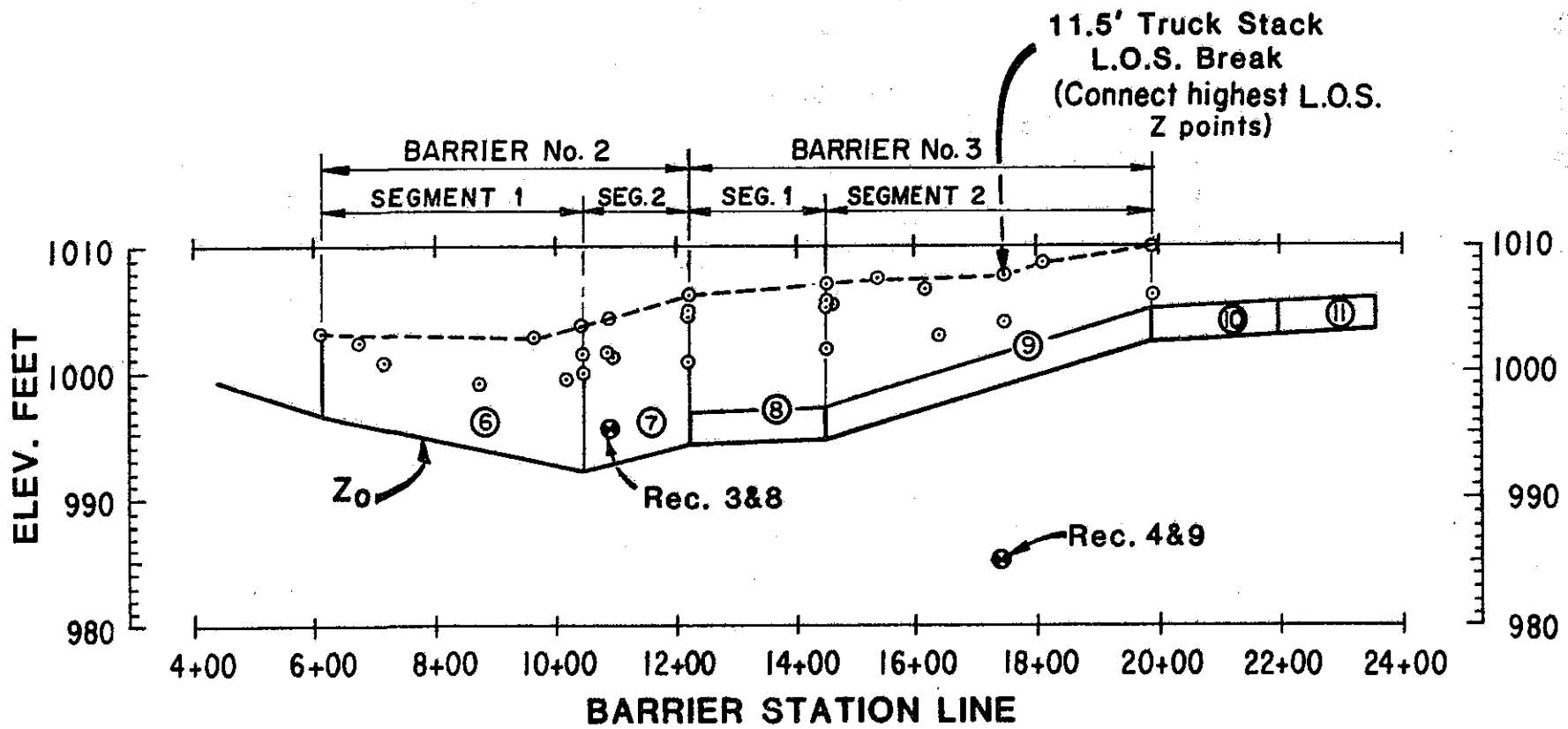
```
                 * 11.5' TRUCK STACK LINE-OF-SIGHT CALCULATIONS *

                                                                          Page 1
Input File-BCR PROB2B          Lane No.-1  Barrier No.-3  Max. DT-1000
Receiver(s)- 3  4  8  9
-------------------------------------------------------------------------------
          TRANSLAB DESIGN 1 - WITH 11.5 FT L.O.S. BREAK CONSTRAINT.
-------------------------------------------------------------------------------
     X        Y       ZO     Rec    DT    LOS Z  Height    BD   Desc.
-------------------------------------------------------------------------------
    Bar. Segment 1          |                                  |
   1309     1082    994.2   |  4    716   1000.9     6.7     0 | Bar. End 12+21WLL
   1309     1082    994.2   |  3    192   1004.4    10.2     0 | Bar. End 12+21WLL
   1309     1082    994.2   |  9    620   1004.7    10.5     0 | Bar. End 12+21WLL
   1309     1082    994.2   |  8    227   1006.1    11.9     0 | Bar. End 12+21WLL
   1537     1082    994.6   |  4    409   1001.9     7.3   229 | Bar. End 14+50WLL
   1537     1082    994.6   |  3    495   1005.4    10.8   229 | Bar. End 14+50WLL
   1537     1082    994.6   |  9    383   1005.7    11.1   229 | Bar. End 14+50WLL
   1537     1082    994.6   |  8    442   1007.1    12.5   229 | Bar. End 14+50WLL
    Bar. Segment 2          |                                  |
   1550     1082    994.8   |  3    512   1005.5    10.7    12 | Lane End
   1624     1082    995.8   |  8    535   1007.5    11.7    87 | Lane End
   1703     1082    997.0   |  9    241   1006.5     9.5   166 | Lane End
   1725     1082    997.3   |  4    166   1002.8     5.5   188 | Lane End
   1831     1082    998.8   |  4     82   1003.8     5.0   294 | Near Pt.
   1831     1082    998.8   |  9    193   1007.7     8.9   294 | Near Pt.
   1897     1082    999.8   |  3    987   1008.8     9.0   360 | Lane End
   2043     1082   1001.8   |  8    999*  1011.5     9.7   506 | Lane End
   2075     1082   1002.3   |  4    342   1006.1     3.8   538 | Bar. End 14+50WLL
   2075     1082   1002.3   |  9    336   1010.0     7.7   538 | Bar. End 14+50WLL
-------------------------------------------------------------------------------
   DT = Distance to Truck (from Rec.)
   BD = Barrier Distance (along Bar. from segment pt.)

   * THIS POINT WAS NOT USED, BECAUSE IT WAS ALMOST AT THE
     MAXIMUM RECEIVER TO TRUCK DISTANCE SET FOR 1000'.
```

```
(1) = List in Barrier Order
(2) = List in Receiver Order
(3) = Quit
>2
```

```
                    * 11.5' TRUCK STACK LINE-OF-SIGHT CALCULATIONS *

                                                                          Page 1
Input File-BCR PROB2B          Lane No.-1  Barrier No.-3  Max. DT-1000
Receiver(s)- 3  4  8  9
-------------------------------------------------------------------------------
          TRANSLAB DESIGN 1 - WITH 11.5 FT L.O.S. BREAK CONSTRAINT.
-------------------------------------------------------------------------------
     X        Y       ZO    Seg    DT   LOS Z  Height    BD   Desc.
-------------------------------------------------------------------------------
    Receiver 3             |                                  |
   1309     1082    994.2  |  1   192  1004.4    10.2     0  | Bar. End 12+21WLL
   1537     1082    994.6  |  1   495  1005.4    10.8   229  | Bar. End 14+50WLL
   1550     1082    994.8  |  2   512  1005.5    10.7    12  | Lane End
   1897     1082    999.8  |  2   987  1008.8     9.0   360  | Lane End
    Receiver 4             |                                  |
   1309     1082    994.2  |  1   716  1000.9     6.7     0  | Bar. End 12+21WLL
   1537     1082    994.6  |  1   409  1001.9     7.3   229  | Bar. End 14+50WLL
   1725     1082    997.3  |  2   166  1002.8     5.5   188  | Lane End
   1831     1082    998.8  |  2    82  1003.8     5.0   294  | Near Pt.
   2075     1082   1002.3  |  2   342  1006.1     3.8   538  | Bar. End 14+50WLL
    Receiver 8             |                                  |
   1309     1082    994.2  |  1   227  1006.1    11.9     0  | Bar. End 12+21WLL
   1537     1082    994.6  |  1   442  1007.1    12.5   229  | Bar. End 14+50WLL
   1624     1082    995.8  |  2   535  1007.5    11.7    87  | Lane End
   2043     1082   1001.8  |  2   999  1011.5     9.7   506  | Lane End
    Receiver 9             |                                  |
   1309     1082    994.2  |  1   620  1004.7    10.5     0  | Bar. End 12+21WLL
   1537     1082    994.6  |  1   383  1005.7    11.1   229  | Bar. End 14+50WLL
   1703     1082    997.0  |  2   241  1006.5     9.5   166  | Lane End
   1831     1082    998.8  |  2   193  1007.7     8.9   294  | Near Pt.
   2075     1082   1002.3  |  2   336  1010.0     7.7   538  | Bar. End 14+50WLL
-------------------------------------------------------------------------------
   DT = Distance to Truck (from Rec.)
   BD = Barrier Distance (along Bar. from segment pt.)



     (1) = List in Barrier Order
     (2) = List in Receiver Order
     (3) = Quit
     >3
R;

>
```

PROBLEM 2B

Plotting 11.5' Truck Stack
Line-of-sight (L.O.S.) Break
(Data from L.O.S. Program)



LEGEND

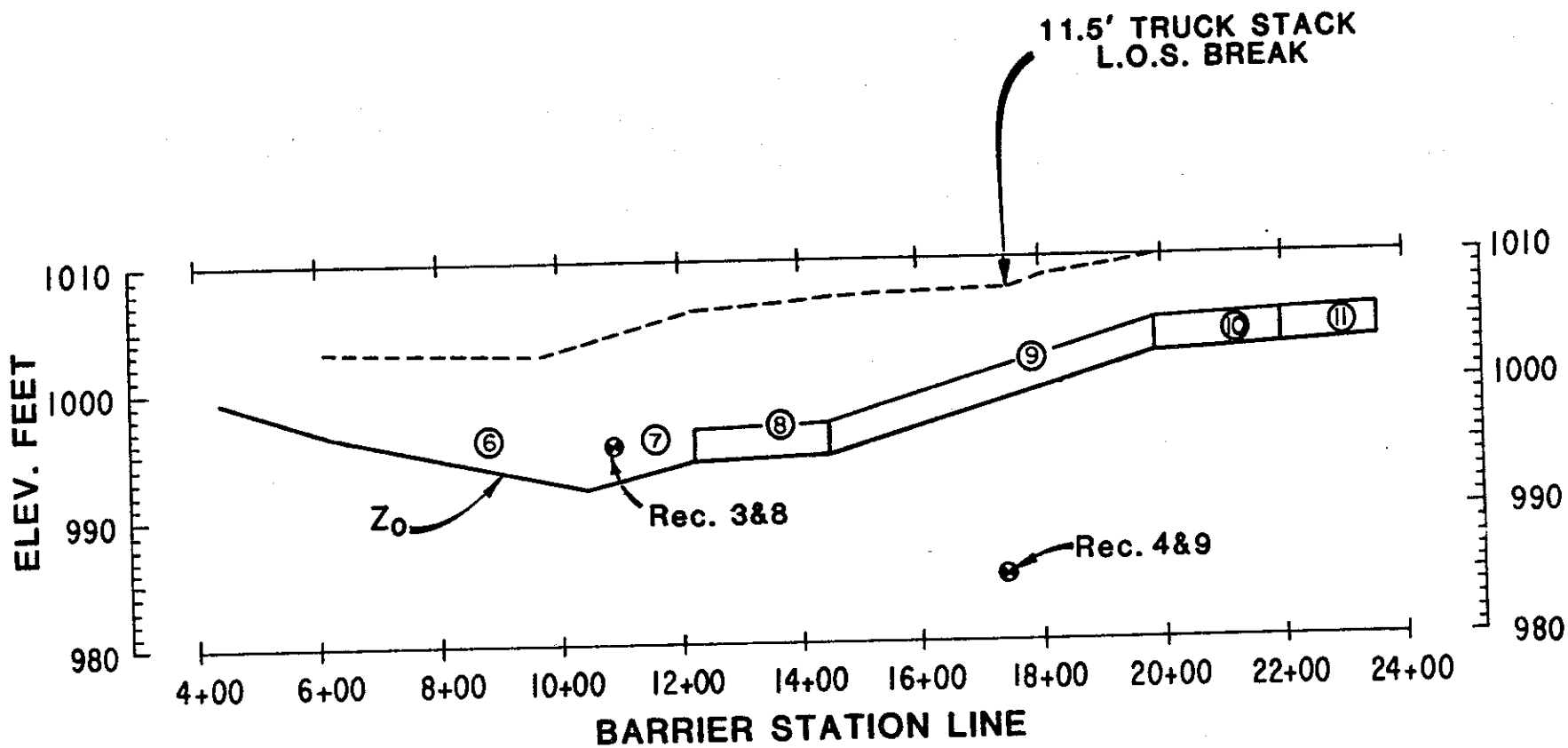
- ⑧ Barrier Element No.
- ⊗ Receiver Location and No.
- ⊙ L.O.S. Z Per "LOS" Program (Using input file for Problem 2B)

SCALE

Hor.: 100'
Vert.: 10'

PROBLEM 2

Work Sheet for Barrier Design



LEGEND

⑧ Barrier Element No.

⊗ Receiver Location and No.

