



U.S. Department
of Transportation
Federal Highway
Administration

FHWA TRAFFIC NOISE MODEL[®] USER'S GUIDE

FHWA-PD-96-009
DOT-VNTSC-FHWA-98-1

Final Report
January 1998

Skew View

Parallel Barrier View

Perspective View

Sound Level Results Table

Barrier Segment	Start Station	End Station	Barrier Type	Barrier Height (ft)	Barrier Length (ft)	Barrier Area (sq ft)	Barrier Volume (cu ft)
A-1	0.0	1.0	GG	71.8	11	789.8	1111.1
B-1	1.0	2.0	GG	71.8	12	861.6	1222.2
C-1	2.0	3.0	GG	74.7	13	971.1	1333.3
D-1	3.0	4.0	GG	74.7	12	836.4	1111.1
E-1	4.0	5.0	GG	74.7	11	821.7	1111.1
F-1	5.0	6.0	GG	74.7	11	821.7	1111.1
G-1	6.0	7.0	GG	74.7	11	821.7	1111.1
H-1	7.0	8.0	GG	74.7	11	821.7	1111.1
I-1	8.0	9.0	GG	74.7	11	821.7	1111.1
J-1	9.0	10.0	GG	74.7	11	821.7	1111.1
K-1	10.0	11.0	GG	74.7	11	821.7	1111.1
L-1	11.0	12.0	GG	74.7	11	821.7	1111.1
M-1	12.0	13.0	GG	74.7	11	821.7	1111.1
N-1	13.0	14.0	GG	74.7	11	821.7	1111.1
O-1	14.0	15.0	GG	74.7	11	821.7	1111.1
P-1	15.0	16.0	GG	74.7	11	821.7	1111.1

Barrier Seg. Descriptions Table

Barrier Segment	Barrier Type	Barrier Height (ft)	Barrier Length (ft)	Barrier Area (sq ft)	Barrier Volume (cu ft)
A-1	GG	71.8	11	789.8	1111.1
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P-1	GG	74.7	11	821.7	1111.1

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Cambridge, MA 02142-1093



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13. ABSTRACT (Maximum 200 words) This User's Guide is for the Federal Highway Administration's Traffic Noise Model (FHWA TNM [®]), Version 1.0 -- the FHWA's computer program for highway traffic noise prediction and analysis. Two companion reports, a Technical Manual and a data report, respectively, describe the acoustics and the vehicle noise-emissions database within TNM. The User's Guide first lists TNM's hardware/software requirements, instructs how to install the program and an optional digitizer, and discusses TNM's file structure. Next it provides definitions of commonly used terminology. Finally, it details each TNM menu item, including overviews of all TNM procedures: Setup, Input, Calculate, Barrier Analysis, Parallel Barriers, and Contours. Also included are the following appendices: FHWA Policy, Details of All Input Types, Input-error Messages, Comparison of TNM with STAMINA 2.0/OPTIMA, Certified Output for the Official TNM Test Case, and REMEL Data Base.					
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METRIC/ENGLISH CONVERSION FACTORS

ENGLISH TO METRIC

LENGTH (APPROXIMATE)

1 inch (in) = 2.5 centimeters (cm)
 1 foot (ft) = 30 centimeters (cm)
 1 yard (yd) = 0.9 meter (m)
 1 mile (mi) = 1.6 kilometers (km)

AREA (APPROXIMATE)

1 square inch (sq in, in²) = 6.5 square centimeters (cm²)
 1 square foot (sq ft, ft²) = 0.09 square meter (m²)
 1 square yard (sq yd, yd²) = 0.8 square meter (m²)
 1 square mile (sq mi, mi²) = 2.6 square kilometers (km²)
 1 acre = 0.4 hectare (ha) = 4,000 square meters (m²)

MASS - WEIGHT (APPROXIMATE)

1 ounce (oz) = 28 grams (gm)
 1 pound (lb) = .45 kilogram (kg)
 1 short ton = 2,000 pounds (lb) = 0.9 tonne (t)

VOLUME (APPROXIMATE)

1 teaspoon (tsp) = 5 milliliters (ml)
 1 tablespoon (tbsp) = 15 milliliters (ml)
 1 fluid ounce (fl oz) = 30 milliliters (ml)
 1 cup (c) = 0.24 liter (l)
 1 pint (pt) = 0.47 liter (l)
 1 quart (qt) = 0.96 liter (l)
 1 gallon (gal) = 3.8 liters (l)
 1 cubic foot (cu ft, ft³) = 0.03 cubic meter (m³)
 1 cubic yard (cu yd, yd³) = 0.76 cubic meter (m³)

TEMPERATURE (EXACT)

$$^{\circ}\text{C} = 5/9(^{\circ}\text{F} - 32)$$

METRIC TO ENGLISH

LENGTH (APPROXIMATE)

1 millimeter (mm) = 0.04 inch (in)
 1 centimeter (cm) = 0.4 inch (in)
 1 meter (m) = 3.3 feet (ft)
 1 meter (m) = 1.1 yards (yd)
 1 kilometer (km) = 0.6 mile (mi)

AREA (APPROXIMATE)

1 square centimeter (cm²) = 0.16 square inch (sq in, in²)
 1 square meter (m²) = 1.2 square yards (sq yd, yd²)
 1 square kilometer (km²) = 0.4 square mile (sq mi, mi²)
 10,000 square meters (m²) = 1 hectare (ha) = 2.5 acres

MASS - WEIGHT (APPROXIMATE)

1 gram (gm) = 0.036 ounce (oz)
 1 kilogram (kg) = 2.2 pounds (lb)
 1 tonne (t) = 1,000 kilograms (kg) = 1.1 short tons

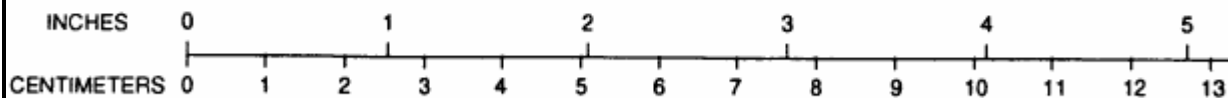
VOLUME (APPROXIMATE)

1 milliliter (ml) = 0.03 fluid ounce (fl oz)
 1 liter (l) = 2.1 pints (pt)
 1 liter (l) = 1.06 quarts (qt)
 1 liter (l) = 0.26 gallon (gal)
 1 cubic meter (m³) = 36 cubic feet (cu ft, ft³)
 1 cubic meter (m³) = 1.3 cubic yards (cu yd, yd³)

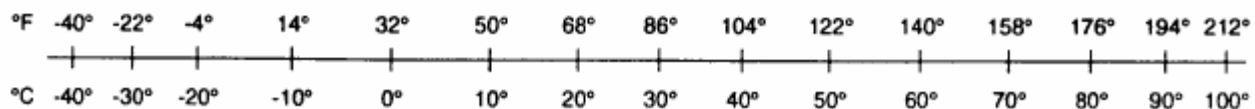
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PREFACE

This User's Guide is for the Federal Highway Administration's Traffic Noise Model (FHWA TNM®), Version 1.0 -- the Federal Highway Administration's computer program for highway traffic noise prediction and analysis. A companion Technical Manual describes the acoustics within TNM, Version 1.0.¹ In addition, a companion technical report documents the vehicle noise-emissions database within TNM.²

Overview of TNM: TNM computes highway traffic noise at nearby receivers and aids in the design of highway noise barriers. As sources of noise, it includes 1994-1995 noise emission levels for the following cruise-throttle vehicle types:

- Automobiles: all vehicles with two axles and four tires -- primarily designed to carry nine or fewer people (passenger cars, vans) or cargo (vans, light trucks) -- generally with gross vehicle weight less than 4,500 kg (9,900 lb);
- Medium trucks: all cargo vehicles with two axles and six tires -- generally with gross vehicle weight between 4,500 kg (9,900 lb) and 12,000 kg (26,400 lb);
- Heavy trucks: all cargo vehicles with three or more axles -- generally with gross vehicle weight more than 12,000 kg (26,400 lb);
- Buses: all vehicles designed to carry more than nine passengers; and
- Motorcycles: all vehicles with two or three tires and an open-air driver/passenger compartment.
- Noise emission levels consist of A-weighted sound levels, one-third octave-band spectra, and subsource-height strengths for the following pavement types:
 - Dense-graded asphaltic concrete (DGAC);
 - Portland cement concrete (PCC);
 - Open-graded asphaltic concrete (OGAC); and
 - A composite pavement type consisting of data for DGAC and PCC combined.

In addition, TNM includes full-throttle noise emission levels for vehicles on upgrades and vehicles accelerating away from the following traffic-control devices:

- Stop signs;
- Toll booths;
- Traffic signals; and
- On-ramp start points.

TNM combines these full-throttle noise emission levels with its internal speed computations to account for the full effect (noise emissions plus speed) of roadway grades and traffic-control devices.

TNM propagates sound energy, in one-third-octave bands, between highway systems and nearby receivers. Sound propagation takes the following factors into account:

- Atmospheric absorption;
- Divergence;
- Intervening ground: its acoustical characteristics and its topography;
- Intervening barriers: walls, berms and their combination;
- Intervening rows of buildings; and
- Intervening areas of heavy vegetation.

TNM computes the effect of intervening ground (defined by its type, or optionally by its flow resistivity) with theory-based acoustics that have been calibrated against field measurements. In addition, TNM allows sound to propagate underneath selected intervening roadways and barriers, rather than being shielded by them.