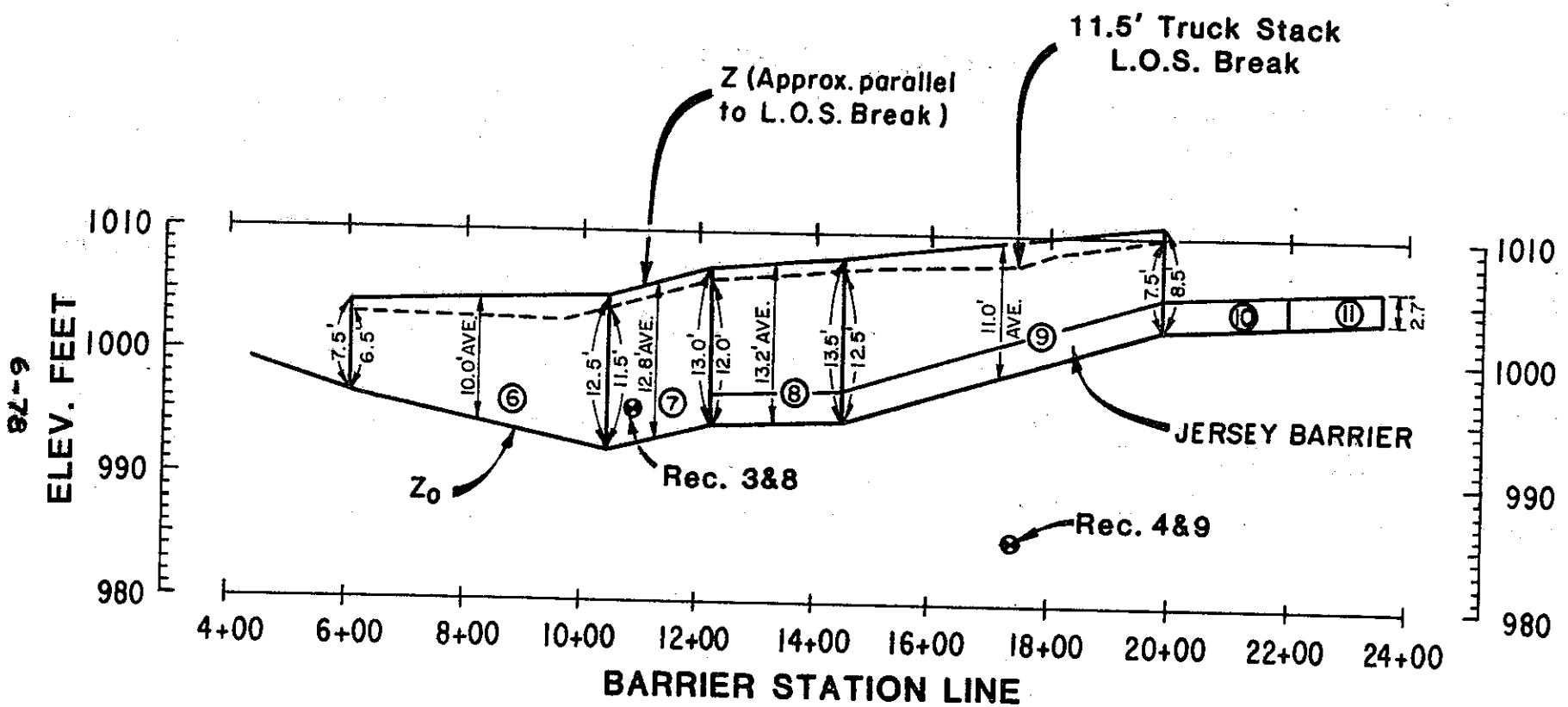
SCALE

Hor.: 100'

Vert.: 10'

PROBLEM 2B

Translab Design I - 11.5' L.O.S. Break
Initial Run



LEGEND

⑧ Barrier Element No.
⊗ Receiver Location and No.

SCALE

Hor.: 100'
Vert.: 10'

```
>RUN SOUNDSYS 2 BCR PROB2B

     **********************
     *      SOUNDSYS      *
     *      05-04-83      *
     **********************

    * * SOUND32 * *

     BCR PROB2B A Found
```

TRANSLAB DESIGN 1-WITH 11.5' L.O.S. BREAK CONSTRAINT.

```
R E S U L T S
***********************************

REC REC ID     DNL   PEOPLE    LEQ
-----------------------------------
 1  REC 1      67.       4.    64.0
 2  REC 2      67.      20.    65.5
 3  REC 3      67.      12.    62.8
 4  REC 4      67.      16.    60.0
 5  REC 5      67.       4.    59.3
 6  REC 6      67.       8.    60.4
 7  REC 7      67.       8.    59.1
 8  REC 8      67.      12.    62.4
 9  REC 9      67.      20.    60.5
-----------------------------------
```

Leq RESULTS FOR Z-HEIGHTS

```
BARRIER TYPE                  COST
-----------------------------------
BERM                            0.
MASONRY                     58370.
MASONRY/JERSEY             135308.
CONCRETE                        0.
-----------------------------------
       TOTAL COST = $      193679.
***********************************
```

COST OF Z-HEIGHT BARRIER

```
    ENTER MENU SELECTION
    (0 = PRINT MENU)
?
>5

          EFFECTIVENESS / COST RATIOS
          ***************************
BAR
ELE     0    1    2    3    4    5    6    7
-----------------------------------------------------------
  1     -   0.*                                   OR1+50
  2     -   0.*                                   OR4+21
  3     -   0.*                                   OR9+13
  4     -   0.*                                   HP16+00
  5     -   0.*                                   HP20+78

  6     -  31.  31.  31.  31.*  30.  28.  26.     6+16WALL
  7     -  38.  37.  35.  32.*  30.  30.  31.     10+48WLL

  8     -  29.  30.  27.  26.*  25.  26.  27.     12+21WLL
  9     -  35.  33.  31.  30.*  27.  24.  24.     14+50WLL

 10     -   0.*                                   19+88BAR
 11     -   0.*                                   21+99BAR
-----------------------------------------------------------
        0    1    2    3    4    5    6    7
```

E/C RATIOS FOR Z-HEIGHTS

DUE TO THE FACT THAT THE Z-HEIGHTS ARE CLOSE TO THE L.O.S. BREAK HEIGHT AND THE Leq RESULTS (PREVIOUS PAGE) WERE BELOW THE DNL OF 67dBA, THE E/C RATIOS CANNOT BE USED EFFECTIVELY IN THIS DESIGN.

```
    ENTER MENU SELECTION
    (0 = PRINT MENU)
?
>6


          BARRIER DATA
          ************

BAR                BARRIER HEIGHTS                    BAR
ELE    0    1    2    3    4    5    6    7          ID        LENGTH  TYPE
-----------------------------------------------------------------------------
 1     -   0.*                                       OR1+50     260.7  BERM
 2     -   0.*                                       OR4+21     476.6  BERM
 3     -   0.*                                       OR9+13     687.0  BERM
 4     -   0.*                                       HP16+00    478.0  BERM
 5     -   0.*                                       HP20+78    275.7  BERM

 6     -   7.   8.   9.  10.* 11.  12.  13.          6+16WALL   432.2  MASONRY
 7     -  10.  11.  12.  13.* 14.  15.  16.          10+48WLL   173.5  MASONRY

 8     -  10.  11.  12.  13.* 14.  15.  16.          12+21WLL   228.6  MASONRY/JERSEY
 9     -   8.   9.  10.  11.* 12.  13.  14.          14+50WLL   537.6  MASONRY/JERSEY

10     -   3.*                                       19+88BAR   211.5  MASONRY/JERSEY
11     -   3.*                                       21+99BAR   153.3  MASONRY/JERSEY
-----------------------------------------------------------------------------
       0    1    2    3    4    5    6    7
```

AVERAGE Z-HEIGHTS

```
    ENTER MENU SELECTION
    (0 = PRINT MENU)
?
>1

    ENTER BARRIER INDEX FOR EACH BARRIER ELEMENT
    (LIST DIRECTED)
?
>5*1,4*3,2*1
```

DROP Z-HEIGHTS 1-INCREMENT, TO APPROX. L.O.S. HEIGHT.
FIRST DESIGN

```
BARRIER HEIGHT INDEX FOR EACH BARRIER SECTION
  1  1  1  1  1  3  3  3  3  1  1
CORRESPONDING BARRIER HEIGHTS FOR EACH SECTION
 0. 0. 0. 0. 0. 9.12.12.10. 3. 3.

    ENTER MENU SELECTION
    (0 = PRINT MENU)
?
>7


R E S U L T S
************************************

REC REC ID    DNL  PEOPLE   LEQ
-----------------------------------
 1  REC 1     67.      4.   64.0
 2  REC 2     67.     20.   66.0
 3  REC 3     67.     12.   63.9
 4  REC 4     67.     16.   60.6
 5  REC 5     67.      4.   59.3
 6  REC 6     67.      8.   60.5
 7  REC 7     67.      8.   59.3
 8  REC 8     67.     12.   63.1
 9  REC 9     67.     20.   61.1
-----------------------------------
```

Leq RESULTS AT APPROXIMATE L.O.S. BREAK HEIGHTS.
FIRST DESIGN

BARRIER TYPE	COST
BERM	.0.
MASONRY	51705.
MASONRY/JERSEY	125974.
CONCRETE	0.

TOTAL COST = $ 177679. COST OF L.O.S. BREAK HEIGHT - BARRIER

****

ENTER MENU SELECTION
(0 = PRINT MENU)
?
>5

EFFECTIVENESS / COST RATIOS
****

BAR ELE	0	1	2	3	4	5	6	7	
1	-	0.*							OR1+50
2	-	0.*							OR4+21
3	-	0.*							OR9+13
4	-	0.*							HP16+00
5	-	0.*							HP20+78
6	-	28.	28.	28.*	27.	26.	23.	21.	6+16WALL
7	-	38.	37.	35.*	32.	30.	30.	31.	10+48WLL
8	-	29.	30.	27.*	26.	25.	26.	27.	12+21WLL
9	-	35.	33.	31.*	30.	27.	24.	24.	14+50WLL
10	-	0.*							19+88BAR
11	-	0.*							21+99BAR
	0	1	2	3	4	5	6	7	

E/C RATIOS AT APPROX. L.O.S. HEIGHTS.

ENTER MENU SELECTION
(0 = PRINT MENU)
?
>6

BARRIER DATA
****

BAR ELE	0	1	2	3	4	5	6	7	BAR ID	LENGTH	TYPE
		BARRIER HEIGHTS									
1	-	0.*							OR1+50	260.7	BERM
2	-	0.*							OR4+21	476.6	BERM
3	-	0.*							OR9+13	687.0	BERM
4	-	0.*							HP16+00	478.0	BERM
5	-	0.*							HP20+78	275.7	BERM
6	-	7.	8.	9.*	10.	11.	12.	13.	6+16WALL	432.2	MASONRY
7	-	10.	11.	12.*	13.	14.	15.	16.	10+48WLL	173.5	MASONRY
8	-	10.	11.	12.*	13.	14.	15.	16.	12+21WLL	228.6	MASONRY/JERSEY
9	-	8.	9.	10.*	11.	12.	13.	14.	14+50WLL	537.6	MASONRY/JERSEY
10	-	3.*							19+88BAR	211.5	MASONRY/JERSEY
11	-	3.*							21+99BAR	153.3	MASONRY/JERSEY
	0	1	2	3	4	5	6	7			

AVERAGE L.O.S. HEIGHTS

```
    ENTER MENU SELECTION
    (0 = PRINT MENU)
?
>1

    ENTER BARRIER INDEX FOR EACH BARRIER ELEMENT
    (LIST DIRECTED)
?    ← DROP BARRIER ELEMENT 6
>5*1,0,3*3,2*1    SECOND DESIGN

BARRIER HEIGHT INDEX FOR EACH BARRIER SECTION
  1  1  1  1  1  0  3  3  3  1  1
CORRESPONDING BARRIER HEIGHTS FOR EACH SECTION
 0. 0. 0. 0. 0. 0.12.12.10. 3. 3.

    ENTER MENU SELECTION
    (0 = PRINT MENU)
?
>7


R E S U L T S
************************************

REC REC ID     DNL  PEOPLE   LEQ
-----------------------------------
 1  REC 1      67.      4.   63.9
 2  REC 2      67.     20.   66.0
 3  REC 3      67.     12.   65.0
 4  REC 4      67.     16.   60.6
 5  REC 5      67.      4.   59.3
 6  REC 6      67.      8.   60.5
 7  REC 7      67.      8.   59.3
 8  REC 8      67.     12.   64.1
 9  REC 9      67.     20.   61.1
-----------------------------------

BARRIER TYPE                 COST
-----------------------------------
BERM                           0.
MASONRY                    17823.
MASONRY/JERSEY            125974.
CONCRETE                       0.
-----------------------------------
       TOTAL COST = $     143797.   ← OPTIMUM DESIGN
************************************
```

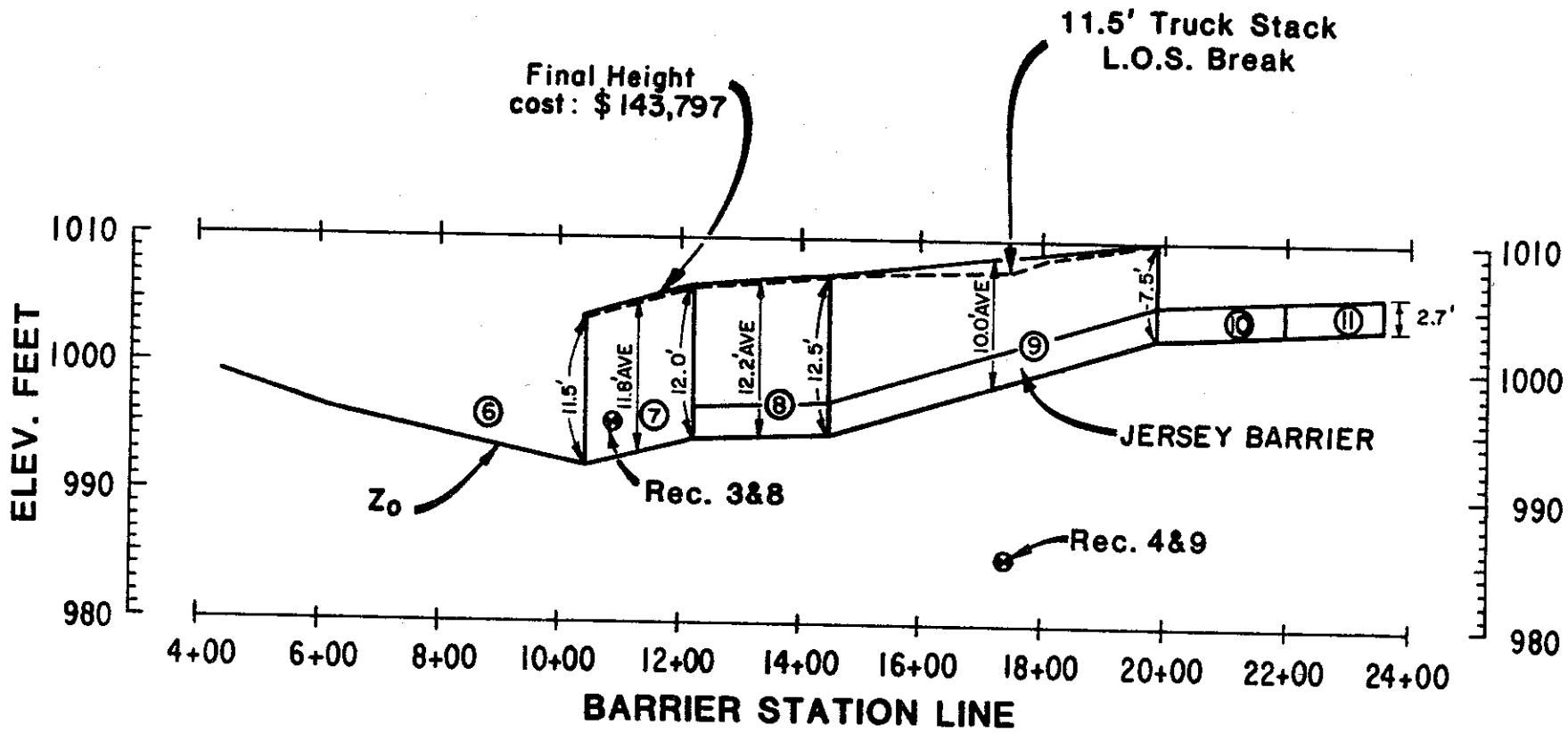
Leq RESULTS AT L.O.S. HEIGHTS, WITHOUT BARRIER ELEMENT 6. (SECOND DESIGN)

```
    ENTER MENU SELECTION
    (0 = PRINT MENU)
?
>5

          EFFECTIVENESS / COST RATIOS
          ***************************
BAR
ELE     0    1    2    3    4    5    6    7
-----------------------------------------------------------
  1     -   0.*                                  OR1+50
  2     -   0.*                                  OR4+21
  3     -   0.*                                  OR9+13
  4     -   0.*                                  HP16+00
  5     -   0.*                                  HP20+78

  6     -*  0.   0.   0.   0.   0.   0.   0.     6+16WALL
  7     -  38.  37.  35.* 32.  30.  30.  31.     10+48WLL

  8     -  29.  30.  27.* 26.  25.  26.  27.     12+21WLL
  9     -  35.  33.  31.* 30.  27.  24.  24.     14+50WLL

 10     -   0.*                                  19+88BAR
 11     -   0.*                                  21+99BAR
-----------------------------------------------------------
        0    1    2    3    4    5    6    7


    ENTER MENU SELECTION
    (0 = PRINT MENU)
?
>6


          BARRIER DATA
          ************

BAR                BARRIER HEIGHTS                  BAR
ELE     0    1    2    3    4    5    6    7        ID        LENGTH  TYPE
-----------------------------------------------------------------------------
  1     -   0.*                                    OR1+50     260.7  BERM
  2     -   0.*                                    OR4+21     476.6  BERM
  3     -   0.*                                    OR9+13     687.0  BERM
  4     -   0.*                                    HP16+00    478.0  BERM
  5     -   0.*                                    HP20+78    275.7  BERM

  6     -*  7.   8.   9.  10.  11.  12.  13.      6+16WALL   432.2  MASONRY
  7     -  10.  11.  12.* 13.  14.  15.  16.      10+48WLL   173.5  MASONRY

  8     -  10.  11.  12.* 13.  14.  15.  16.      12+21WLL   228.6  MASONRY/JERSEY
  9     -   8.   9.  10.* 11.  12.  13.  14.      14+50WLL   537.6  MASONRY/JERSEY

 10     -   3.*                                    19+88BAR   211.5  MASONRY/JERSEY
 11     -   3.*                                    21+99BAR   153.3  MASONRY/JERSEY
-----------------------------------------------------------------------------
        0    1    2    3    4    5    6    7
```

```
    ENTER MENU SELECTION
    (0 = PRINT MENU)
?
>1

    ENTER BARRIER INDEX FOR EACH BARRIER ELEMENT
    (LIST DIRECTED)
?                                  DROP BARRIER ELEMENTS 6 and 9
>5*1,0,2*3,0,2*1                   (THIRD DESIGN)

BARRIER HEIGHT INDEX FOR EACH BARRIER SECTION
  1  1  1  1  1  0  3  3  0  1  1
CORRESPONDING BARRIER HEIGHTS FOR EACH SECTION
 0. 0. 0. 0. 0. 0.12.12. 0. 3. 3.

    ENTER MENU SELECTION
    (0 = PRINT MENU)
?
>7.


R E S U L T S
************************************

REC REC ID     DNL  PEOPLE   LEQ
---------------------------------
 1  REC 1      67.      4.   63.9
 2  REC 2      67.     20.   66.0
 3  REC 3      67.     12.   65.0
 4  REC 4      67.     16.   68.3   Leq above DNL of 67 dBA.
 5  REC 5      67.      4.   60.4
 6  REC 6      67.      8.   61.6
 7  REC 7      67.      8.   60.3
 8  REC 8      67.     12.   64.2
 9  REC 9      67.     20.   64.6
---------------------------------

BARRIER TYPE                COST
---------------------------------
BERM                          0.
MASONRY                   17823.
MASONRY/JERSEY            58236.
CONCRETE                      0.
---------------------------------
       TOTAL COST = $     76059.
************************************


    ENTER MENU SELECTION
    (0 = PRINT MENU)
?
>8
R;

>
```

PROBLEM 2B

Translab Design 1 - 11.5' L.O.S. Break
Final Design



LEGEND

⑧ Barrier Element No.
● Receiver Location and No.

SCALE

Hor.: 100'
Vert.: 10'

Page No._____of_____

CALIFORNIA DEPARTMENT OF TRANSPORTATION

INPUT DATA SHEET FOR SOUND32

Caltrans Version of FHWA Level 2
Noise Prediction and Barrier Design Model
(Based on STAMINA2.0 & OPTIMA programs)

Dist._____ Co._____ Rte_____ P.M._____ Location:_____
Charge:_____ E.A./Spec.Des:_____
Data Prepared by:_____ Date:_____ Checked by:_____ Date_____
File Name & Type: BCR PROB2C Account:_____ Code:_____

TITLE: TRANSLAB DESIGN 2 - NO 11.5' LOS CONSTRAINT- MIN. H=6'

SHEET-B - BARRIER DATA

(Max. 20 Barriers of 1 to 10 segments each)

BARR.(B) NO.	TYPE MATERIAL*	DELZ	P (MAX 3)	COORDINATES X	Y	Zo	Z	DESCRIP. (Max. 8 CHARACTERS)
B,1	1	0	0	281	1232	1012	1012	OR1+50
				529	1152	1004	1004	OR4+21
				1000	1080	994	994	OR9+13
				1687	1079	996.5	996.5	HP16+00
				2165	1079	1001	1001	HP20+78
				2440	1099	1003	1003	HP23+65
B,2	2	1	3	707.9	1158.4	996.5	1005.5	6+16 WALL
				1137.0	1107.0	992.1	1001.1	10+98 WLL
				1308.6	1081.8	994.2	1003.2	12+21 WLL
B,3	3	1	3	1308.6	1081.8	994.2	1003.2	12+21 WLL
				1537.2	1081.8	994.6	1003.6	14+50 WLL
				2074.8	1081.8	1002.3	1011.3	19+88 WLL
B,4	3	0	0	2074.8	1081.8	1002.3	1005.0	19+88 BAR
				2286.1	1090.0	1002.9	1005.6	21+99 BAR
				2438.7	1104.7	1003.3	1006.0	23+53 BAR

*Material Codes (used for Cost Factors)

1 = Earth Berms
2 = Masonry
3 = Masonry On 2.7' High Jersey Barrier (Type 27)
4 = Concrete (cast in place)
5 = Prefab Conc. Panels
6 = Steel
7 = Wood

FOR STRUCTURE BARRIERS ONLY:

Bar.No.	LANE NO.'s AFFECTED

For Structure Barriers add 90; e.g. 94 = conc. bar on Structure

RWH 4/83

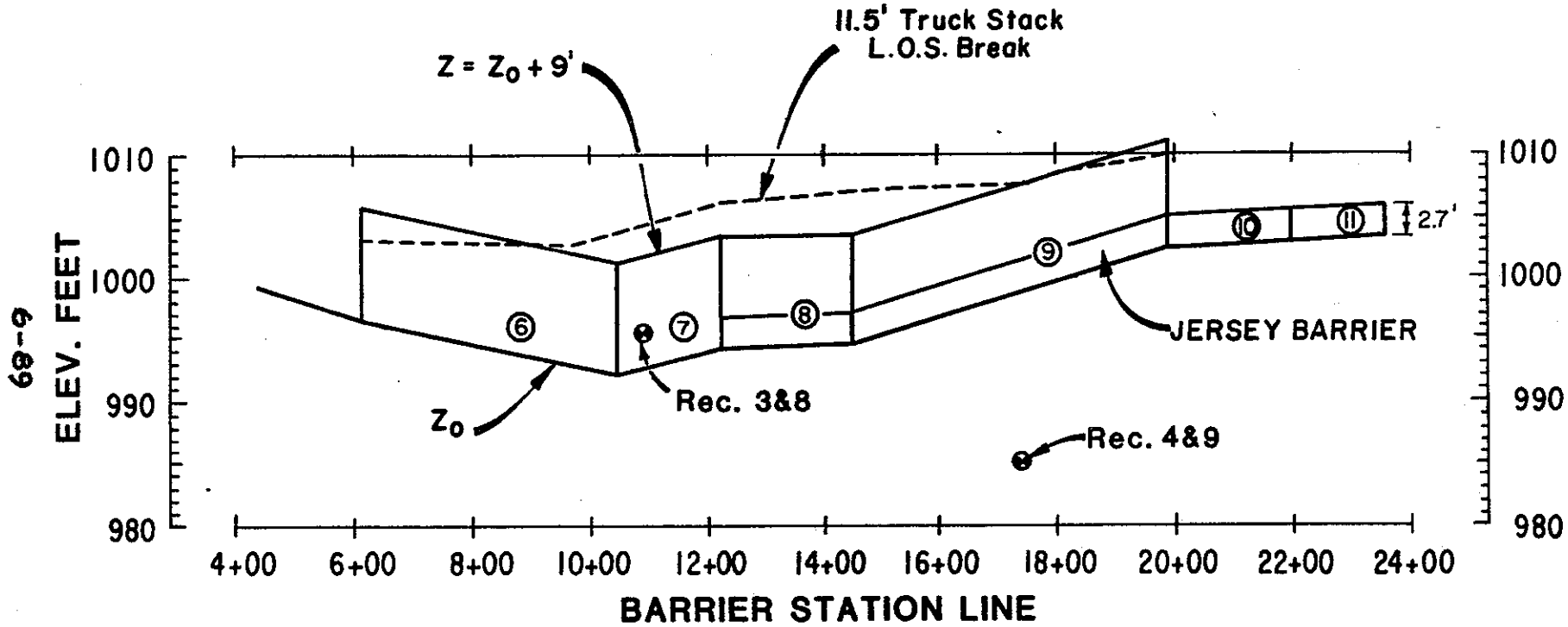
INPUT FILE (IN'WAR')
BCR PROB2C

```
00010 TRANSLAB DESIGN 2 - NO 11.5 FT L.O.S. BREAK CONSTRAINT- 6FT MIN HEIGHT.
00020 T,1
00030 940,50,111,50,158,50
00040 T,2
00050 1042,55,79,55,88,55
00060 T,3
00070 1025,55,28,55,0,55
00080 T,4
00090 429,55,0,55,0,55
00100 T,5
00110 1850,55,118,55,132,55
00120 L,1
00130 N,260.5,1154.5,997.3,STA 1+50 W/B LANE 1(SLOW)
00140 N,520.3,1099.3,994.9,STA 4+21POC
00150 N,1000.0,1060.0,994.6,STA 9+13EC
00160 N,1687.2,1060.0,997.7,STA 16+00POT
00170 N,2165.3,1060.0,1002.3,STA 20+78BC
00180 N,2442.3,1080.0,1004.9,STA 23+65POC
00190 3059.9,1209.2,1004.1,STA 30+00 W/B LANE 1(SLOW)
00200 L,2
00210 N,257.5,1143.0,997.5,STA 1+50 W/B LANE 2
00220 N,518.3,1087.5,995.4,STA 4+21POC
00230 N,1000.0,1048.0,994.8,STA 9+13EC
00240 N,1687.2,1048.0,997.9,STA 16+00POT
00250 N,2165.3,1048.0,1002.9,STA20+78BC
00260 N,2444.0,1068.1,1005.9,STA23+65POC
00270 3062.4,1197.5,1004.4,STA 30+00 W/B LANE 2
00280 L,3
00290 N,254.5,1131.5,997.7,STA 1+50 W/B LANE 3
00300 N,516.4,1075.7,995.9,STA 4+21POC
00310 N,1000.0,1036.0,994.9,9+13EC
00320 N,1687.2,1036.0,998.0,STA 16+00POT
00330 N,2165.3,1036.0,1003.7,STA 20+78BC
00340 N,2445.7,1056.2,1006.9,STA 23+65POC
00350 3065.0,1185.8,1004.6,STA 30+00 W/B LANE 3
00360 L,4
00370 N,251.5,1120.0,997.9,STA 1+50 W/B LANE 4
00380 N,514.4,1063.9,996.4,STA 4+21POC
00390 N,1000.0,1024.0,995.1,STA 9+13EC
00400 N,1687.2,1024.00,998.2,STA 16+00POT
00410 N,2165.3,1024.0,1004.4,STA 20+78BC
00420 N,2447.4,1044.3,1007.8,STA 23+65POC
00430 3067.5,1174.1,1004.9,STA 30+00 W/B LANE 4
00440 L,5
00450 N,235.0,1036.0,997.6,STA 1+50 CL E/B LANES (LANE 5)
00460 N,503.6,998.8,997.1,STA 4+21POC
00470 N,1000.0,958.0,995.1,STA 9+13EC
00480 N,1687.2,958.0,998.3,STA 16+00POT
00490 N,2165.3,958.0,1006.6,STA 20+78BC
00500 N,2456.8,978.9,1013.0,STA 23+65POC
00510 3081.5,1109.6,1004.5,STA 30+00 CL E/B LANES (LANE 5)
00520 B,1,1,0,0
00530 281,1232,1012,1012,OR1+50
00540 529,1152,1004,1004,OR4+21
00550 1000,1080,994,994,OR9+13
00560 1687,1079,996.5,996.5,HP16+00
00570 2165,1079,1001,1001,HP20+78
00580 2440,1099,1003,1003,HP23+65
00590 R,1,67,4
```

```
00600 515,1314,1005,REC 1
00610 R,2,67,20
00620 726,1214,1001,REC 2
00630 R,3,67,12
00640 1182,1140,995.5,REC 3
00650 R,4,67,16
00660 1831,1142,985,REC 4
00670 R,5,67,4
00680 2135,1148,978,REC 5
00690 R,6,67,8
00700 2153,1186,978,REC 6
00710 R,7,67,8
00720 2147,1304,978,REC 7
00730 R,8,67,12
00740 1182,1235,995.5,REC 8
00750 R,9,67,20
00760 1831,1253,985,REC 9
00770 D,4.5
00780 A,1,2
00790 B,2,2,1,3
00800 707.9,1158.4,996.5,1005.5,6+16WALL
00810 1137.0,1107.0,992.1,1001.1,10+48WLL
00820 1308.6,1081.8,994.2,1003.2,12+21WLL
00830 B,3,3,1,3
00840 1308.6,1081.8,994.2,1003.2,12+21WLL
00850 1537.2,1081.8,994.6,1003.6,14+50WLL
00860 2074.8,1081.8,1002.3,1011.3,19+88WAL
00870 B,4,3,0,0
00880 2074.8,1081.8,1002.3,1005.0,19+88BAR
00890 2286.1,1090.0,1002.9,1005.6,21+99BAR
00900 2438.7,1104.7,1003.3,1006.0,23+53BAR
00910 K,-1
00920 A,1
00930 K,-3
00940 A,2
00950 K,-4
00960 A,3,4,8,9
00970 K,-7
00980 A,5,6,7
00990 C
>
```

PROBLEM 2C

Translab Design 2 - Without 11.5' L.O.S. Break
Initial Run



LEGEND

⑧ Barrier Element No.
⊗ Receiver Location and No.