During calculation, TNM perturbs intervening barriers up and down from their input height, to calculate for multiple heights. Then during acoustical design of selected barriers, combined with selected receivers, TNM displays sound-level results for any combination of height perturbations. It also contains an input-height check, to determine if noise barriers break the lines-of-sight between sources and receivers. In addition, it provides summary cost and benefit information for each barrier design, from user-supplied unit barrier costs and land-use information.

For selected cross sections, TNM also computes the effect of multiple reflections between parallel barriers or retaining walls that flank a roadway. The TNM user can then enter the computed parallel-barrier degradations as adjustment factors for individual receivers in TNM's calculation of receiver sound levels.

TNM computes three measures of highway traffic noise:

- L_{Aeq1h} : hourly A-weighted equivalent sound level (1HEQ);
- L_{dn} : day-night average sound level (DNL); and
- L_{den} : Community Noise Equivalent Level (CNEL), where "den" stands for day/evening/night.

TNM computes these three noise measures at user-defined receiver locations, where it also computes several diagnostics to aid in noise-barrier design. In addition, it computes three types of contours:

- Sound-level contours;
- Noise Reduction, i.e., insertion-loss, contours for noise barriers; and
- Level-difference contours between any two noise-barrier designs.

TNM runs under Microsoft® Windows Version 3.1 (or later). Within Windows, it allows digitized input using a generic Windows digitizer driver, plus the import of DXF files from CAD programs and input files from STAMINA 2.0/OPTIMA. Note: TNM will run under Microsoft® Windows 95 or Windows NT, however, TNM is a 16-bit program and will not take full advantage of the 32-bit architecture associated with Windows 95 or NT.

To aid during input and to document the resulting input and barrier designs, TNM shows the following graphical views:

- Plan views;
- Skew sections;
- Perspective views, including a specialized perspective view for noise-barrier design; and
- Roadway profiles.

One aspect of TNM which will enhance usability substantially is that most graphics, input dialogs, and output tables are dynamically linked. In other words, if you have a TNM Plan View on your computer display, as well as a roadway input dialog, you can select the roadway graphically (see Section 5.5), move it to a new location (see Section 5.7), and the new coordinates will be reflected in the input dialog in real time. Similarly, if you have a TNM Barrier Perspective View on your computer display, as well as a Diagnosis by Barrier Segment table, you can select a barrier segment

graphically (see Section 5.5), move it up and down (see Section 10.6), and the associated barrier costs will change accordingly.

TNM Version 1.0 replaces FHWA's prior pair of computer programs, STAMINA 2.0/OPTIMA. In addition, TNM's technical manual replaces FHWA's prior prediction model: *FHWA Highway Traffic Noise Prediction Model*, FHWA-RD-77-108.³

Organization of this User's Guide:

- Section 1. Getting Started:** Discusses TNM's hardware and software requirements, program and digitizer installation, and TNM's file structure;
- Section 2. Terminology:** Presents pertinent terminology used throughout the User's Guide.
- Section 3. Overview of Program:** Overviews all TNM procedures: Setup, Input, Calculate, Barrier Analysis, Parallel Barriers, and Contours;
- Section 4. File Menu:** Discusses how to open, save, import, and print files;
- Section 5. Edit Menu:** Describes TNM's editing options and CAD-like capabilities;
- Section 6. View Menu:** Describes TNM graphical views and their creation and manipulation;
- Section 7. Setup Menu:** Details the entry of TNM user information and preferences, plus the registration of plans and profiles on the digitizer;
- Section 8. Input Menu:** Details the entry of TNM input: roadways, receivers, barriers, building rows, terrain lines, ground zones, tree zones, and contour zones;
- Section 9. Calculate Menu:** Discusses TNM's sound-level calculations;
- Section 10. Barrier Analysis Menu:** Details the acoustical design of noise barriers;
- Section 11. Parallel Barriers Menu:** Discusses input and computation of parallel-barrier degradation for barriers or retaining walls that flank a roadway;
- Section 12. Contours Menu:** Discusses input and computation of contours;
- Section 13. Tables Menu:** Discusses the available output tables for viewing and printing;
- Section 14. Window Menu:** Discusses options for rearranging and closing open windows; and
- Section 15. Help Menu:** Discusses the different help options available to the user.

This guide concludes with the following appendices:

Appendix A. FHWA Policies for Highway Traffic Noise Prediction Using TNM;

Appendix B. Details of All Input Types;

Appendix C. Input-error Messages;

Appendix D. Comparison of TNM with STAMINA 2.0/OPTIMA;

Appendix E. Certified Output for the Official TNM Test Case;

Appendix F. REMEL Data Base;

References

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FHWA TNM Announcement and Order Form

FHWA TNM Registration Card

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FHWA TNM REGISTRATION CARD175

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1. GETTING STARTED

This section:

- Discusses how to use this User's Guide and the conventions used within it;
- Lists contents of your FHWA TNM[®] package;
- Lists TNM's hardware and software requirements;
- Instructs how to install TNM and set up an optional digitizer;
- Lists and discusses TNM files: those installed on your hard drive, those you import into TNM, and those generated by TNM;
- Lists important precautions and policies about TNM, Version 1.0; and
- Discusses available sources of additional technical support.

1.1 How to Use This User's Guide

This User's Guide is essential to both the experienced and inexperienced TNM user. It provides information on every aspect of the program. Use it as your main information source. New users should also use the "TNM Trainer," the interactive tutorial that is included in the TNM package (See Section 1.2). For quick reference help, users can select the Help menu while using TNM. In addition, TNM sometimes "pops up" brief help information during various operations (see Section 7.1).

The different typefaces and icons conventions used in this User's Guide are as follows:

Bold Bold is used for emphasis and to introduce new terms, which are defined in Section 2, Terminology.

Underline Underline is used to denote an available shortcut key to invoke a menu or submenu item. For example, to invoke the Help menu while using TNM, press the Alt+H keys.



A light bulb icon points out helpful tips, suggestions, engineering hints, and shortcuts that may save you time.



A stop sign icon represents warnings and when you should pay special attention to what you're doing to avoid unexpected results.



A Department of Transportation icon points out when you should refer to Appendix A for FHWA policies relating to a topic.

1.2 Contents of the TNM Package

Your TNM package should contain the following:

- Two TNM manuals: This User's Guide and the TNM Technical Manual;
- The FHWA TNM software on three 3½" diskettes;
- One CD-ROM with the "TNM Trainer" tutorial; and
- The TNM registration card located on the last page of this User's Guide. Please fill out and return this card. Registered owners are entitled to receive technical support (see Section 1.8) and information on upgrades and supplementary guides.

1.3 Hardware and Software requirements

Unlike its predecessor, STAMINA, TNM is a Windows-based program with increased capabilities (see Appendix D for a comparison of the two programs) and complex acoustic algorithms (refer to the TNM Technical Manual). However, the model's increased capabilities and theoretical basis result in fairly extensive run-times. TNM will currently run typical studies in between 1 and 2 hours on state-of-the-art personal computers (PCs); and the more complex studies (previously unachievable with STAMINA) are expected to take no longer than an overnight run. These run-times are substantially longer than those of STAMINA. However, the notable improvements in accuracy (refer to the TNM Technical Manual), flexibility, and ease of use should more than compensate. Additionally, the sound theoretical base upon which TNM has been structured will allow for easy incorporation of other acoustical effects, e.g., atmospheric, as future studies are completed, and TNM run-times will be greatly reduced as computer hardware technology continues to advance.

A run-time comparison of a moderately complex, STAMINA test case (see Appendix E for a description of the case), imported into TNM, is shown below for several computer platforms (it should be noted that TNM is most efficient running under the Windows NT operating system). The test case consists of the following: 9 roadways, 1 barrier (with 3 perturbations up and down), 2 terrain lines, and 32 receivers.

Run-Time (hrs) Versus Computer Platform*

Windows Operating System	Pentium 90	Pentium Pro 200	Pentium 166	Pentium 200	Pentium II 300
3.1	19	11	10	8	5
95	20	18	11	9	6
NT 4.0/3.51	12	8	7	6	4

*Note: The fastest, tested computer platform for TNM is currently a Pentium II 300 running Windows NT Version 4 or 3.51.

The recommended computer system requirements for TNM Version 1.0 are:

- Computer: IBM-compatible PC;
- Processor: 120 MHZ Pentium (or faster);
- Memory: 32 MB (or more);
- Disk Drive: 3.5 inch, 1.44 MB;
- Mouse input device;
- Monitor: Accelerated Super VGA (1024 x 768), 16 colors, configured with "small" fonts;
- Software: Microsoft® Windows 3.1 (or later): Note: TNM will run under Microsoft® Windows 95 or Windows NT, however, TNM is a 16-bit program and will not take full advantage of the 32-bit architecture associated with Windows 95 or NT.
- 10 MB of hard-disk space for the TNM system (including sample runs); and
- Up to 1 MB of hard-disk space for each TNM run.

Although TNM may run on a less efficient computer than recommended above, some capabilities may be affected, including the graphical user interface or the speed of the noise calculations. If you have a lower-grade monitor, you will often have to slide the input forms left and right as you enter input. More importantly, TNM will clip some information during input and you will not be able to enter some information at the far right of input headers. For this reason, lower-resolution monitors and even Super VGA monitors without built-in "small fonts" are not compatible with TNM.

Optional digitizer: If you wish to digitize coordinates from plan sheets or roadway profiles, you will need the following:

- **Digitizer:** Any manufacturer/model that meets the LCS/Telegraphics Wintab Interface Specification, preferably with a 16-button puck.

Your digitizer will work with TNM if you find a file called WINTAB.DLL on your hard disk. If not, obtain WINTAB.DLL from your digitizer manufacturer and install it as the manufacturer instructs.