SCALE

Hor.: 100'
Vert.: 10'

```
SOUNDSYS 2

    **********************
    *      SOUNDSYS      *
    *      05-04-83      *
    **********************

   * * SOUND32 * *


    Enter Input FILE NAME >BCR*PROB2C

    BCR PROB2C A Found


    Barrier Cost file = CALIF BAR$
    CALIFORNIA BARRIER COST (IN 1980 DOLLARS)
    Valid Barrier types
     1  - 91    BERM
     2  - 92    MASONRY
     3  - 93    MASONRY/JERSEY
     4  - 94    CONCRETE


    1)  Change Barrier Cost file
    2)  List data as processed (Now Off)
    3)  Abort run
    4)  Go
         WHICH >1
    Enter Barrier Cost file >FHWA BAR$

    FHWA BAR$ A Found

    Barrier Cost file = FHWA BAR$ A
    COST DATA FROM LATEST VERSION OF BCR FROM FHWA
    Valid Barrier types
     1  - 91    BERM
     2  - 92    MASONRY
     3  - 93    WOOD
     4  - 94    CONCRETE
     5  - 95    STEEL


    1)  Change Barrier Cost file
    2)  List data as processed (Now Off)
    3)  Abort run
    4)  Go
         WHICH >3

    PROCESSING HALTED
R;
>
```

TRANSLAB DESIGN2
NO 11.5 FT L.O.S. BREAK
CONSTRAINT 6 FT. MIN. H
EXAMPLE OF COST FILE
CHANGE.

```
RUN SOUNDSYS

     **********************
     *      SOUNDSYS      *
     *      05-04-83      *
     **********************

     (1) = RUN SOUND3
     (2) = RUN SOUND32
     (3) = RUN LOS

     WHIT? ?
>2 BCR PROB2C

    * * SOUND32 * *

     BCR PROB2C A Found

EXECUTION BEGINS...


R E S U L T S
**********************************

REC REC ID    DNL  PEOPLE   LEQ
-------------------------------
 1  REC 1     67.      4.   64.0
 2  REC 2     67.     20.   65.2
 3  REC 3     67.     12.   66.6
 4  REC 4     67.     16.   62.1
 5  REC 5     67.      4.   60.8
 6  REC 6     67.      8.   61.9
 7  REC 7     67.      8.   61.6
 8  REC 8     67.     12.   64.6
 9  REC 9     67.     20.   63.2
-------------------------------

BARRIER TYPE                COST
-------------------------------
BERM                          0.
MASONRY                   47482.
MASONRY/JERSEY           114151.
CONCRETE                      0.
-------------------------------
       TOTAL COST = $    161634.
**********************************


    ENTER MENU SELECTION
    (0 = PRINT MENU)
?

>0

     0).....PRINT MENU
     1).....CHANGE BARRIER HEIGHT INDEX
     2).....CHANGE BARRIER TYPES
     3).....CHANGE PEOPLE PER RECEIVER
     4).....CHANGE DESIGN NOISE LEVELS
     5).....PRINT E/C RATIOS
     6).....PRINT BARRIER HEIGHT INDEX
     7).....PRINT LEQS
     8).....STOP
```

TRANSLAB DESIGN 2 - WITHOUT 11.5' L.O.S. BREAK CONSTRAINT - MINIMUM H = 6'

Leq RESULTS FOR 2-HEIGHTS

COST OF 2-HEIGHT BARRIER

```
ENTER MENU SELECTION
(0 = PRINT MENU)
?
>5

        EFFECTIVENESS / COST RATIOS
        ***************************
BAR
ELE    0    1    2    3    4    5    6    7
-----------------------------------------------------------
  1    -   0.*                                   OR1+50
  2    -   0.*                                   OR4+21
  3    -   0.*                                   OR9+13
  4    -   0.*                                   HP16+00
  5    -   0.*                                   HP20+78

  6    -  35.   34.   34.   34.*  33.   32.   32.   6+16WALL
  7    -  41.   39.   39.   38.*  38.   37.   36.   10+48WLL

  8    -  33.   31.   29.   29.*  29.   29.   29.   12+21WLL
  9    -  37.   34.   33.   32.*  31.   30.   29.   14+50WLL

 10    -   0.*                                   19+88BAR
 11    -   0.*                                   21+99BAR
-----------------------------------------------------------
       0    1    2    3    4    5    6    7
```

E/C RATIOS FOR Z-HEIGHTS

INITIAL PATH CHOSEN FOR FIRST DESIGN (BASED ON NEARLY EQUAL E/C RATIOS AND Leq RESULTS FOR Z-HEIGHTS)

```
ENTER MENU SELECTION
(0 = PRINT MENU)
?
>6

        BARRIER DATA
        ************
BAR                BARRIER HEIGHTS                  BAR
ELE    0    1    2    3    4    5    6    7         ID        LENGTH  TYPE
-----------------------------------------------------------------------------
 1     -   0.*                                     OR1+50     260.7   BERM
 2     -   0.*                                     OR4+21     476.6   BERM

 3     -   0.*                                     OR9+13     687.0   BERM
 4     -   0.*                                     HP16+00    478.0   BERM
 5     -   0.*                                     HP20+78    275.7   BERM

 6     -   6.    7.    8.    9.*  10.   11.   12.   6+16WALL   432.2   MASONRY
 7     -   6.    7.    8.    9.*  10.   11.   12.   10+48WLL   173.5   MASONRY

 8     -   6.    7.    8.    9.*  10.   11.   12.   12+21WLL   228.6   MASONRY/JERSEY
 9     -   6.    7.    8.    9.*  10.   11.   12.   14+50WLL   537.7   MASONRY/JERSEY

10     -   3.*                                     19+88BAR   211.5   MASONRY/JERSEY
11     -   3.*                                     21+99BAR   153.3   MASONRY/JERSEY
-----------------------------------------------------------------------------
       0    1    2    3    4    5    6    7
```

Z-HEIGHTS

```
    ENTER MENU SELECTION
    (0 = PRINT MENU)
?
>1

    ENTER BARRIER INDEX FOR EACH BARRIER ELEMENT
    (LIST DIRECTED)
?
>6*1,7,4*1      FIRST DESIGN

BARRIER HEIGHT INDEX FOR EACH BARRIER SECTION
  1  1  1  1  1  1  7  1  1  1  1
CORRESPONDING BARRIER HEIGHTS FOR EACH SECTION
 0. 0. 0. 0. 0. 6.12. 6. 6. 3. 3.

    ENTER MENU SELECTION
    (0 = PRINT MENU)
?
>7


R E S U L T S
***********************************

REC REC ID     DNL   [illegible]FLE   LEQ
-------------------------------------
 1  REC 1      67.       4.    64.0
 2  REC 2      67.      20.    66.0
 3  REC 3      67.      12.    66.6
 4  REC 4      67.      16.    64.4   Leq RESULTS FOR FIRST DESIGN
 5  REC 5      67.       4.    61.0
 6  REC 6      67.       8.    62.2
 7  REC 7      67.       8.    62.0
 8  REC 8      67.      12.    66.3
 9  REC 9      67.      20.    64.4
-------------------------------------

BARRIER TYPE                  COST
-------------------------------------
 BERM                            0.
 MASONRY                     40946.
 MASONRY/JERSEY              94382.
 CONCRETE                        0.
-------------------------------------
        TOTAL COST = $     135328.   COST OF FIRST DESIGN
***********************************


    ENTER MENU SELECTION
    (0 = PRINT MENU)
?
>5


          EFFECTIVENESS / COST RATIOS
          ***************************
BAR
ELE     0     1     2     3     4     5     6     7
-----------------------------------------------------------
  1     -    0.*                                      OR1+50
  2     -    0.*                                      OR4+21
  3     -    0.*                                      OR9+13
  4     -    0.*                                      HP16+00
  5     -    0.*                                      HP20+78

  6     -    0.*  0.    0.    0.    0.    0.    0.    6+16WALL  ← "0" E/C RATIOS
  7     -   41.   39.   39.   38.   38.   37.   36.*   10+48WLL   INDICATE WALL
                                                                 AT 6' HEIGHT,
  8     -   30.*  29.   26.   25.   26.   27.   27.    12+21WLL   (INDEX NO. 1) IS
  9     -   37.*  33.   33.   32.   30.   29.   28.    14+50WLL   LESS EFFECTIVE
                                                                 THAN EXISTING
 10     -    0.*                                      19+88BAR   BERM.
 11     -    0.*                                      21+99BAR
-----------------------------------------------------------
        0     1     2     3     4     5     6     7
```

```
    ENTER MENU SELECTION
    (0 = PRINT MENU)
?
>6


          BARRIER DATA
          ************

BAR                BARRIER HEIGHTS                    BAR
ELE    0    1    2    3    4    5    6    7          ID        LENGTH  TYPE
-----------------------------------------------------------------------------
 1     -   0.*                                       OR1+50     260.7   BERM
 2     -   0.*                                       OR4+21     476.6   BERM
 3     -   0.*                                       OR9+13     687.0   BERM
 4     -   0.*                                       HP16+00    478.0   BERM
 5     -   0.*                                       HP20+78    275.7   BERM

 6     -   6.*  7.   8.   9.  10.  11.  12.          6+16WALL   432.2   MASONRY

 7     -   6.   7.   8.   9.  10.  11.  12.*         10+48WLL   173.5   MASONRY

 8     -   6.*  7.   8.   9.  10.  11.  12.          12+21WLL   228.6   MASONRY/JERSEY
 9     -   6.*  7.   8.   9.  10.  11.  12.          14+50WLL   537.7   MASONRY/JERSEY

10     -   3.*                                       19+88BAR   211.5   MASONRY/JERSEY
11     -   3.*                                       21+99BAR   153.3   MASONRY/JERSEY
-----------------------------------------------------------------------------
       0    1    2    3    4    5    6    7


    ENTER MENU SELECTION
    (0 = PRINT MENU)
?
>1

    ENTER BARRIER INDEX FOR EACH BARRIER ELEMENT
    (LIST DIRECTED)
?      ← Drop Barrier Element 6 (second Design)
>5*1,0,7,4*1

BARRIER HEIGHT INDEX FOR EACH BARRIER SECTION
  1  1  1  1  1  0  7  1  1  1  1
CORRESPONDING BARRIER HEIGHTS FOR EACH SECTION
 0. 0. 0. 0. 0. 0.12. 6. 6. 3. 3.

    ENTER MENU SELECTION
    (0 = PRINT MENU)
?
>7
```

```
R E S U L T S
**********************************

REC REC ID     DNL  PEOPLE   LEQ
-------------------------------
 1  REC 1      67.      4.   63.9
 2  REC 2      67.     20.   66.0
 3  REC 3      67.     12.   66.6
 4  REC 4      67.     16.   64.4
 5  REC 5      67.      4.   61.0
 6  REC 6      67.      8.   62.2
 7  REC 7      67.      8.   62.0
 8  REC 8      67.     12.   66.3
 9  REC 9      67.     20.   64.4
-------------------------------
```

Leq RESULTS OF SECOND DESIGN

```
BARRIER TYPE                COST
-------------------------------
BERM                          0.
MASONRY                   18213.
MASONRY/JERSEY            94382.
CONCRETE                      0.
-------------------------------
       TOTAL COST = $    112595.
```

COST OF SECOND DESIGN

```
**********************************


    ENTER MENU SELECTION
    (0 = PRINT MENU)
?
>5


          EFFECTIVENESS / COST RATIOS
          ***************************
BAR
ELE    0    1    2    3    4    5    6    7
-----------------------------------------------
  1    -   0.*                                  OR1+50
  2    -   0.*                                  OR4+21
  3    -   0.*                                  OR9+13
  4    -   0.*                                  HP16+00
  5    -   0.*                                  HP20+78

  6    -*  0.   0.   0.   0.   0.   0.   0.     6+16WALL
  7    -  41.  39.  39.  38.  38.  37.  36.*    10+48WLL

  8    -  30.* 29.  26.  25.  26.  27.  27.     12+21WLL
  9    -  37.* 33.  33.  32.  30.  29.  28.     14+50WLL

 10    -   0.*                                  19+88BAR
 11    -   0.*                                  21+99BAR
-----------------------------------------------
       0    1    2    3    4    5    6    7
```

```
    ENTER MENU SELECTION
    (0 = PRINT MENU)
?
>6


        BARRIER DATA
        ************

BAR                BARRIER HEIGHTS                    BAR
ELE    0    1    2    3    4    5    6    7          ID        LENGTH  TYPE
-------------------------------------------------------------------------------
 1     -   0.*                                       OR1+50     260.7  BERM
 2     -   0.*                                       OR4+21     476.6  BERM
 3     -   0.*                                       OR9+13     687.0  BERM
 4     -   0.*                                       HP16+00    478.0  BERM
 5     -   0.*                                       HP20+78    275.7  BERM

 6     -*  6.   7.   8.   9.  10.  11.  12.          6+16WALL   432.2  MASONRY
 7     -   6.   7.   8.   9.  10.  11.  12.*         10+48WLL   173.5  MASONRY

 8     -   6.*  7.   8.   9.  10.  11.  12.          12+21WLL   228.6  MASONRY/JERSEY
 9     -   6.*  7.   8.   9.  10.  11.  12.          14+50WLL   537.7  MASONRY/JERSEY

10     -   3.*                                       19+88BAR   211.5  MASONRY/JERSEY
11     -   3.*                                       21+99BAR   153.3  MASONRY/JERSEY
-------------------------------------------------------------------------------
       0    1    2    3    4    5    6    7


    ENTER MENU SELECTION
    (0 = PRINT MENU)
?
>1

    ENTER BARRIER INDEX FOR EACH BARRIER ELEMENT
    (LIST DIRECTED)
?
>5*1,0,6,4*1
```

Lower Barrier element 7 by increment (1 ft) (Third design)

```
BARRIER HEIGHT INDEX FOR EACH BARRIER SECTION
  1  1  1  1  1  0  6  1  1  1  1
CORRESPONDING BARRIER HEIGHTS FOR EACH SECTION
 0. 0. 0. 0. 0. 0.11. 6. 6. 3. 3.

    ENTER MENU SELECTION
    (0 = PRINT MENU)
?
>7


 R E S U L T S
 ***********************************

REC REC ID     DNL   PEOPLE    LEQ
-------------------------------------
 1  REC 1      67.       4.    63.9
 2  REC 2      67.      20.    66.0
 3  REC 3      67.      12.    66.9
 4  REC 4      67.      16.    64.4
 5  REC 5      67.       4.    61.0
 6  REC 6      67.       8.    62.2
 7  REC 7      67.       8.    62.0
 8  REC 8      67.      12.    66.4
 9  REC 9      67.      20.    64.4
-------------------------------------
```

Leq RESULTS OF THIRD DESIGN

BARRIER TYPE	COST
BERM	0.
MASONRY	16652.
MASONRY/JERSEY	94382.
CONCRETE	0.

TOTAL COST = $ 111034.

COST OF THIRD DESIGN

****

ENTER MENU SELECTION

(0 = PRINT MENU)

?
>5

EFFECTIVENESS / COST RATIOS
****

BAR ELE	0	1	2	3	4	5	6	7	
1	-	0.*							OR1+50
2	-	0.*							OR4+21
3	-	0.*							OR9+13
4	-	0.*							HP16+00
5	-	0.*							HP20+78
6	-*	0.	0.	0.	0.	0.	0.	0.	6+16WALL
7	-	41.	39.	39.	38.	38.	37.*	36.	10+48WLL
8	-	30.*	29.	26.	25.	26.	27.	27.	12+21WLL
9	-	37.*	33.	33.	32.	30.	29.	28.	14+50WLL
10	-	0.*							19+88BAR
11	-	0.*							21+99BAR
	0	1	2	3	4	5	6	7	

ENTER MENU SELECTION

(0 = PRINT MENU)

?
>6

BARRIER DATA
****

BAR ELE	0	1	2	3	4	5	6	7	BAR ID	LENGTH	TYPE
		BARRIER HEIGHTS									
1	-	0.*							OR1+50	260.7	BERM
2	-	0.*							OR4+21	476.6	BERM
3	-	0.*							OR9+13	687.0	BERM
4	-	0.*							HP16+00	478.0	BERM
5	-	0.*							HP20+78	275.7	BERM
6	-*	6.	7.	8.	9.	10.	11.	12.	6+16WALL	432.2	MASONRY
7	-	6.	7.	8.	9.	10.	11.*	12.	10+48WLL	173.5	MASONRY
8	-	6.*	7.	8.	9.	10.	11.	12.	12+21WLL	228.6	MASONRY/JERSEY
9	-	6.*	7.	8.	9.	10.	11.	12.	14+50WLL	537.7	MASONRY/JERSEY
10	-	3.*							19+88BAR	211.5	MASONRY/JERSEY
11	-	3.*							21+99BAR	153.3	MASONRY/JERSEY
	0	1	2	3	4	5	6	7			

```
    ENTER MENU SELECTION
    (0 = PRINT MENU)
?
>1

    ENTER BARRIER INDEX FOR EACH BARRIER ELEMENT
    (LIST DIRECTED)
?
>5*1,0,5,4*1
```

Lower Barrier Element 7 By 1 Increment (1ft) (Fourth Design)

```
BARRIER HEIGHT INDEX FOR EACH BARRIER SECTION
  1  1  1  1  1  0  5  1  1  1  1
CORRESPONDING BARRIER HEIGHTS FOR EACH SECTION
 0. 0. 0. 0. 0. 0.10. 6. 6. 3. 3.

    ENTER MENU SELECTION
    (0 = PRINT MENU)
?
>7


R E S U L T S
**********************************
```

REC	REC ID	DNL	PEOPLE	LEQ
1	REC 1	67.	4.	63.9
2	REC 2	67.	20.	66.0
3	REC 3	67.	12.	67.4
4	REC 4	67.	16.	64.4
5	REC 5	67.	4.	61.1
6	REC 6	67.	8.	62.2
7	REC 7	67.	8.	62.0
8	REC 8	67.	12.	66.6
9	REC 9	67.	20.	64.4

Receiver 3 over DNL of 67dBA

Leq RESULTS OF FOURTH DESIGN

BARRIER TYPE	COST
BERM	0.
MASONRY	15090.
MASONRY/JERSEY	94382.
CONCRETE	0.

```
        TOTAL COST = $   109473.
**********************************
```

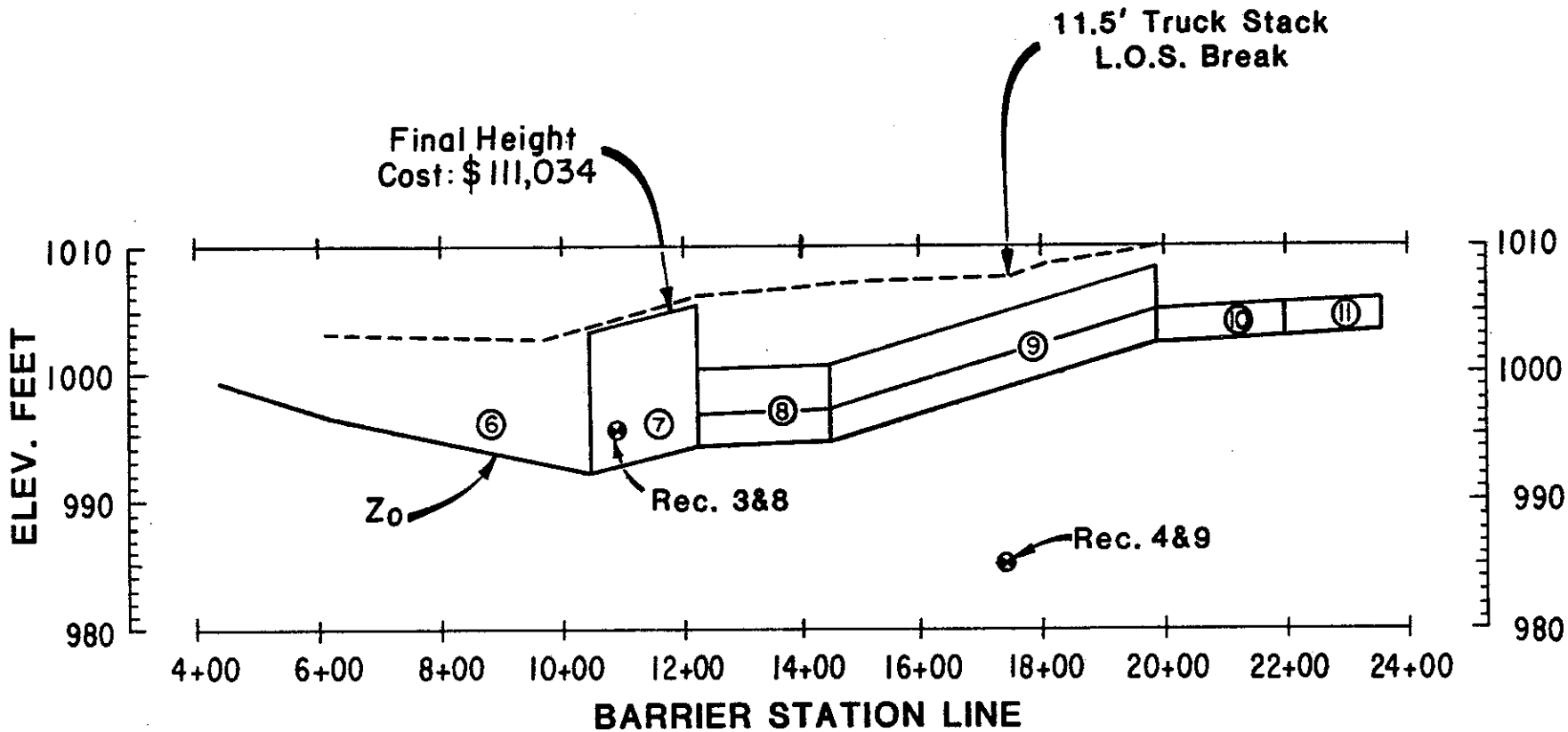
COST OF FOURTH DESIGN.

```
    ENTER MENU SELECTION
    (0 = PRINT MENU)
?
>8
R:
```

CHOOSE THIRD DESIGN AS OPTIMUM

PROBLEM 2C

Translab Design 2 - Without 11.5' L.O.S. Break
Final Design



LEGEND

⑧ Barrier Element No.
⊗ Receiver Location and No.

SCALE

Hor.: 100'
Vert.: 10'

PROBLEM 2A, 2B & 2C

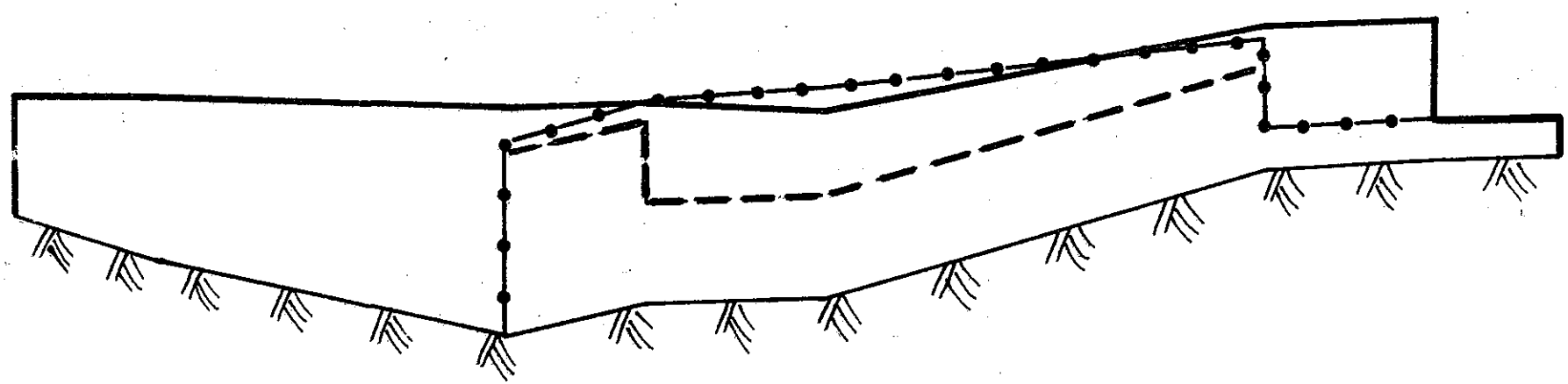
COMPARISON OF BARRIER COSTS

Barrier Costs

Problem 2A $214,705 = 100%

Problem 2B $143,797 = 67.0% Reduction = 33.0%

Problem 2C $111,034 = 51.7% Reduction = 48.3%



LEGEND

Problem 2A - Actual Design

Problem 2B - Translab Design 1 - With 11.5 Ft. L.O.S. Break Constraint

Problem 2C - Translab Design 2 - W/O L.O.S. Break Constraint

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. Caltrans Noise Manual, "II-4.10, Instructions For Level II Program, SOUND3, Caltrans Version of STAMINA 1.0", California Department of Transportation, July 1981.

3. Barry, T.M., Reagan J.A., "FHWA Highway Traffic Noise Prediction Model", FHWA-RD-77-108, Federal Highway Administration, December 1978.

4. Federal Highway Program Manual, Volume 7, Chapter 7, Section 3, "Procedures For Abatement of Highway Traffic Noise and Construction Noise", Transmittal 348, Federal Highway Administration, August 9, 1982.

5. Kassel, J.T., "Design Information Bulletin No. 58, Noise Barrier", Memorandum, California Department of Transportation, December 8, 1980.

DERIVATION OF E/C RATIOS

Introduction

SOUND32 calculates so-called effectiveness/cost ratios for each barrier section at each height to help the user design cost-efficient barrier systems. This section presents first a mathematical description of how the E/C ratios are derived, and second, a discussion of why the ratios are defined as they are.

Mathematical Description

Actually, what the user sees in the matrix (table) of so-called E/C ratios are the ratios of the change in effectiveness to the change in cost for each height of each barrier section. Therefore, the E/C ratios could be more accurately called $\Delta E/\Delta C$ ratios. The ratios are the increase in effectieness divided by the increase in cost brought about by the increase in height for each barrier section. To compute these changes at a specified height, the values of effectiveness and cost are computed at the specified height, z, and at heights greater than (z+DELZ) and less than (z-DELZ) the specified height. Changes in these values are then determined and averaged.

The effectiveness, E_b,i, of barrier section b, at height i, is based on the population-weighted, DNL-weighted sound energy that goes over the top of the barrier summed over all receivers, W_b,i.

$$W_{b,i} = \sum_{r=1}^{R} P_r 10^{\left(\frac{L_{b,i,r}}{10}\right)} 10^{\left(\frac{67-D_r}{10}\right)} , \qquad \text{(A-1)}$$

where P_r = number of people represented by receiver, R

$10^{\left(\frac{L_{b,i,r}}{10}\right)}$ = sound energy passing over barrier b, at height i, to receiver r

D_r = DNL at receiver r

R = total number of receivers

b = index over barrier sections

i = index over barrier section heights

r = index over receivers

The effectiveness at height i is defined as the difference between the weighted sound energy at height i and the weighted sound energy at the ground height (i=1). So,

$$E_{b,i} = -(W_{b,i} - W_{b,1}) \qquad \text{(A-2)}$$

We want to determine the <u>change</u> in effectiveness with respect to the change in cost at barrier height i, so the first step is to determine the increase in effectiveness from height i to height i+1. That is,

$$\Delta E_{b,i} = E_{b,i+1} - E_{b,i} \qquad \text{(A-3)}$$

Now,

$$E_{b,i+1} = -(W_{b,i+1} - W_{b,1}) \qquad \text{(A-4)}$$

And substituting (A-) and (A-) into (A-), we get

$$\Delta E_{b,i} = -(W_{b,i+1} - W_{b,1}) - [-(W_{b,i} - W_{b,i})]$$

$$\Delta E_{b,i} = -(W_{b,i+1} - W_{b,i}) \qquad \text{(A-5)}$$

So, the change in effectiveness from height i to height i+1 is based only on the weighted sound energy at height i and height i+1, and not on the energy at the ground height.