Potential conflict between WINTAB.DLL files: TNM's installation program puts a copy of WINTAB.DLL in directory TNM\PROGRAM on your hard disk. This version of WINTAB.DLL works for some digitizers. Unfortunately, it interferes with other digitizers. If your digitizer does not work with TNM, then delete the file TNM\PROGRAM\ WINTAB.DLL. Be careful not to delete your own digitizer's version of WINTAB.DLL, which should be in some other directory.

Without a digitizer, you will still be able to type coordinates into TNM's input dialogs. In addition, you will be able to import coordinates from STAMINA 2.0/OPTIMA input files (see Section 4.7.1) and from DXF files made by CAD (computer-aided design) programs (see Section 4.7.2), e.g., Intergraph MicroStation®, and AutoCAD®. The optional 16-button puck will allow you to enter Z coordinates from the digitizer, using the puck's alphanumeric keypad. Without this capability, you will still be able to enter Z coordinates from your computer keyboard.

1.4 Installation

To install TNM on your computer:

1. Insert the TNM CD-ROM into your CD-ROM drive.
2. Within the Windows Program Manager, select Run from the main menu. Type Drive:SETUP.EXE, and then press Return.
3. When the Custom Installation box appears on your screen, select Set Location to tell the setup program where to locate TNM on your hard drive.



Location of TNM on your hard drive: You may locate TNM anywhere on your hard drive. The default location is in your root directory, C:\. Many people locate their computer programs and data files in separate directories, to better organize their work. Installed TNM subdirectories and files are listed in Section 1.5.

Then after the setup program is done, configure your computer display to work with TNM:

1. Click on the Windows Setup icon in the Main program group, or find and run WINSETUP.EXE or SETUP.EXE, which should be in the Windows subdirectory on your hard drive.
2. Select Options, Change System Settings from WINSETUP's main menu.

3. Click the down-arrow next to Display, and then select a display with the following characteristics:
 - Resolution: 1024 x 768 or greater
 - Colors: 16 or greater
 - Font size: smallest available, which is often called “small” or sometimes “normal.” Note that this is not your word processor's font size. Instead, this is the font size for the computer display. It will make all your fonts smaller, in all your programs. If you find no font sizes listed through WINSETUP.EXE, follow the next set of instructions instead of this set.
4. Select OK and then Options, Exit.

If you found no font sizes listed through WINSETUP.EXE or SETUP.EXE:

1. Find and run the setup program that came with your computer's monitor and display card.
2. Find the location within the program where you can change your display's resolution. Change it to 1024 x 768 or greater.
3. Also find the location where you can change your display's number of colors. Change it to 16 or greater.
4. Also find the location where you can change your display's font size. Often you must press Advanced to find your font-size choices. Change size to the smallest font size listed there. If you cannot find font-size options within your computer display's setup program, call the monitor manufacturer to ask about font size. TNM requires “small” display fonts.
5. When your setup program asks to restart Windows, answer Yes.

If the TNM icon does not show up within Windows after installation:

1. Determine your Windows directory: *[YourWindowsDirectory]*. Most often, it is C:\WINDOWS.
2. Add the following line to your AUTOEXEC.BAT file:

```
SET WINDIR=[YourWindowsDirectory]
```

Do not include any spaces in this line of text, other than the space between SET and WINDIR. In addition, do not end the line with a period.

Example: SET WINDIR=C:\WINDOWS

To set up your digitizer:

1. Install your digitizer according to its manufacturer's instructions.
2. Always turn on your digitizer before starting TNM.

TNM test case:

A TNM official test case is included in each TNM software package (see Appendix E).



See Appendix A for FHWA policy related to TNM test cases.

1.5 TNM Files

1.5.1 Subdirectories and files installed with TNM. Table 1 describes the subdirectories and files installed with TNM.



File deletion: Please be careful not to delete or rename any files installed with TNM. If you delete/rename any of them by accident, then restore them to your hard disk by re-installing TNM. Re-installation will not disturb your own input files.

Table 1. Files installed with TNM.

Subdirectory	File	Purpose
TNM/EXAMPLES/RESULTS	MARSTON.DXF STAMINA.DAT	Sample DXF file, for import into TNM. Sample STAMINA 2.0/OPTIMA input file, for import into TNM.
TNM/HELP	*.WRI FHWA.HLP TNM.HLP	Last minute notes for you to read. FHWA policy portion of TNM's built-in help. The remainder of TNM's built-in help.
TNM/PROGRAM	*.DLL TXT.DSC TNM.EXE FHWA.HLP TNM.HLP USDOT.ICO CHKLIST.MS *.WRI	Various dynamic link libraries used by TNM An auxiliary file needed by TNM to display text. The TNM program, itself. An auxiliary file needed to display the FHWA policy portion of TNM's built-in help. An auxiliary file needed to display TNM's built-in help. The US DOT icon, used within TNM. An auxiliary file used by TNM. Last minute notes for you to read.
TNM\PROGRAM\DICT	_OBJECTS.DAT _OBJECTS.IDX	Initiation file for new TNM run. Initiation file for new TNM run.
TNM\PROGRAM\NMPLOT	*.*	Miscellaneous files needed to run NMPLOT Version 3.05, which TNM uses to draw contours from TNM's computed sound levels.

1.5.2 Files imported into TNM. You can import two types of files into TNM (see Section 4.7):

- DXF files made by CAD programs such as Intergraph MicroStation[®], and AutoCAD[®];
- STAMINA 2.0/OPTIMA input files, which are usually identified with a .DAT file extension. Note: TNM will only import official STAMINA 2.0/OPTIMA input files.

TNM comes with one of each file type. You supply actual files for your own projects. You may put these files anywhere you wish on your hard drive, or even on floppy disks. You may also give them any extension you wish. TNM recognizes them by their content, not their extension.

1.5.3 Files generated by TNM. As you input data into TNM, calculate sound levels, design barriers and so forth, you must periodically save your input/results to your hard drive. TNM

automatically creates a separate subdirectory on your hard disk for each of your TNM "runs." You will decide its name when you first save the run (Select File, Save in the main menu). In each directory, TNM then stores everything about that run, in files of various types.



File deletion: Please be careful not to delete or rename any files generated by TNM. If you do, you will lose information about your input and/or results.

1.6 Screen Savers and TNM, Version 1.0

Please exercise the following precaution when using TNM, Version 1.0:

- Screen savers: TNM sometimes crashes when certain screen savers start to save. If this happens to you, please discontinue your screen saver when running TNM.

1.7 Source Code Licensing Agreement

The FHWA TNM is a registered copyright and trademark, which encompasses the User's Guide, Technical Manual, and software source and executable codes. For developers interested in obtaining the software source code, acceptance of the TNM Source Code Licensing Agreement is a prerequisite. Under the terms of the Licensing Agreement, any modifications, enhancements, or derivatives of TNM, as well as distribution of the modified source code, which makes reference to the FHWA's trademarks, are strictly prohibited without the express written permission of the FHWA.



See Appendix A for FHWA policy related to TNM Copyright and Trademark.

1.8 Technical Support

Services are available to help you with your questions. Be sure to send in the TNM registration card located on the last page of this User's Guide. Registered owners are entitled to receive technical support and information on upgrades and supplementary guides. For installation and supplementary guide information, users may contact the Center for Microcomputers in Transportation (McTrans) at (352) 392-0378, or on the World Wide Web (<http://www-mctrans.ce.ufl.edu>). For technical support, users may contact the Volpe Center, Acoustics Facility at (617) 494-2372, or FHWA at (202) 366-2073.

2. TERMINOLOGY

This section presents pertinent terminology used throughout the User's Guide. These terms are highlighted with boldface type when they first appear in subsequent sections. Note: Definitions are generally consistent with those of References 6 through 9.

A-WEIGHTING: A weighting network used to account for changes in level sensitivity as a function of frequency. The A-weighting network de-emphasizes the high (6.3 kHz and above) and low (below 1 kHz) frequencies, and emphasizes the frequencies between 1 kHz and 6.3 kHz, in an effort to simulate the relative response of the human ear.

ACOUSTIC ENERGY: Commonly referred to as the mean-square sound-pressure ratio, sound energy, or just plain energy, acoustic energy is the square of the ratio of the mean-square sound pressure (often frequency weighted), and the reference mean-square sound pressure of 20 :Pa, the threshold of human hearing. It is arithmetically equivalent to $10^{(\text{SPL}/10)}$, where SPL is the sound pressure level, expressed in decibels.

COMMUNITY NOISE EQUIVALENT LEVEL (CNEL, denoted by the symbol, L_{den}): A 24-hour time-averaged L_{AE} (see definition on Page 10), adjusted for average-day sound source operations. In the case of highway noise, a single operation is equivalent to a single vehicle pass-by. The adjustment includes a 5-dB penalty for vehicle pass-bys occurring between 1900 and 2200 hours, local time, and a 10-dB penalty for those occurring between 2200 and 0700 hours, local time. The L_{den} noise descriptor is used primarily in the State of California. L_{den} is computed as follows:

$$L_{\text{den}} = L_{\text{AE}} + 10 \cdot \log_{10}(N_{\text{day}} + 3 \cdot N_{\text{eve}} + 10 \cdot N_{\text{night}}) - 49.4 \quad (\text{dB})$$

where:

- L_{AE} = Sound exposure level in dB (see definition on Page 10);
- N_{day} = Number of vehicle pass-bys between 0700 and 1900 hours, local time;
- N_{eve} = Number of vehicle pass-bys between 1900 and 2200 hours, local time;
- N_{night} = Number of vehicle pass-bys between 2200 and 0700 hours, local time; and
- 49.4 = A normalization constant which spreads the acoustic energy associated with highway vehicle pass-bys over a 24-hour period, i.e., $10 \cdot \log_{10}(86,400 \text{ seconds per day}) = 49.4 \text{ dB}$.