Now, the total barrier section cost, C_b,i, is just the cost per linear foot A_b,i for height i, multiplied by the length of the barrier, S_b, or

$$C_{b,i} = A_{b,i}S_b \quad .$$

And, the change in cost, C_b,i, is

$$\Delta C_{b,i} = C_{b,i+1} - C_{b,i} = S_b(A_{b,i+1} - A_{b,i}) \qquad \text{(A-6)}$$

So, the ratio of the change in effectiveness to change in cost for a change in height from i to i+1 is

$$\Theta_{b,i} = \frac{\Delta E_{b,i}}{\Delta C_{b,i}} \qquad \text{(A-7)}$$

If we substitute Eq. (A-1) for heights i and i+1 in Eq (A-5), and the resulting (A-5) and (A-6) into (A-7), we get

$$\Theta_{b,i} = \frac{-\left[\sum_{r=1}^{R} P_r 10^{\left(\frac{L_{b,i+1,r}}{10}\right)} 10^{\left(\frac{67-D_r}{10}\right)} - \sum_{r=1}^{R} P_r 10^{\left(\frac{L_{b,i,r}}{10}\right)} 10^{\left(\frac{67-D_r}{10}\right)}\right]}{S_b(A_{b,i+1}-A_{b,i})} \qquad \text{(A-8)}$$

But Eq. (A-8) gives θ only for a change in barrier section height from i to i+1. What is needed is the value of θ <u>at</u> height i. SOUND32determines the ratio of change in effectiveness to change in cost at height i by averaging θ_b,i and $\theta_b,i-1$ (the ratio of change in effectiveness to change in cost for a change of height from i-1 to i). Specifically the expression used to determine the ratio at height i, $\xi_{b,i}$, is

$$\xi_{b,i} = 10 \log [\Theta_{b,i}\Theta_{b,i-1}]^{1/2} \qquad \text{(A-9)}$$

At the maximum barrier height, where i - n, $\theta_{b,n}$ cannot be computed since no n+1 height exists. Therefore, $\theta_{b,n-1}$, which is based on W_n and W_n-1, is used to compute $\xi_{b,n}$ as follows:

$$\xi_{b,n} = 10 \log \Theta_{b,n-1} \qquad \text{(A-10)}$$

Thus, Eqs. (A-8), (A-9), and (A-10) completely define the matrix that contains the ratios of changes in effectiveness to changes in cost for each height of each barrier section. This is an array of manageable dimensions (bxi) that can be easily scanned to determine relative cost effectiveness for each barrier section. Choosing a system of barrier section-heights that have equal or nearly equal values of $\xi_{b,i}$ means the resultant barrier system will be balanced with respect to cost and effectiveness.

Why $\Delta E/\Delta C$?

OPTIMA calculates and tabulates ratios of the change in effectiveness to the change in cost, and not simply the ratio of the effectiveness to cost. This section describes why by way of example.

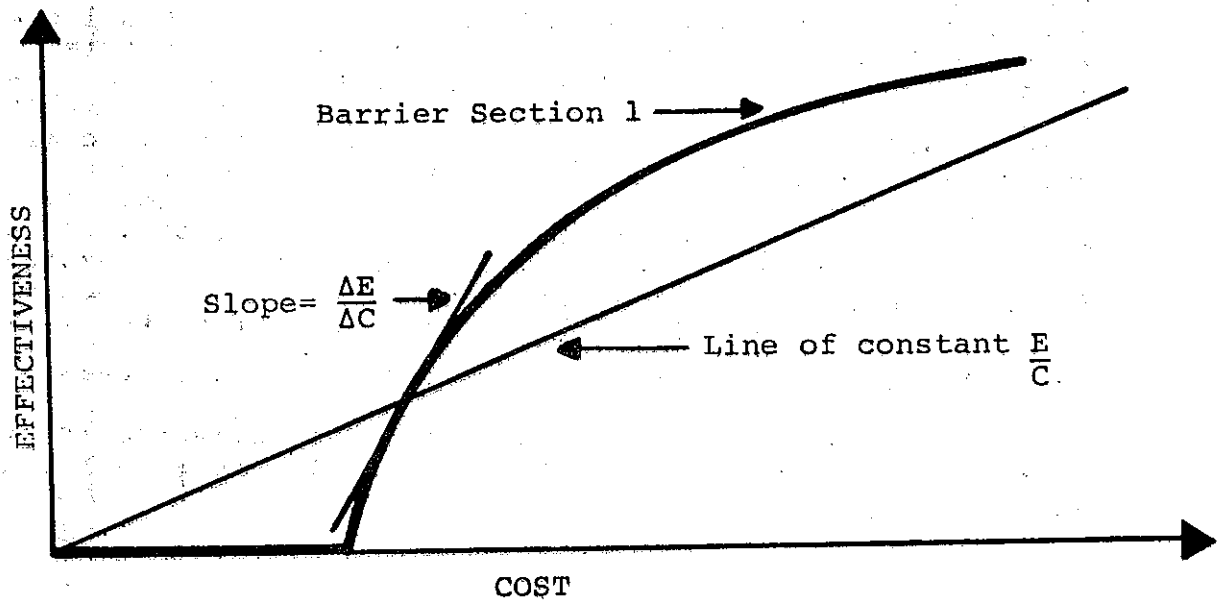
Figure A-1 shows two graphs of effectiveness vs. cost for two different sections of the same barrier. Section 1 has to be built up several feet before it breaks the line-of-sight to the receivers, therefore, some cost is attributed to the barrier before any effectiveness is realized. Section 2 is at the top of a small cut and therefore, the barrier exhibits effectiveness as any cost above zero is applied.

In addition to the heavy curve indicating the path the barrier follows as height is increased, is a straight line shown on both graphs. The line represents a constant ratio of effectiveness to cost. At the point where the lines intersect the barrier curves. the slope of the curve is shown with a straight line segment. The slope of the curve indicates the change in effectiveness with respect to the change in cost, or $\Delta E/\Delta C$ for that ratio of effectiveness to cost (E/C).

Note that the slope of the curve for barrier section 1 is much steeper than that for section 2. This means that for a given change in cost, there will be a much more significant change in effectiveness for barrier section 1 than for

section2. The conclusion that one can draw here is that significant cost savings could result with no overall chance in effectiveness if money were transferred from barrier section 2 to section 1. That is because for section 2, a a large cost reduction can be realized with only a small loss in effectiveness by moving back on the curve, toward the origin. That loss in effectiveness can be made up by barrier section 1 with only a small increase in cost by moving slightly up the section 1 curve. Therefore, the only situation in which a money transfer would not be advantageous, is one in which the slopes are equal. When the slopes are equal, $\Delta E_1/\Delta C_1 - \Delta E_2/\Delta C_2$, and the barrier system is said to be "balanced" with respect to cost and effectiveness.

Only the situation where the slopes of effectiveness/cost ratios for each barrier section are equal ensures a balanced barrier system.



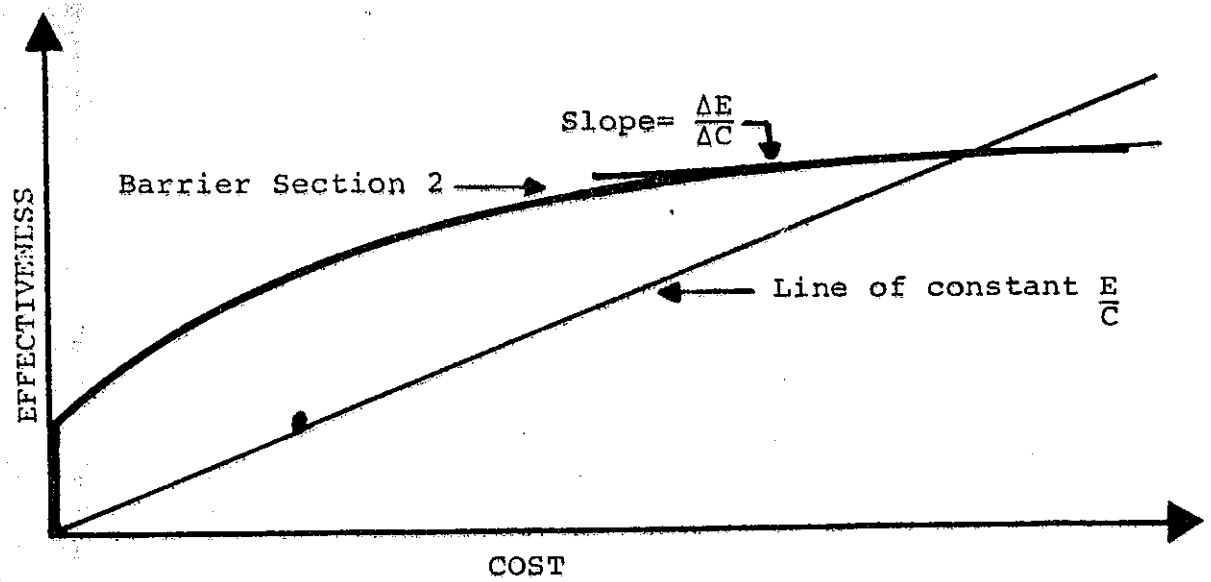


FIGURE A-1 EFFECTIVENESS VS. COST FOR TWO SECTIONS OF THE SAME BARRIER

COST FACTORS

B.1 DERIVATION

The barrier cost factors in the default SOUND32 barrier cost file, CALIF BAR$, were derived from two major sources: historical Caltrans barrier data, and the BBN version of STAMINA 2.0/OPTIMA of 2/81. At the present, only four sets of cost factors are available in CALIF BAR$; masonry wall, masonry wall on concrete 'jersey' barrier, concrete wall (cast in place), and earth berm (see Figure B-1). Additional cost factors will be available in the near future for wood, steel and precast concrete panels.

The cost factors are explicit to material and construction cost for the barrier only. They do not include clearing and grubbing, removing existing fences or structures, contour grading, landscaping, traffic control, shoulder paving, etc. The factors, however, do include the costs for barrier foundations.

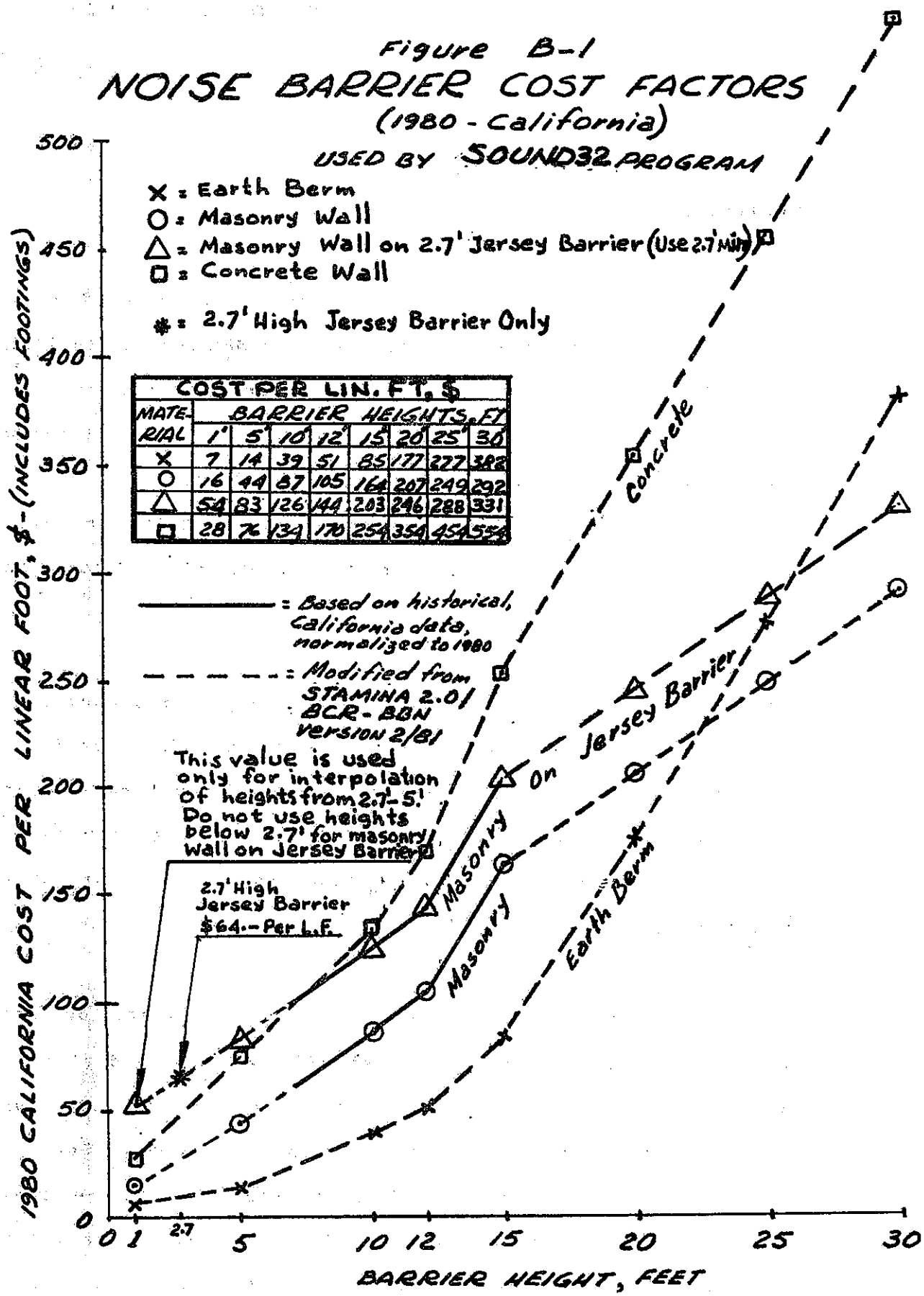
The cost factors are considered to be most accurate for masonry walls and masonry walls on 'jersey' barriers and at heights between 7 ft. and 15 ft. For the two masonry types, inter-material cost comparisons may be made. For other materials inter-material cost comparisons should be avoided (e.g. cost of masonry vs. cost of concrete). Intra-material cost comparisons, however, are considered more accurate (eg.

Figure B-1

NOISE BARRIER COST FACTORS

(1980 - California)

USED BY SOUND32 PROGRAM



COST PER LIN. FT. $								
MATERIAL	BARRIER HEIGHTS, FT							
	1'	5'	10'	12'	15'	20'	25'	30'
X	7	14	39	51	85	177	227	382
O	16	44	87	105	164	207	249	292
△	54	83	126	144	203	246	288	331
□	28	76	134	170	254	354	454	554

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cost ratio's between a 10 ft. earth berm and 15 ft. berm).

Masonry Walls. The Caltrans Office of Structures Estimating Section derived unit costs of soundwall materials for 1980. The in-place unit cost of various medium weight concrete block types ranged from $5.75 to $6.70 per square foot, depending on face patterns, texture and color. An average of $6.25 per square foot was used for CALIF BAR$. This average is in close agreement with that of 30 Caltrans masonry sound walls built between 1978 and 1980, adjusted to 1980 dollars ($6.23 per square foot). Table B-1 shows the historical costs of these walls, and adjustments to 1980 dollars. The price indices for 1977 and 1980 were given by the Office of Structures and pertain to sound walls only. The indices for 1978 and 1979 were estimated using general construction price indices prorated between the 1977 and 1980 values. In the last two columns the table presents the total wall cost per linear foot and the cost of foundation alone per linear foot for 1980. The total wall cost is comprised of material and construction cost of masonry units plus footings. The footing costs include spread and trench footing and cast-in-drilled-hole concrete piles (CIDHCP). They form the bases for the footing costs included in CALIF BAR$ cost factors.

Although the Office of Structures 1980 sound wall material unit costs included a detailed cost break down for various pile dimensions and quantities of trench footings, these could not be

Table B-1

HISTORICAL COSTS OF 30 MASONRY SOUND WALLS

PROJECTS					LENGTH OF WALL	AVE. HEIGHT	TOTAL COST*	COST OF FOOTING**	TOTAL COST PER L.F.	COST OF FTG PER L.F.	YEAR	PRICE INDEX	1980 TOTAL COST PER L.F.	1980 COST OF FTG PER L.F.
No	Dis	Co.	Rte	P.M.										
1	4	CC	680	R7.8/8.1	1793'	14.5'	249,696	109,296	139.3	61.0	1978	107.4	175	77
2	4	Ala	17	R23.3/23.9	1485'	12.9'	116,500	21,000	78.5	14.0	1978	107.4	99	18
3	7	LA	5	15.6/15.8	1000'	12.3'	110,649	22,305	110.7	22.3	1978	107.4	139	28
4	5	SB	101	15.5/15.7	697'	14.8'	98,200	26,100	112.2	37.4	1978	107.4	141	47
5	4	CC	680	R7.8/8.1	1940'	13.4'	245,548	96,048	126.6	49.5	1978	107.4	159	62
6	3	Sac	5	21.6/21.8	567'	14.5'	60,923	7,590	107.4	13.4	1979	135.6	107	13
7	4	Ala	680	R21.2/21.7	2700'	9.3'	179,630	59,930	66.5	22.2	1979	135.6	66	22
8	11	SD	8	9.9	768'	9.2'	59,700	17,100	77.7	22.3	1979	135.6	78	22
9	11	SD	5	R52.9	1014'	9.9'	70,000	20,000	69.0	19.7	1979	135.6	69	20
10	7	LA	10	R11.4/12.6	5118'	7.0'	245,230	66,230	48.0	12.9	1979	135.6	48	13
11	7	LA	10	R18.6/19.1	1613'	12.1'	156,948	47,748	97.3	29.6	1979	135.6	97	29
12	7	LA	5	15.1/15.8	5032'	8.6'	392,936	132,080	78.1	26.2	1979	135.6	78	26
13	3	Sac	5	17.1/18.6	4451'	13.3'	575,760	256,836	129.4	57.7	1979	135.6	129	57
14	4	SCl	680	2.2	325'	10.0'	39,154	13,804	120.5	42.4	1979	135.6	120	42
15	4	Son	101	19.4	640'	12.0'	77,014	26,040	120.3	40.7	1979	135.6	120	41
16	7	LA	2	R20.5	91'	9.2'	13,900	5,600	152.7	61.8	1979	135.6	152	62
17	8	SBd	10	7.7	385'	12.8'	44,520	14,850	115.6	38.5	1979	135.6	115	38
18	6	Mad	99	10.5/10.7	1120'	9.8'	84,480	27,280	75.4	24.5	1979	135.6	75	24
19	7	LA	7	19.5/20.5	7463'	16.7'	752,682	183,612	100.8	24.6	1979	135.6	100	25
20	8	Riv	15	14.4/18.6	766'	8.2'	79,500	16,500	103.8	21.5	1979	135.6	103	21
21	7	LA	605	R11.1/12.1	1111'	8.6'	87,200	24,800	78.5	22.3	1979	135.6	78	22
22	7	LA	60	R2.2/2.4	942'	15.2'	102,950	31,450	109.3	33.4	1980	135.0	109	33
23	7	LA	101	19.7	326'	8.9'	28,280	7,980	86.7	24.5	1980	135.0	87	25
24	10	Mer	99	23.5/23.9	1728'	16.1'	153,481	35,160	88.8	20.3	1980	135.0	89	20
25	7	LA	210	R39.8/41.6	3925'	12.4'	350,832	89,299	89.4	22.8	1980	135.0	89	23
26	7	LA	5	34.8/36.0	8367'	10.0'	695,654	200,880	83.1	24.0	1980	135.0	83	24
27	3	Sac	5	16.1/17.9	6792'	7.5'	557,570	328,655	82.1	48.4	1980	135.0	82	48
28	11	SD	805	21.4	1071'	7.8'	76,314	28,000	71.3	26.2	1980	135.0	71	26
29	6	Tul	99	18.2/19.3	3200'	13.1'	272,180	97,668	85.1	30.5	1980	135.0	85	31
30	7	Ora	91	R1.2/1.4	865'	12.5'	81,638	22,348	94.4	25.8	1980	135.0	94	26

* Materials + construction of wall + footing only. Does not include landscaping, removing existing, clearing, etc.
** Includes both cast-in-drilled-hole-concrete piles, and trench footing.

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readily used to derive 'typical' foundation costs for masonry walls. Unlike the masonry unit costs, the cost of foundations is not linearly related to height of wall. Other variables, such as soil type, location of wall, etc. determine the depth, spacing and dimensions of piles and other footings. The variations in foundation quantities for a given wall height made it necessary to depend completely on the historical data.

Figure B-2a presents a plot of footing costs vs. wall height for the 30 masonry sound walls. These projects did not include any masonry walls on 'jersey' barriers. Six data points do not conform to the 'mainstream'. Three were much higher, and three considerably lower than the others.

Futher analyses indicated that these six 'outliers' appeared to be due to unusual circumstances such as difficult terrain and soil conditions, existing foundations or unusually low bid prices. The six projects were therefore not considered in the footing cost analysis. A 'best fit' curve was drawn through the remaining 24 data points (Figure B-2a) and included in the masonry wall costs factors in CALIF BAR$. Since the average height of the 24 projects ranged from 7 to 15 ft., the cost factors are most accurate between these heights.

Figure B-2b, shows a comparison of the $6.25 per sq. ft. line for masonry units and the 1980 cost per L.F. of masonry units for all

30 projects (averaging $6.23 per sq. ft.). The costs in this plot were derived from Table B-1, by taking the difference between the total costs and the footing costs for 1980.

The curve of footing costs was combined with the straight line masonry unit cost and 'smoothed' to produce the masonry wall cost factors shown in Figures B-1 and B-3. The latter figure shows a comparison with the historical total costs.

The CALIF BAR$ masonry wall cost factors were used to 'predict' the costs per L.F. for the 30 sound walls, then plotted against the actual, or observed, cost per L.F. Figure B-4 shows these plots. Once again, the 6 projects were excluded from the analysis. A regression line through the remaining 24 points indicates that the CALIF BAR$ masonry wall cost factors slightly overpredicted the costs for lower barriers and slightly under predicted costs of higher barriers. The cross-over occurs at $112 per L.F. which corresponds with a 12.4 ft. high masonry wall. The CALIF BAR$ masonry wall cost factors appear to be most accurate for this height.

<u>Masonry Walls on Jersey Barriers.</u> Limited historical data showed no significant cost differences in foundations of masonry walls on jersey barriers compared to those without jersey barriers.

Figure B-2

MASONRY WALLS
COST BREAK DOWN, 1980

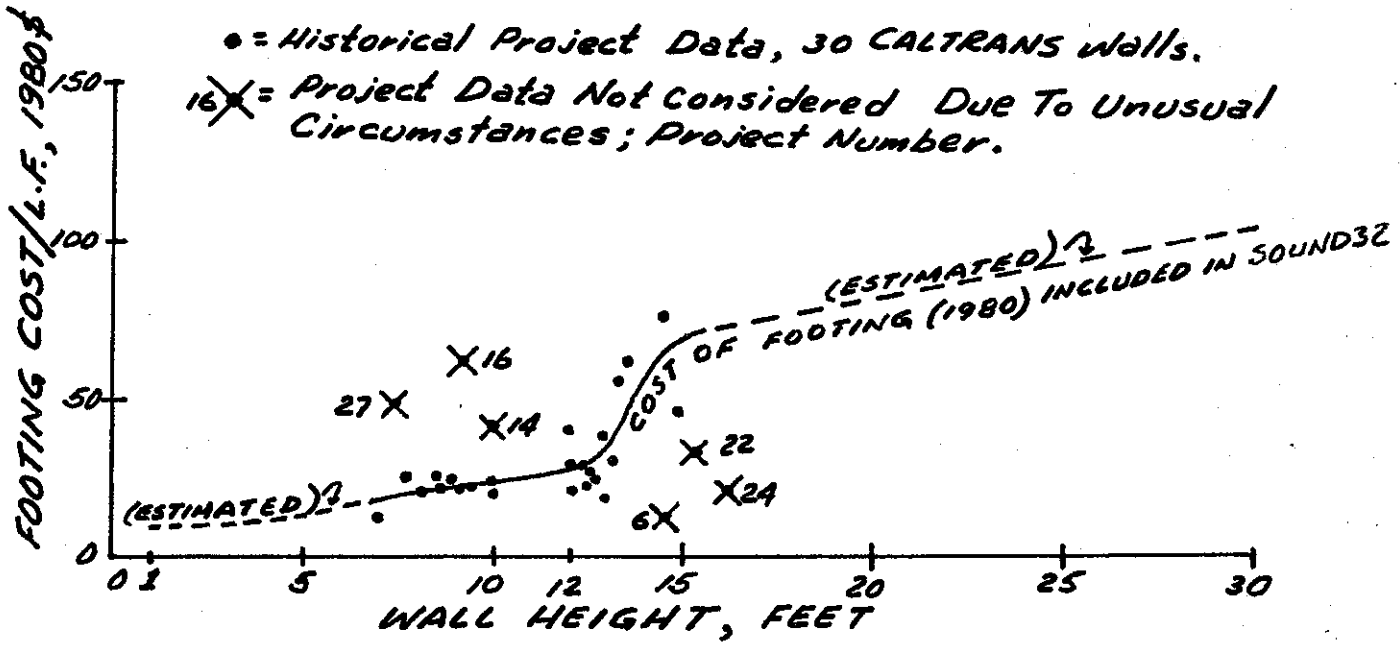


Figure B-2a, Footing (Trench & CIDH/C Piles)

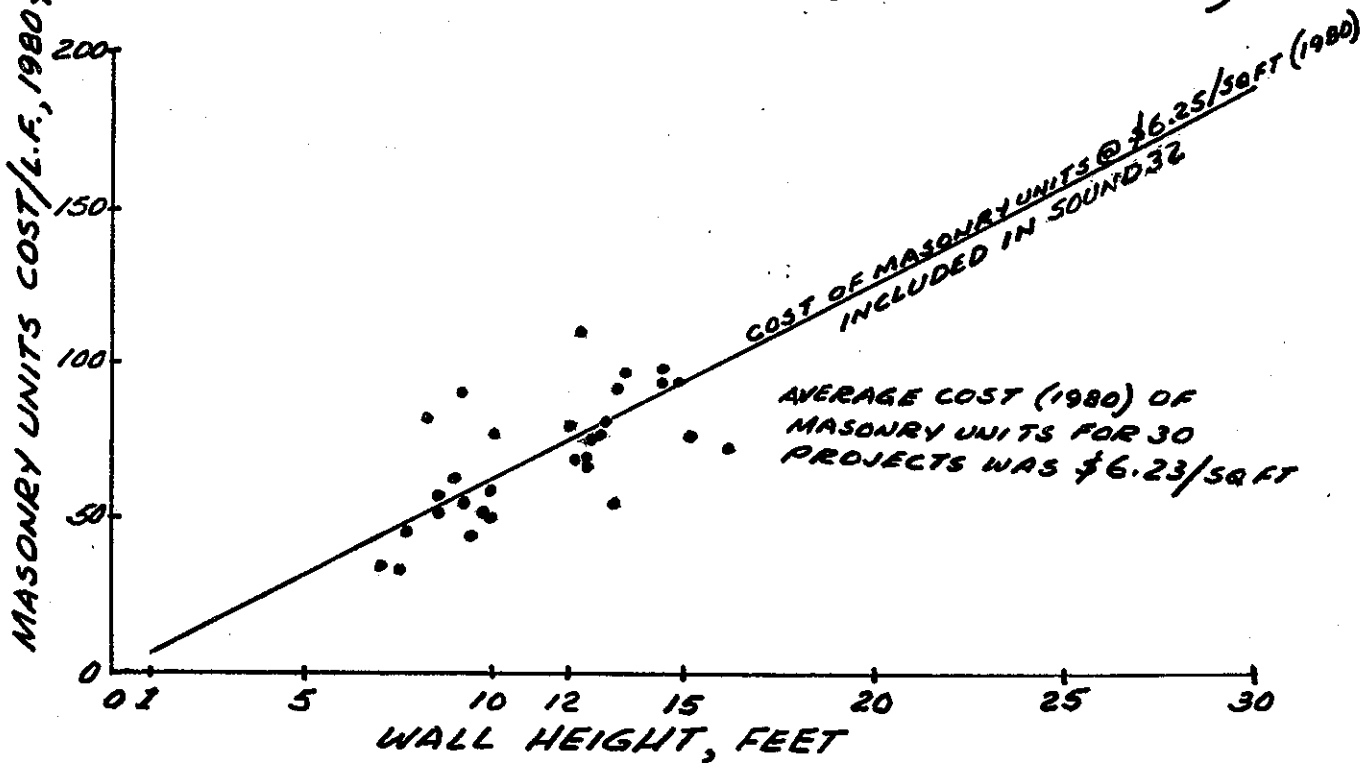


Figure B-2b, Masonry Units

Figure B-3

MASONRY WALLS

Comparison Of Historical Cost Data (normalized to 1980$) vs. SOUND32 Cost Factors