In accordance with the technical definition, a 5-dB penalty is added to evening operations when computing the L_{den} noise metric. The 5-dB penalty, expressed in terms of a weighting factor, is equivalent to 3.16 not 3. However, in Title 21 Subchapter 6, 5001 of California state law, a factor of 3 is used. Since the State of California is the primary user of the L_{den} metric, it was decided that TNM would be consistent with state law, rather than the traditional technical definition. It is anticipated that this subtle difference will be of no practical consequence in the computations.

CONTOUR: Graphical plot consisting of a smooth curve, statistically regressed through points of equal level.

DAY-NIGHT AVERAGE SOUND LEVEL (DNL, denoted by the symbol, L_{dn}): A 24-hour time-averaged L_{AE} (see definition on Page 10), adjusted for average-day sound source operations. In the case of highway noise, a single operation is equivalent to a single vehicle pass-by. The adjustment includes a 10-dB penalty for vehicle pass-bys occurring between 2200 and 0700 hours, local time. L_{dn} is computed as follows:

$$L_{dn} = L_{AE} + 10 * \log_{10}(N_{day} + N_{eve} + 10 * N_{night}) - 49.4 \quad (\text{dB})$$

where:

- L_{AE} = Sound exposure level in dB (see definition on Page 10);
- N_{day} = Number of vehicle pass-bys between 0700 and 1900 hours, local time;
- N_{eve} = Number of vehicle pass-bys between 1900 and 2200 hours, local time;
- N_{night} = Number of vehicle pass-bys between 2200 and 0700 hours, local time; and
- 49.4 = A normalization constant which spreads the acoustic energy associated with highway vehicle pass-bys over a 24-hour period, i.e., $10 * \log_{10}(86,400 \text{ seconds per day}) = 49.4 \text{ dB}$.

DECIBEL (dB): A unit of measure of sound level. The number of decibels is calculated as ten times the base-10 logarithm of the square of the ratio of the mean-square sound pressure (often frequency weighted), and the reference mean-square sound pressure of 20 :Pa, the threshold of human hearing.

DEGRADATION: The increase in noise levels at receivers due to multiple reflections of the noise between parallel barriers.

DIFFRACTED WAVE: A sound wave whose front has been changed in direction by an obstacle in the propagation medium, typically air for the purposes of this User's Guide.

DIVERGENCE: The spreading of sound waves from a source in a free field environment. In the case of highway noise, two types of divergence are common, spherical and cylindrical. Spherical divergence is that which would occur for sound emanating from a point source, e.g., a single vehicle pass-by. It is independent of frequency, and is computed using a $20 * \log_{10}(d1/d2)$ relationship. For example, if the sound level from a point source at 15 m was 90 dB, at 30 m it would be 84 dB due to divergence, i.e., $90 + 20 * \log_{10}(15/30)$. Cylindrical divergence is that which would occur for sound emanating from a point source moving along a line, or a line source, e.g., a continuous stream of roadway traffic. It is independent of frequency, and is computed using a $10 * \log_{10}(d1/d2)$ relationship. For example, if the sound level from a line source at 15 m was 90 dB, at 30 m it would be 87 dB due to divergence, i.e., $90 + 10 * \log_{10}(15/30)$.

DXF: Drawing Exchange Format (CAD graphics data in a text format)

EQUIVALENT SOUND LEVEL (TEQ, denoted by the symbol, L_{AeqT}): Ten times the base-10 logarithm of the square of the ratio of time-average, mean-square, instantaneous A-weighted sound pressure, during a stated time interval, T (where $T=t_2-t_1$), and the reference mean-square sound pressure of 20 :Pa, the threshold of human hearing, e.g., 1HEQ, denoted by the symbol, L_{Aeq1H} , represents the hourly equivalent sound level. L_{AeqT} is related to L_{AE} by the following equation:

$$L_{AeqT} = L_{AE} - 10 * \log_{10}(t_2-t_1) \quad (\text{dB})$$

where L_{AE} = Sound exposure level in dB (see definition on Page 10).

EXISTING LEVEL: The measured or calculated existing noise level at a given location.

FREE FIELD: A sound field whose boundaries exert a negligible influence on the sound waves. In a free-field environment, sound spreads spherically from a source and decreases in level at a rate of 6 dB per doubling of distance from a point source, and at a rate of 3 dB per doubling of distance from a line source.

GRADE: The slope of the roadway, or roadway segment (expressed in percent). For example, a roadway that is 400 m in length and its end is 20 m higher in elevation relative to its start, has a 5-percent grade, i.e., $20/400 * 100$ percent. Note: TNM does not consider a roadway to have a grade unless the grade is 1.5 percent or greater.

GROUND ATTENUATION: The change in sound level, either positive or negative, due to intervening ground between source and receiver. Ground attenuation is a relatively complex acoustic phenomenon, which is a function of ground characteristics, source-to-receiver geometry, and the spectral characteristics of the source. A commonly used rule-of-thumb for propagation over soft ground (e.g., grass) is that ground effects will account for about 1.5 dB per doubling of distance. However, this relationship is quite empirical and tends to break down for distances greater than about 30.5 to 61 m (100 to 200 ft).

GROUND IMPEDANCE: A complex function of frequency relating the sound transmission characteristics of a ground surface type. Measurements to determine ground impedance must be made in accordance with the ANSI Standard for measuring ground impedance, scheduled for publication in 1998.¹⁰

GUI: Graphical User Interface.

HARD GROUND: Any highly reflective surface in which the phase of the sound energy is essentially preserved upon reflection; examples include water, asphalt, and concrete.

IMPACT CRITERION LEVEL: The level defined by a State Highway Agency (SHA). It should be at least 1 dBA less than FHWA's appropriate Noise Abatement Criterion.

INSERTION LOSS (IL): The difference in level before and after installation of a barrier, where the source, terrain, ground, and atmospheric conditions have been judged as equivalent.

L_{AE}: See Sound exposure level.

L_{AeqT}: See Equivalent sound level.

L_{den}: See Community noise equivalent level.

L_{dn}: See Day-night average sound level.

LINE-OF-SIGHT: Refers to the direct path from the source to receiver without any intervening objects or topography.

LINE SOURCE: A single point source moving along a line, or multiple point sources moving in one direction radiating sound cylindrically. Note: Sound levels measured from a line source decrease at a rate of 3 dB per doubling of distance.

NOISE: Any unwanted sound. “Noise” and “sound” are used interchangeably in this document.

NOISE BARRIER: The structure, or structure together with other material, that potentially alters the noise at a site from a BEFORE condition to an AFTER condition.

NOISE REDUCTION COEFFICIENT (NRC): A single-number rating of the sound absorption properties of a material; it is the arithmetic mean of the Sabine absorption coefficients (see below) at 250, 500, 1000, and 2000 Hz, rounded to the nearest multiple of 0.05.

NOISE REDUCTION GOAL: The amount of noise reduction that is desired. This value should be defined by a respective SHA and should typically be in the range of 5-10 dBA. Noise barriers must provide at least a 5-dBA reduction in highway traffic noise levels in order to provide noticeable and effective attenuation. A noise barrier should be designed to achieve the greatest reduction possible, but in no instance less than 5 dBA.

PARALLEL BARRIER: The condition where two noise barriers flank a roadway, i.e., one on each side.

PERTURBATION The height increment that a noise barrier’s input height is increased (perturbed up) or decreased (perturbed down) during the barrier design process.

POINT SOURCE: Source that radiates sound spherically. Note: Sound levels measured from a point source decrease at a rate of 6 dB per doubling of distance.

REMEL: Reference Energy Mean Emission Level.

SABINE ABSORPTION COEFFICIENT (α_{Sab}): Absorption coefficient obtained in a reverberation room by measuring the time rate of decay of the sound energy density with and without a patch of the sound-absorbing material under test laid on the floor. These measurements are performed in accordance with the American Society of Testing and Materials (ASTM) Standard C 423-90a.¹¹

SOFT GROUND: Any highly absorptive surface in which the phase of the sound energy is changed upon reflection; examples include terrain covered with dense vegetation or freshly fallen snow. (Note: at grazing angles greater than 20 degrees, which can commonly occur at short ranges, or in the case of elevated sources, soft ground becomes a good reflector and can be considered hard ground).

SOUND ABSORPTION COEFFICIENT (α): (See also Sabine Absorption Coefficient) The ratio of the sound energy, as a function of frequency, absorbed by a surface, to the sound energy incident upon that surface.

SOUND EXPOSURE LEVEL (SEL, denoted by the symbol, L_{AE}): Over a stated time interval, T (where $T=t_2-t_1$), ten times the base-10 logarithm of the ratio of a given time integral of squared

instantaneous A-weighted sound pressure, and the product of the reference sound pressure of 20 :Pa, the threshold of human hearing, and the reference duration of 1 sec. The time interval, T, must be

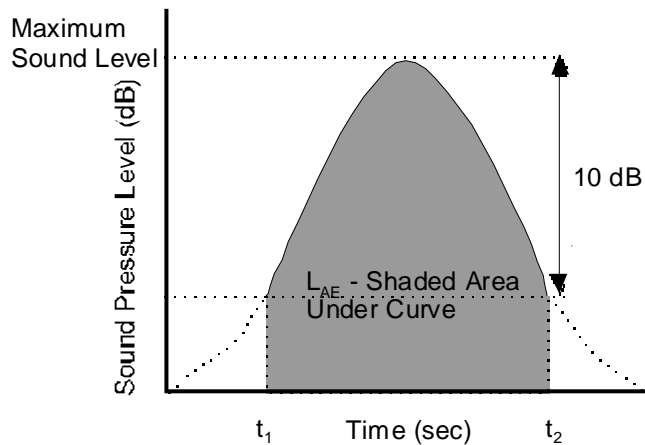


Figure 1. Graphical representation of LAE.

long enough to include a majority of the sound source’s acoustic energy. As a minimum, this interval should encompass the 10 dB down points (see Figure 1).

In addition, LAE is related to LAeqT by the following equation:

$$L_{AE} = L_{AeqT} + 10 \cdot \log_{10}(t_2 - t_1) \tag{dB}$$

where LAeqT = Equivalent sound level in dB (see definition above).

SOUND PRESSURE LEVEL (SPL): Ten times the base-10 logarithm of the square of the ratio of the mean-square sound pressure, in a stated frequency band (often weighted), and the reference mean-square sound pressure of 20 :Pa, the threshold of human hearing.

$$SPL = 10 \cdot \log_{10}(p^2 / p_{ref}^2) \tag{dB}$$

where:

p = mean-square sound pressure; and

p_{ref} = reference mean-square sound pressure of 20 :Pa.

SPECTRUM: A signal's resolution expressed in component frequencies or fractional octave bands.

TOLERANCE: The allowable maximum difference between computed noise values and linearly-interpolated noise values at a given observer point (applicable for TNM contour computations only).

3. OVERVIEW OF PROGRAM

This section:

- Introduces the main screen of TNM, including TNM's main menu
- Describes TNM's graphical views, input dialogs, and tables -- including how to manipulate them with the main menu and keyboard; and
- Overviews TNM's six main procedures, which appear explicitly in its main menu:
 - Setup;
 - Input;
 - Calculate;
 - Barrier Analysis;*
 - Parallel Barriers; and
 - Contours.

3.1 The Main Screen

Figure 2 shows TNM's main screen, including a plan view of an existing TNM run, an output table and an input dialog box. Sections 3.1.1 through 3.1.10 discuss the major screen items shown in Figure 2.

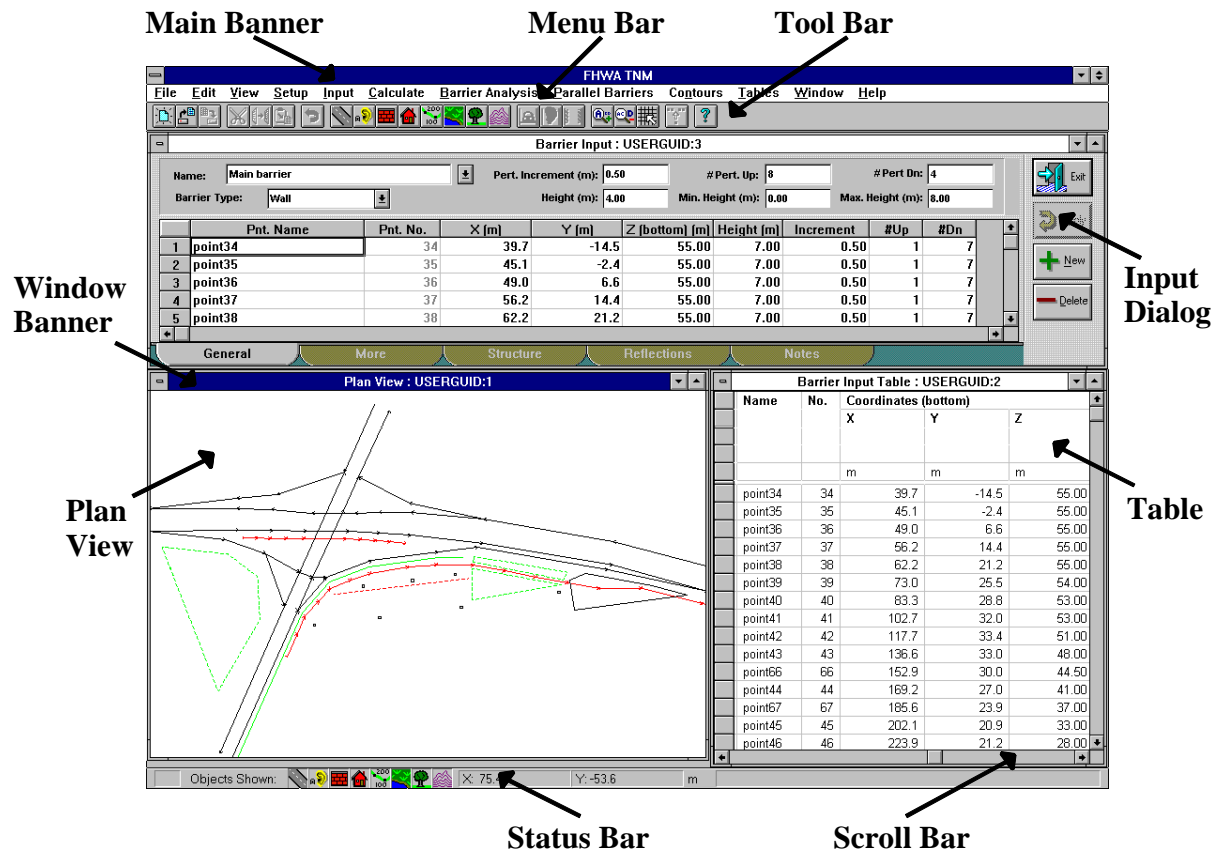


Figure 2. The TNM screen.

* As previously noted, all terms defined in the Terminology section (see Section 2) are highlighted when they first appear in the main body of the text of this User's Guide.

3.1.1 Main Banner. The main banner shows the name of the window you have maximized. When you maximize a window by double-clicking its window banner, or by clicking on the up arrow in the upper-right corner of the window, that window fills the entire screen. Upon first invoking the TNM program, the main banner shows “FHWA TNM.”

3.1.2 Window Banners. A window banner shows the name of the opened window and its associated run name. Note: When you have more than one window open/displayed, the window whose banner is highlighted, is the "active" window. All editing/inputting is done in the active window. Any non-active windows, dynamically linked to the active window, will be able to effect those edits. To activate a window, use the mouse to click anywhere on that window. That window's banner will then be highlighted. Once a window is “active,” you may move the position of that window by holding down the left mouse button on the window banner, and dragging the entire window to a new desired position. In Figure 2, the Plan View is the active window.

3.1.3 Menu Bar. The Menu Bar allows you to invoke all TNM functions. Following are available pull-down menus: File, Edit, View, Setup, Inut, Calculate, Barrier Analysis, Parallel Barriers, Contours, Tables, Window, and Help. Display pull-down menus by using a mouse to select a menu name from the Menu Bar. Menu items that offer a sub-menu have an arrow following. All currently selectable menu and sub-menu options are displayed in **bold**. You can also use keyboard shortcuts to select menus, menu items, and sub-menus (see Section 3.1.7).

3.1.4 Scroll Bars. Horizontal and vertical scroll bars are provided to pan your active viewing window. Panning is particularly useful when you are using a zoomed-in view.

3.1.5 Tool Bar. The Tool Bar provides quick access to editing and zoom features, as well as input objects. Note: When you point to a Tool Bar icon, TNM displays a short description of the icon's function in the Status Bar (see Section 3.1.6). The Tool Bar contains the following tools:



The File New Tool for creating a new run (see Section 4.2);



The File Open Tool for opening a previously saved run (see Section 4.3);



The File Save Tool for saving the current run (see Section 4.4);



The Cut Tool for cutting a selection and placing it on the Windows clipboard (see Section 5.2);



The Copy Tool for copying a selection and placing it on the Windows clipboard (see Section 5.3);



The Paste Tool for inserting Windows clipboard contents at the insertion point (see Section 5.4);



The Undo Tool for reversing the last edit operation performed (see Section 5.1);



The *Roadway Input Tool* for graphically inputting a roadway in a plan view (see Section 8.3);



The *Receiver Input Tool* for graphically inputting receivers in a plan view (see Section 8.4);



The *Barrier Input Tool* for graphically inputting a barrier in a plan view (see Section 8.5);



The *Building Row Input Tool* for graphically inputting a building row in a plan view (see Section 8.6);



The *Terrain Line Input Tool* for graphically inputting a terrain line in a plan view (see Section 8.7);



The *Ground Zone Input Tool* for graphically inputting a ground zone in a plan view (see Section 8.8);



The *Tree Zone Input Tool* for graphically inputting a tree zone in a plan view (see Section 8.9);



The *Contour Zone Input Tool* for graphically inputting a contour zone in a plan view (see Section 8.10);



The *Parallel Barrier Source Tool* for graphically inputting a roadway during Parallel Barrier analysis (see Section 11.5);



The *Parallel Barrier Receiver Tool* for graphically inputting analysis locations during Parallel Barrier analysis (see Section 11.7);



The *Parallel Barrier Surface Tool* for graphically inputting a cross section during Parallel Barrier analysis (see Section 11.6);

The *Zoom-In Tool* for magnifying a user-defined area (see Section 6.3);





The *Zoom-Out Tool* for reducing the current view by 25 percent (see Section 6.4);





The *Snap Tool* for snapping the cursor to objects or points of objects.



The Snap tool is helpful during (1) input, e.g., creating a barrier exactly parallel to a roadway. To

do this, click  , then  , then click mouse over the roadway points. Double-click the mouse to end input. Move the barrier (see Section 5.7) to the final desired offset position relative to the roadway; and (2) parallel barrier analysis input, e.g., adding an additional surface to the

parallel barrier cross section. To do this, click  , then  , then click mouse on the existing surface point that you will snap to, then click to create new surface points. Double-click the mouse to end input.