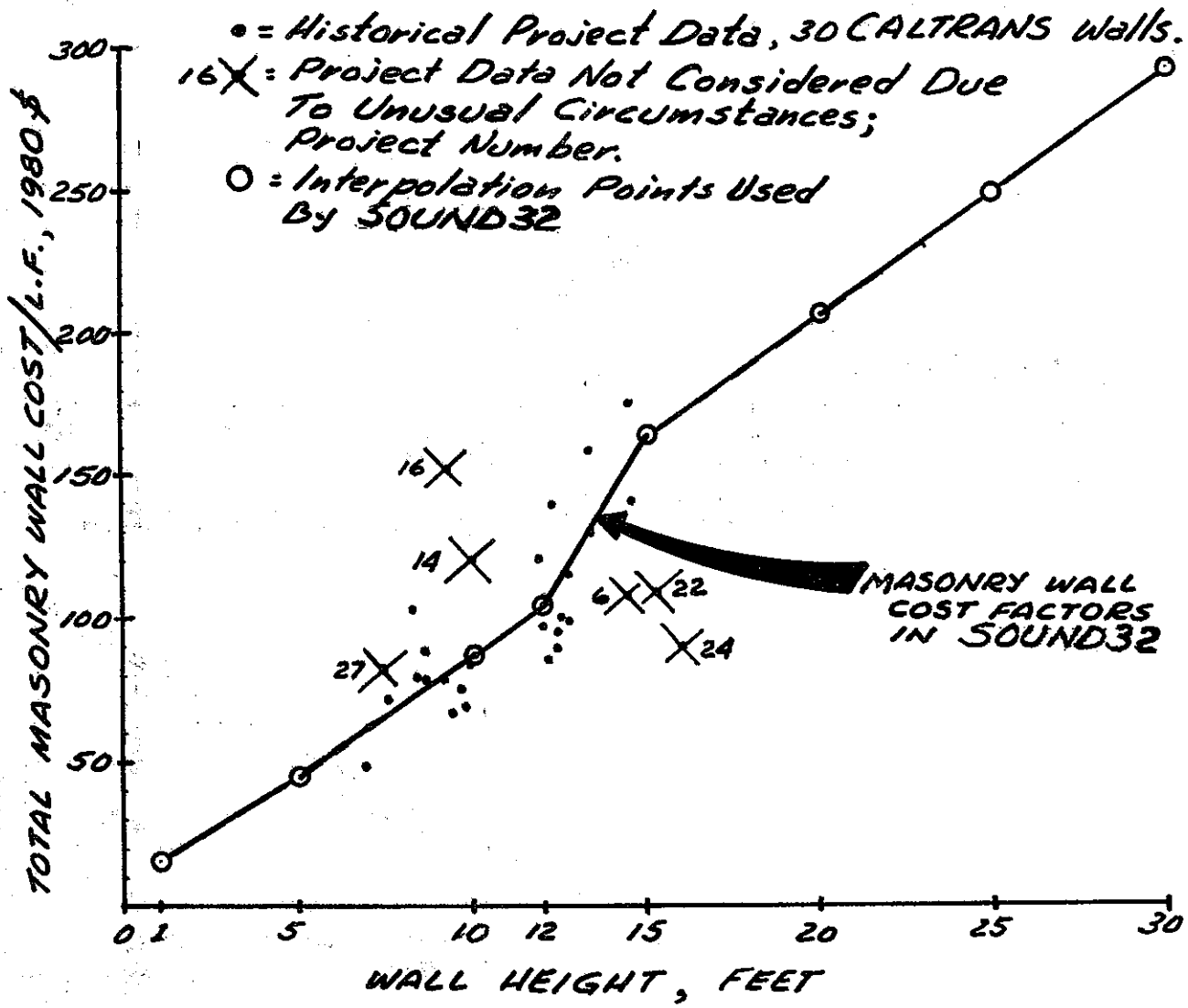
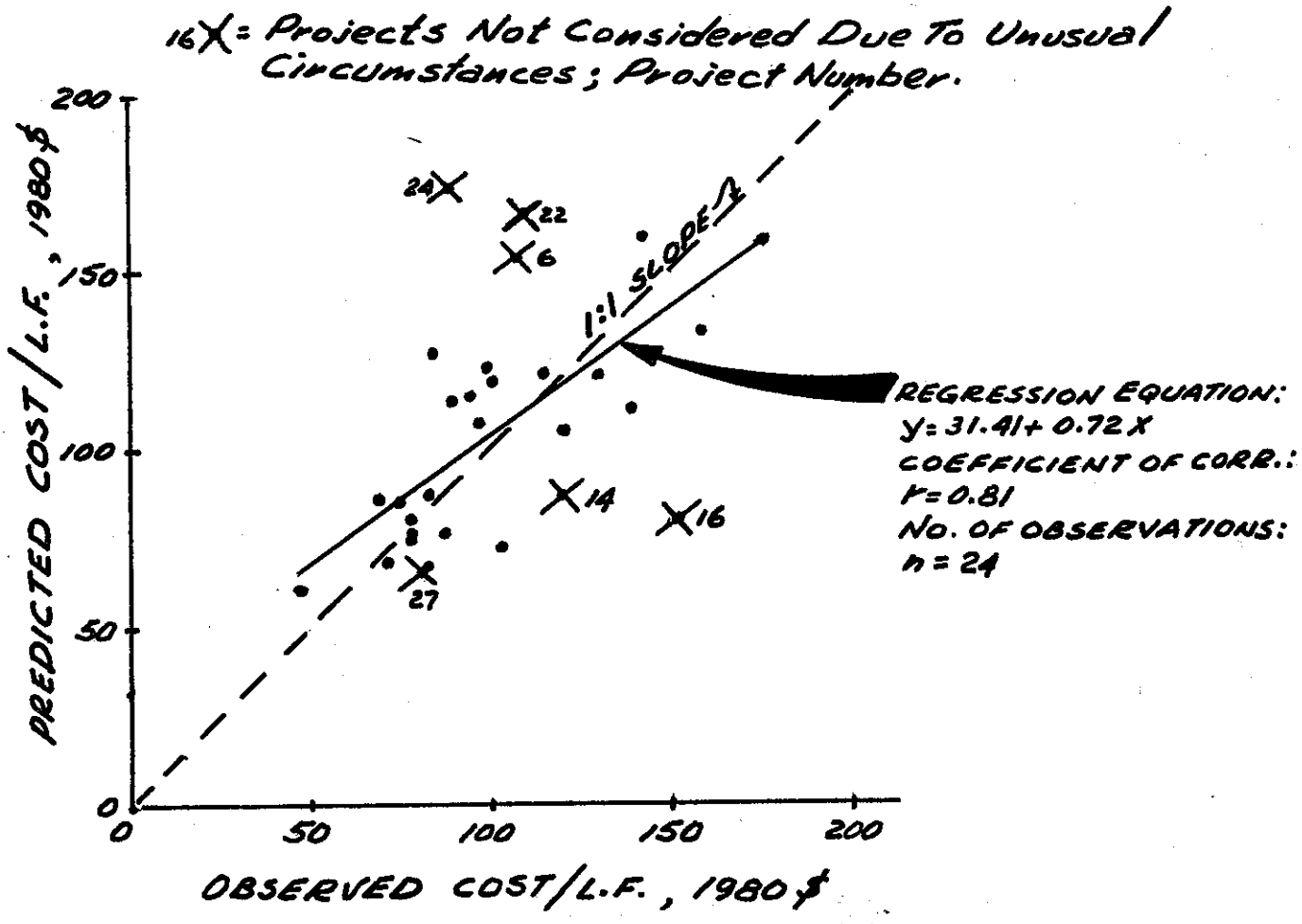


Figure B-4

MASONRY WALLS

Comparison Of Observed 1980 Costs of 30 CALTRANS Walls Vs. Predicted Costs per SOUND32



The average cost of a type 27 barrier was determined for 21 projects and adjusted to 1980 dollars. The average cost of the 2.7 ft. high barriers was $64 per L.F. The cost of a 2.7 ft. high masonry barrier is $25.50 per L.F. using CALIF BAR$ factors. Both include foundations that are assumed to have the same average cost. The cost difference between the barriers, $38.50 or $39 per L.F., then, is due to the difference between the concrete safety shape and the masonry units for the first 2.7 ft. above the ground.

For any height above the 2.7 ft. high jersey barrier this difference remains constant. Therefore the masonry wall on top of a jersey barrier costs $39 per L.F. more than a masonry wall of the same height. Obviously, heights below 2.7 ft. should not be used, and a height of 2.7 ft. indicates a jersey barrier by itself.

<u>Earth Berms.</u> The cost of earth berms were derived by applying ratios between the cost of berms vs. cost of masonry barriers at given heights in the BBN version of STAMINA 2.0/OPTIMA of 2/81, to the California masonry barrier. The assumption was that earth berms were affected by the same inflation rate as masonry walls. The user is cautioned to be aware of the variables affecting earth berm costs, such as imported borrow, etc.

<u>Concrete Walls.</u> Concrete wall costs were obtained in the same

manner as earth berm, by applying ratios between concrete wall costs and masonry wall costs in the BBN version of STAMINA 2.0/OPTIMA to the California masonry barrier.

B.2 FILE STRUCTURE

Barrier cost files must be formatted as follows:

line-a	title	(80 characters max.)
line-b	number of bar. heights	(20 max.)
line-c	list of bar. heights	
line-d	number of different bar. material types	(10 max.)
line-e	barrier material	(16 characters max.)
line-f	cost per linear ft. at heights listed in line-c	

Note: Repeat lines e and f for the number of different barrier types on line-d.

The first barrier listed in the file is calculated as an earth mound (berm) and all other barriers are assumed to be thin screens (walls). Thus, the first barrier listed in the file should always be a berm.

The default barrier cost file, CALIF BAR$, currently contains four barrier material types with cost data for eight heights.

```
 CALIFORNIA BARRIER COST (IN 1980 DOLLARS)
8
1.0, 5.0, 10.0, 12.0, 15.0, 20.0, 25.0, 30.0
4
BERM
7.0, 14.0, 39.0, 51.0, 85.0, 177.0, 277.0, 382
MASONRY
16.0, 44.0, 87.0, 105.0, 164.0, 207.0, 249.0, 292.0
MASONRY/JERSEY
54.0, 83.0, 126.0, 144.0, 203.0, 246.0, 288.0, 331.0
CONCRETE
28.0, 76.0, 134.0, 170.0, 254.0, 354.0, 454.0, 554.0
```

COMPARISON OF SOUND3 AND SOUND32

Unlike the batch mode nature of SOUND3, SOUND32 allows the user to view various outputs, evaluate results and select options from an interactive menu with the following features not available with SOUND3:

* barrier height selection
* barrier material selection
* barrier length and cost information
* barrier effectiveness/cost information

SOUND32 also has provisions for calculating barriers on structures and for dBA constant adjustments (K-constants).

SOUND32 no longer supports the following features which are available in SOUND3:

* Absorptive ground cover calculations
* barrier reflection calculations
* multiple problems stacked in one input file
* individual lane segment leq's

Input Files. Every effort has been made to limit the differences in input file structure between SOUND3 and SOUND32. Users wishing to convert their existing SOUND3 files to SOUND32 files will find the following:

* Title line - No change needed.
* Traffic data - No change needed.

* Lane data - No change needed.
  Number of allowable lanes increased from 20 to 30 and segments per lane from 10 to 15.

* Barrier data - Barrier types must be changed from A-wall, R-wall or Berm to a barrier material type number.
  Add incremental height change (DELZ) and number of perturbations (P).
  Insert barrier ground elevations (ZO).
  Shorten barrier point descriptions to 8 characters or less.

* Receivers - Add design noise level and people per receiver (may be omitted if default values of DNL=67 and people=500 are acceptable).
  Maximum number of receivers increased from 15 to 40.

* Drop-off rates - No change.

* Ground cover - SOUND32 does not support absorptive ground cover calculations. Any blocks of ground cover coding will have to be deleted. See Section 2.5 on K-constants for possible alternative to ground covers.

* Calculation option - While SOUND32 does not offer the Leq's by lane segment option that is available in SOUND3, SOUND32 will accept the SOUND3 calculation option data. VC1 and VC2 will be read as VC and C1 and C2 will be read as C.

* Stacked problems - SOUND32 is not able to handle stacked problem input files. Any data contained in the input file after the calculation option will be ignored by SOUND32. In many cases the multiple runs made with stacked SOUND3 files can be done using perturbed barrier heights and the barrier height index selection process available in SOUND32.

LOS PROGRAM INSTRUCTIONS

The LOS program calculates noise barrier elevations at various points along a 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 a drawing of the barrier profile the user can design a noise barrier which meets the truck stack L-O-S requirements of Design Bulletin No. 58. (5)

Input to the LOS program is a data file containing information on the location of the lane occupied by the trucks, the location of the barrier and the locations of receivers.

For user convenience LOS can read input files prepared for SOUND3 or SOUND32. If the user is creating a file solely to run LOS the file need only contain the following:

* a title line.
* 1 block of lane data.
* 1 block of barrier data.
* 1 or more receiver definitions.

The LOS program may be run by selecting LOS from the menu in SOUNDSYS or by running the program directly from CMS. Upon entry into LOS the program first prompts the user for the name of his input file. If the input file does not have a filetype of SOUND3 or SOUND32 the program will then ask which type of file is

being used. The program then prompts the user for the lane number, barrier number and list of receiver numbers to use. LOS then extracts the data from the file and then prompts the user for the maximum receiver to truck distance that should be calculated. The truck to receiver distance is used to limit the L-O-S listing to areas adjacant 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 for 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 distance, LOS then calculates the barrier intercepts and prints the number of points calculated. The user then has the option of listing the points in barrier order or receiver order.

Example run:

```
RUN LOS

     * LOS *

    File Name (or HELP) ?>LTEST SOUND32

    Lane number to use ?>2

    Barrier number ?>1

    Enter list of receivers to use
    (seperated by commas)  (max. = 40)
    >1,2,3,5

    Got data

    Enter the max. receiver to truck distance you want calculated
    >1000


     20  Points calculated

    (1) = List in Barrier Order
    (2) = List in Receiver Order
    (3) = Quit
    >1

    Set paper at top of form & hit return
```

```
                 * 11.5' TRUCK STACK LINE-OF-SIGHT CALCULATIONS *

                                                                    Page 1
Input File-LTEST SOUND32        Lane No.-2  Barrier No.-1  Max. DT-1000
Receiver(s)- 1  2  3  5
-----------------------------------------------------------------------------
                              EXAMPLE LOS RUN
-----------------------------------------------------------------------------
     X        Y       ZO    Rec    DT    LOS Z  Height    BD   Desc.
-----------------------------------------------------------------------------
   Bar. Segment 1          |                                  |
  -500      88     25.0   |  2   589    37.1    12.1    300  | Bar. End ANG PT
  -500      88     25.0   |  1   710    37.6    12.6    300  | Bar. End ANG PT
  -500      88     25.0   |  3   949    39.4    14.4    300  | Bar. End ANG PT
  -500      88     25.0   |  5   770    41.0    16.0    300  | Bar. End ANG PT
  -800      90     26.0   |  2   992    37.2    11.2      0  | Bar. End BEG B-1
   Bar. Segment 2          |                                  |
  -100      76     27.0   |  2   127    36.0     9.0    400  | Bar. End ANG PT-2
  -100      76     27.0   |  1   210    36.8     9.8    400  | Bar. End ANG PT-2
  -100      76     27.0   |  3   419    39.1    12.1    400  | Bar. End ANG PT-2
  -100      76     27.0   |  5   305    41.1    14.1    400  | Bar. End ANG PT-2
   Bar. Segment 3          |                                  |
     0      76     26.2   |  1   137    36.8    10.6    100  | Near Pt.
    78      76     25.5   |  5   167    41.2    15.7    178  | Near Pt.
   125      76     25.1   |  3   115    39.1    14.0    225  | Near Pt.
   200      76     24.5   |  2   516    36.1    11.6    300  | Bar. End STA 6+40
   200      76     24.5   |  1   346    36.8    12.3    300  | Bar. End STA 6+40
   200      76     24.5   |  3   177    39.1    14.6    300  | Bar. End STA 6+40
   200      76     24.5   |  5   242    41.2    16.7    300  | Bar. End STA 6+40
   Bar. Segment 4          |                                  |
   350      76     25.0   |  2   762    36.1    11.1    150  | Bar. End END
   350      76     25.0   |  1   574    36.8    11.8    150  | Bar. End END
   350      76     25.0   |  3   420    39.2    14.2    150  | Bar. End END
   350      76     25.0   |  5   425    41.2    16.2    150  | Bar. End END
-----------------------------------------------------------------------------
  DT = Distance to Truck (from Rec.)
```