The *Interpolate Tool* for interpolating Z coordinates from pre-existing points in a Roadway Profile View; and



The Interpolate tool can only be active when a Roadway Profile View is active. It, in conjunction with the roadway input tool, is used to graphically move an existing point's elevation (Z coordinate), on a roadway, or roadway segment. In the Plan View, select a desired roadway, or roadway segment (see Section 5.5), then open a Roadway Profile View (see Section 6.1.2). Click

on . The cursor becomes .

To move an existing point's elevation, click the cursor at a horizontal position where a roadway point already exists, but at a different elevation (note: the cursor guides help you to ensure you are directly over the desired existing point). TNM will then move the existing point to the new Z coordinate where the cursor is positioned.

Note (1): To create a new point at a desired Z coordinate, click  to de-activate the tool, then click new points at desired horizontal and vertical coordinates (H and Z) relative to the existing roadway (note: the cursor guides help you to avoid creating new point directly over existing roadway points, or horizontally beyond the furthest start/end point of the roadway). TNM will then automatically use existing roadway points left and right of each new point to interpolate the new point's H and Z coordinates.

Note (2): To simply add a point exactly in the middle of two existing points, see Section 5.8.



The Help Tool for invoking TNM help (see Section 15).

3.1.6 Status Bar. The Status Bar appears at the bottom of the TNM screen. It gives you information on your currently selected menu item, object, or action, and displays which types of items are shown in the active window. It also provides the coordinates of the current cursor position, if the active view is a graphic.

3.1.7 Keyboard Shortcuts. TNM provides keyboard shortcuts for choosing menus, menu items, and sub-menus. All main menus and many sub-menu and menu items have an underlined letter within the command. All you need to do is press the Alt key and the associated keyboard letter in sequence to use a shortcut. For example, to create a skew section: press Alt+V for the View menu, then N to select New View, then S to select Skew Section.

In addition, TNM provides several keyboard shortcuts for the menu items available in the View menu. To zoom-in 25 percent, press the PgUp key. To zoom-out 25 percent, press the PgDn key. To pan the view, use the arrow keys, or depress the left mouse button and drag to a new position. In Perspective Views, the view can be rotated in all directions by using the Ctrl and arrow keys. Information on Keyboard Shortcuts is also available in the Help menu.

3.1.8 Graphical Views.

Table 2 describes the purpose of TNM's graphical views and lists the other views and tables you will normally use, concurrently. Section 6 describes these graphical views in more detail. In addition, their

specific uses during input appear in Section 8. In addition, their uses during barrier analysis, parallel-barrier analysis and contouring appear in Sections 10, 11, and 12 respectively.

Table 3 describes how to manipulate graphical views using the main TNM menu. You may also manipulate graphical views with the keyboard or mouse, as described in Table 4. Section 6 describes these view-manipulation options in more detail.


Table 2. Summary of TNM's graphical views.

View	General purpose	Concurrently use	For this purpose
<u>P</u> lan view	Digitize coordinates. Look at everything in plan.	Input dialogs Input tables	To input text To observe multiple input objects at the same time
<u>R</u> oadway profile	Digitize roadway Z coordinates.	Roadway input dialog Roadway input table	
<u>S</u> kew section	Investigate breaks in lines of sight between roadways and receivers.	Plan View	To locate skew section
<u>P</u> erspective view	Look at everything in perspective, especially barrier shapes as you input barrier heights.	Plan View	

Table 3. Manipulation of TNM graphical views using the main menu.

To cause this	Menu item	And then	TNM will then
Zoom in	<u>V</u> iew, <u>Z</u> oom <u>I</u> n	Draw a rectangle.	Zoom in to fill the screen with your rectangle.
Zoom out	<u>V</u> iew, <u>Z</u> oom <u>O</u> ut		Zoom out by approximately 25 percent.
Locate an item in all views (selected in all views)	<u>V</u> iew, <u>C</u> enter View by Item		Center the selected item in the graphical view. You must have only one item selected.
Pan	<u>V</u> iew, <u>P</u> an <u>L</u> eft (or <u>R</u> ight, etc.)		Pan the view left (or right, etc.) by approximately 25 percent.
Rotate	<u>V</u> iew, <u>R</u> otate <u>C</u> lockwise (or <u>C</u> ounter-Clockwise)		Rotate the entire view clockwise (or counter-clockwise) by approximately 15 degrees.
Show everything	<u>V</u> iew, <u>F</u> ull		Zoom out or in, as needed, to fill the screen with your full input.
Get rid of unwanted line remnants	<u>V</u> iew, <u>R</u> ed <u>r</u> aw View		Redraw the view.

Table 4. Manipulation of graphical views.

To cause this	Do this	TNM will then
Zoom in	Press PgUp.	Zoom in by approximately 25 percent.
Zoom out	Press PgDn.	Zoom out by approximately 25 percent.
Pan	Press an arrow key. OR	Pan the entire view in the arrow's direction by approximately 25 percent.
Pan	Hold the left mouse button down for 2 seconds. After the cursor changes to  , then drag the mouse.	Pan the entire view by the amount you dragged the mouse.
Rotate a Perspective View	Press Ctrl+Arrow	Rotate the entire view in increments of approximately 15 degrees.

3.1.9 Input Dialogs. TNM input dialogs accept all your text input. Typically, you will enter your objects using a digitizer or mouse; however, you can also type coordinates into these dialogs to enter object coordinates. You enter input with input dialogs, discussed above, not with TNM tables. Section 8 details the entire TNM input process. Conversely, you print data from graphical views and tables, not with input dialogs. Figure 3 shows a typical TNM input dialog.

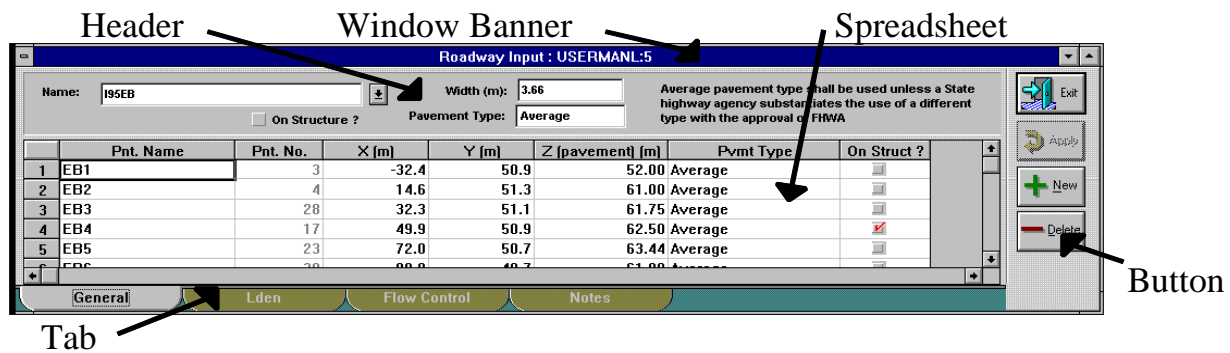





Figure 3. Typical input dialog.

Each input dialog refers to one type of TNM object -- for example, one roadway. The type of object appears in its window banner. Below the banner is a header area, which refers to the entire object. Below the header is a spreadsheet area, with one row for each segment. Below the spreadsheet are several "tabs." When you click a tab, the header and spreadsheet show information pertaining to that tab. At the right of the input dialog are the following buttons:

-  : Exits the input dialog, after prompting you to "apply" changes you have made.

-  : Applies your changes to the run's database and thereby to the graphical views and tables that are open on the screen.
-  : Starts a new input object of this type.
-  : Deletes this entire input object (not just a segment of it), after confirmation.

You can resize, minimize, maximize, tile, or cascade dialog boxes in the normal Windows manner (see Section 14). If you narrow them, however, you may cut off their header information at the right. With some restrictions, you can also edit, copy, paste, and cut spreadsheet information in the normal spreadsheet manner (see Section 5).

3.1.10 Tables. TNM tables provide input and result summaries for documentation and printout purposes only. In addition, they show results of TNM calculations, so you may watch sound levels change as you move barrier tops up and down. You enter input with input dialogs, discussed above, not with TNM tables. Conversely, you print data from graphical views and tables, not with input dialogs. Section 13 describes all available TNM tables.

Figure 4 shows a typical TNM table. At the top of the table is header information that pertains to your TNM run: general information and project information. The bulk of the table documents your input or results data for this run, one input type per table. Below the table are your “notes.”

Header

Roadway Input Table : USERGUID:2											
Company Name				Date							
User, TNM Serial Number				Version							
INPUT: ROADWAYS				Client / Contract				Average pavement type shall be used unless a State highway agency substantiates the use of a different type with the approval of FHWA			
PROJECT/CONTRACT:				C:\TNM\EXAMPLES\USERGUID							
RUN:											
Roadway Name	Width	Points		Coordinates (pavement)			Flow Control		Segment		
		Name	No.	X	Y	Z	Control Device	Speed Constraint	Percent Vehicles Affected	Pvmt Type	On Struct?
	m			m	m	m		km/h	%		
I95EB	3.7	EB1	3	-32.4	50.9	52.00				Average	
		EB2	4	14.6	51.3	61.00				Average	
		EB3	28	32.3	51.1	61.75				Average	
		EB4	17	49.9	50.9	62.50				Average	Y
Turtle Road NB	3.7	TN1	11	10.9	-67.4	54.86	Signal	0.00	40	Average	
		TN2	12	45.3	9.5	54.86				Average	
		TN3	56	53.2	26.8	54.86				Average	
		TN4	72	69.2	61.6	54.86				Average	
I95WB	3.7	WB1	31	320.3	10.1	20.00				Average	
		WB2	32	259.3	32.0	22.00				Average	
		WB3	33	209.2	45.5	32.00				Average	
Roadway12	3.7	R1	68	28.6	39.2	54.00				Average	
		R2	69	38.2	11.7	54.86				Average	
Turtle to I95WB	3.7	R1	82	69.5	81.5	54.86	Onramp	16.00	100	Average	
		R2	83	34.4	69.8	62.00				Average	
		R3	84	13.7	67.8	61.00				Average	
I95WB to Turtle Not modeled precisely. Turtle to I95WB Not modeled precisely. I95EB:EB4 Structure roadway segment. I95WB:WB7 Structure roadway segment.											

Notes

Figure 4. Typical TNM table.

TNM input tables document your input for later printout. In addition, they collect everything together for each input type, so you can observe it collectively on the screen during the input process. TNM provides the following tables to document your input:

- Sound-level Input: Roadways;
- Sound-level Input: Traffic for TNM Vehicles;
- Sound-level Input: Traffic for User-defined Vehicles;
- Sound-level Input: Receivers;
- Sound-level Input: Barriers;
- Sound-level Input: Building Rows;
- Sound-level Input: Terrain Lines;
- Sound-level Input: Ground Zone;
- Sound-level Input: Tree Zones;
- Sound-level Input: Contour Zones;
- Sound-level Input: Receiver Adjustment Factors; and
- Sound-level Input: Structure Barriers.

TNM results tables document results for each of your barrier designs (one height for each barrier segment). They allow you to watch sound-level changes as you move barrier tops up and down during barrier analysis. They also allow you to diagnose poor barrier performance, to help your barrier design better achieve your goals. TNM provides the following tables to document your results:

- Sound-level Results: Sound Levels;
- Sound-level Results: Diagnosis by Barrier Segment;
- Sound-level Results: Diagnosis by Vehicle Type;
- Barrier Descriptions; and
- Barrier-Segment Descriptions.

TNM parallel barrier tables document your parallel-barrier input and results at your chosen analysis locations. TNM provides the following parallel barrier tables:

- Parallel Barriers: Roadways for TNM Vehicles;
- Parallel Barriers: Roadways for User-defined Vehicles;
- Parallel Barriers: Cross Section; and
- Parallel Barriers: Analysis Locations.



One aspect of TNM which will enhance usability substantially is that most graphics, input dialogs, and output tables are dynamically linked. In other words, if you have a TNM Plan View on your computer display, as well as a roadway input dialog, you can select the roadway graphically (see Section 5.5), move it to a new location (see Section 5.7), and the new coordinates will be reflected in the input dialog in real time. Similarly, if you have a TNM Barrier Perspective View on your computer display, as well as a Diagnosis by Barrier Segment table, you can select a barrier segment graphically (see Section 5.5), move it up and down (see Section 10.6), and the associated barrier costs will change accordingly.

3.2 Overview of TNM Procedures

3.2.1 Primary procedures. TNM includes four primary procedures:

- Setup;
- Input;
- Calculate;
- Barrier Analysis.

These four procedures appear as shaded rectangles in Figure 5. This figure outlines these procedures, links them together, and shows their relationship to your TNM input (on the left) and printouts (on the right). Within each shaded rectangle are reminders to save your work often. Saving your TNM run will preserve everything about it on disk. Because this is most important, "Save your file" appears throughout the figure. In addition, you must remember your important barrier designs during barrier analysis, so that you can recall them later if you wish. The figure reminds you with "Remember Design."

Setup: The first shaded rectangle in Figure 5 is Setup. During setup, you enter your user information and preferences. The arrow to the left of the setup rectangle reminds you of this. Also as part of setup, you register plan sheets and other XY-coordinate input on the digitizer, so that TNM knows their scale and orientation. Digitizer registration tells TNM the position and orientation of input items on your digitizer. Section 7 details the setup procedure.

Input: The second shaded rectangle in Figure 5 is Input. During input, you enter all information from your project plans, profiles, sections, topography, maps, aerial photographs, and traffic. Shown to the right of the input rectangle, input tables and graphics document your input, both on the screen and on hard copy. You inform TNM about your input information by: (1) entering it directly with the mouse, digitizer, and/or keyboard, (2) importing STAMINA 2.0/OPTIMA input files, and/or (3) importing **DXF** files. Section 8 details TNM's input process, including detailed instructions for each type of input: roadways, receivers, barriers, building rows, terrain lines, ground zones, tree zones, and contour zones.

Calculate: The third shaded rectangle in Figure 5 is Calculate. After input, you tell TNM to calculate all the acoustics: sound emission from traffic, sound propagation, and sound reception at receivers. Barriers have an input height and a series of perturbations up and down from that height. TNM calculates for all barrier **perturbations**, up and down from your barrier input heights, to prepare for barrier analyses.

After calculation, TNM automatically sets each barrier segment to its input height, computes the resulting sound levels, and then generates various results tables. As with input tables, these results tables appear on your screen and can be printed or saved on disk. If you are interested only in your barrier input heights, without perturbations, your work with TNM is complete. However, for results of barrier segments with varying perturbations, see Section 10 to perform a Barrier Analysis. Section 9 summarizes TNM's sound-level calculations.

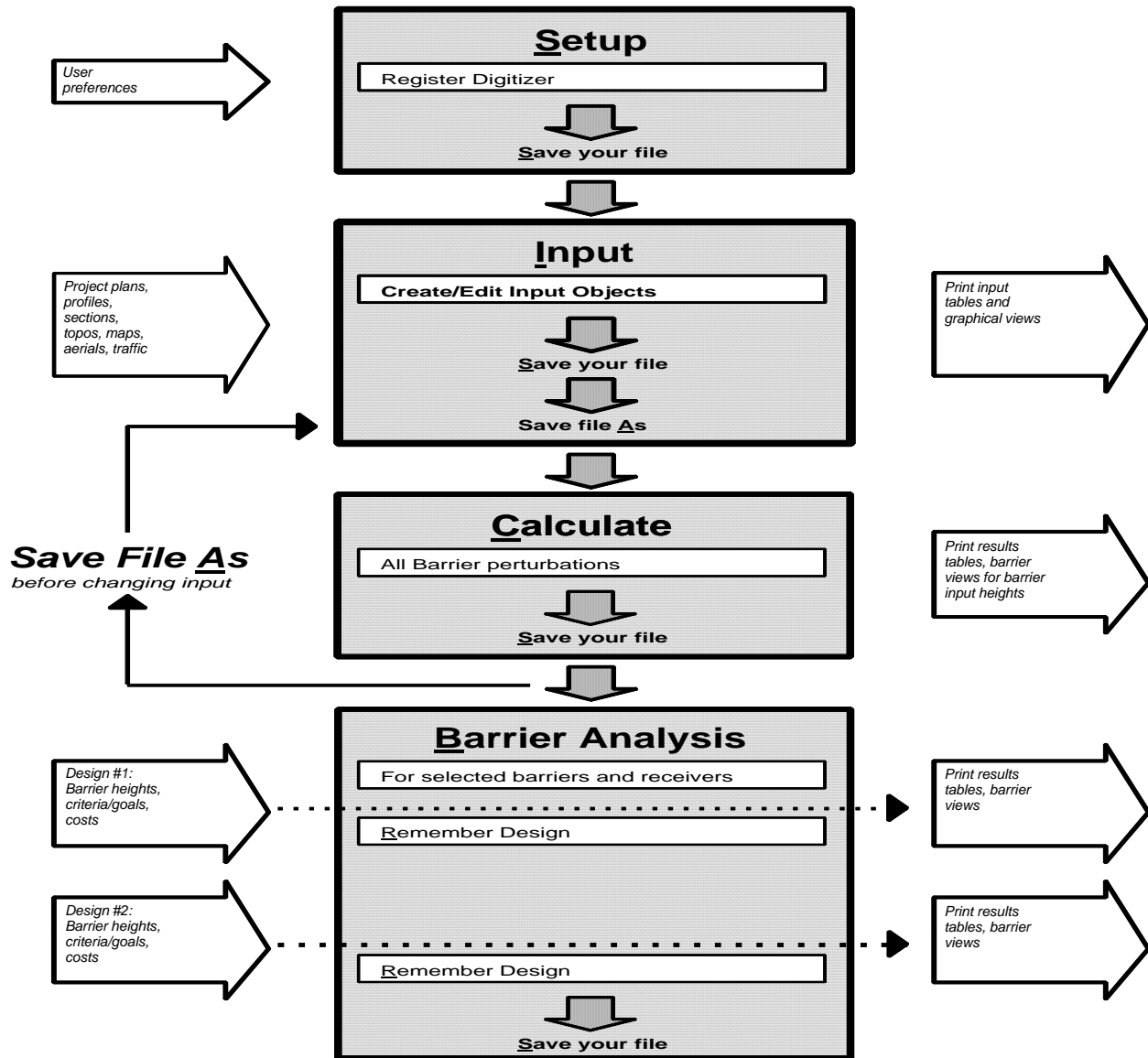


Figure 5. TNM work flow: Primary procedures.



Save your file. Figure 5 also shows a feedback loop, from Calculate and Barrier Analysis back to Interface. The loop emphasizes the importance of saving your file. When input changes, sound levels also change. So once you have calculated sound levels, always Save your original file, then use Save As (to a new file name) before changing your input. This is because, unlike most programs, TNM will not allow you to change input and then use Save As. Once you change input, TNM will force you to Save (to the old name) before it will allow you to Save As (to the new name). TNM works in this manner because multiple files, not just a single file, are saved in TNM. Keep in mind, if you try to change most types of input data (with the exception of barrier costs, additional costs, receiver **existing level**, **impact criteria level**, **noise reduction goal**, and substantial increase) after calculating without saving your original file,

TNM warns you that prior results will be lost and asks if you wish to make the change or not. In short:

- Save your original file, then
 - Save As to a new file name, and only then
 - Change your run.
-

Barrier Analysis: The fourth shaded rectangle in Figure 5 is Barrier Analysis. During barrier analysis, you investigate the sound levels for perturbed barrier heights. You may want to investigate all of the barriers and receivers in the current run, or only selected barriers and receivers. The figure shows a left-to-right arrow for each barrier design. To the left, you enter specific heights for each barrier in the design, plus specific criteria/goals for each receiver and unit barrier costs. Then TNM tabulates the resulting sound levels and barrier statistics and then generates various tables. This set of perturbed heights and barrier design goals is called a TNM barrier design.

As you experiment with different barrier heights and possibly different criteria/goals/ costs, you will find some barriers of lasting interest. These you Remember, so that they are saved along with the run's file and can be recalled later for restudy, further modification of barrier heights, or printout. Section 10 details barrier analysis within TNM.

3.2.2 Secondary procedures. TNM includes the following secondary procedures:

- Parallel Barriers;
- Contours.

These two procedures appear as shaded rectangles in Figure 6 on the following page. This figure outlines how these procedures show their relationship to TNM's primary procedures.

Parallel Barriers: The first shaded rectangle in Figure 6 is Parallel Barriers. If you wish to compute parallel-barrier **degradation**, you first locate the position of the parallel barriers on your plan view and then enter parallel barrier menu options. TNM's parallel barrier Calculate option will compute parallel-barrier degradations for the receivers you selected, which you can generalize as receiver adjustment factors. Parallel barrier tables document your input and results. Section 11 details parallel barrier analysis within TNM.

Contours: The second shaded rectangle in Figure 6 is Contours. TNM allows for three types of contours: sound-level contours, noise-reduction contours, i.e., **insertion loss** contours, and level-difference contours. For each contour set, you first enter contour zone input to tell TNM where you wish it to compute contours, plus your desired precision (contour **tolerance** and minimum grid spacing) and receiver height above the ground. TNM then uses your input to interpolate ground elevations and generate an initial contour grid of receivers at your requested height above the ground. Then you tell TNM which remembered barrier design you wish to use for this contour set. Sometimes you may use your input barrier heights; sometimes you may wish contours for a particular combination of perturbed barrier heights.

With all this input, TNM then computes sound levels at all receiver grid points. As it does this, it subdivides the initial contour grid of receivers, as necessary, to obtain your requested contour

precision. This process of subdividing results in additional grid points where sound levels vary abruptly over short distances, as near the edge of noise barriers or very close to roadways.

When calculations are complete for the subdivided grid of receivers, TNM constructs a grid file on your hard drive, which you can name for later recall. In the background, TNM then runs the internal NMPLOT Version 3.05 computer program and sends it the grid file and your current values of contour minimum level, maximum level, and level step. When NMPLOT is done, TNM displays contour results in your plan view on the screen. If you wish, you can change the minimum level, maximum level, and level step, and tell TNM to resubmit the existing grid file for additional contours. Section 12 details contours within TNM.

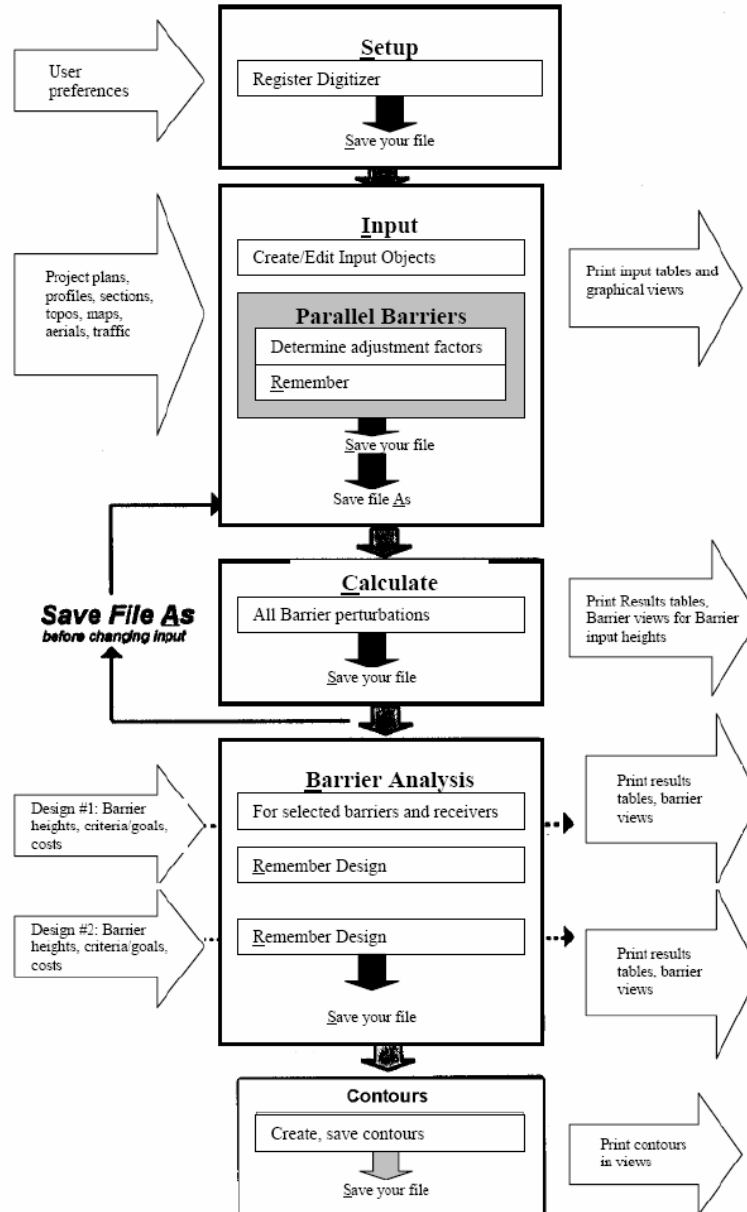


Figure 6. Expanded TNM work flow: Secondary procedures.

4. FILE MENU

The File menu contains options that allow you to create a new TNM run, as well as to open, save, and close your TNM run. In addition, the File menu allows you to import a STAMINA2.0/ OPTIMA file, as well as a DXF file. You can also enter printer information and exit TNM through this menu.

4.1 Concept of a TNM Run

Everything you do within TNM you do within a TNM "run." You enter input into a run, you calculate with that run's input, and TNM stores your results along with that input. All the barrier designs that you ask TNM to "remember," it remembers along with that run when you save it to your hard drive. Parallel-barrier sections/computations and all sets of sound-level contours are remembered/saved in the same manner. While the "File" menu name is a bit of a misnomer, it is used for consistency with most-windows based programs.

In short, when you open a TNM run, all associated attributes, e.g., input and results, are available. When you save a run on your hard drive, you save everything about it:

- All input for that run;
- All results TNM has calculated from that input.

Moreover, TNM saves everything about a single run in a single subdirectory, which you name. For this reason, if you wish to share a run with someone else, simply give that person the run's entire subdirectory.



A TNM run has only one requirement: all its input must have the same coordinate system. If your overall project has a single coordinate system -- for example, a state coordinate grid -- you might want to enter all input into a "master" run and then split the master run into smaller sub-runs for computation:


1. **Master run:** Digitize/type all input for your full project into one "master" TNM run.
2. **Runs you make from the master run:** Do not calculate or do barrier analysis with the master run, for the run is too large. It contains too many input objects too remote from too many receivers. Instead, make a series of smaller sub-runs (A, B, C, and so forth) from the complete set of input in the master run. To do this:
 - Save As: Save the master run under Run A's new name.
 - Delete: Selectively delete everything not needed for Run A.
 - Save file: Save Run A.
 - Open: Open the master run again, which will have all the original input.
 - Repeat for Run B, Run C, and so forth.

In this manner, you can duplicate selected portions of the master run in smaller individual runs, each relevant to a single barrier design, for actual calculation and barrier analysis.

4.2 New

Tool Bar: 


This selection allows you to create a new run. When you choose this option, the New dialog box appears. Proceed with the following steps:

1. Select a drive and, if desired, a directory within which to create your new run. Note: Because a TNM run is, in itself, a subdirectory of files, TNM will let you create a run anywhere, including within another run.
2. Enter a name for your new run in the Run Name input box and click . TNM creates the new run, writes a few key files into it, and then displays a blank Plan View window.

4.3 Open

Tool Bar: 

This selection will open an existing run. As with the New run selection, you can select a disk drive and a directory path name. Multiple runs can be open at the same time in TNM. When you choose this option, the Open dialog box appears. Proceed with the following steps:

1. Select the drive and directory within which your run is stored. Note: Because a TNM run is, in itself, a subdirectory of files, to open the run, click on the subdirectory.
2. Click . TNM displays the run's Plan View.


4.4 Save

Tool Bar: 

This selection will save your entire run, including barrier and parallel-barrier designs and contours. While more than one run may be open, only the active one is saved. See Section 3.1.2 for selecting a window to be active.

4.5 Save As

This selection is used to save your run under a new name. **Use this selection to rename a run prior to making any changes, if you want to keep the original run with its already computed sound level results.** When you choose this option, the Save As dialog box appears. Proceed with the following steps:

1. Save your run prior to making changes or adding input.
2. Select a drive and, if desired, a directory within which to save your run. Note: Because a TNM run is, in itself, a subdirectory, TNM will let you place your run anywhere, including within another run.
3. Enter a new name in the Run Name input box and click . Now, the file under a new name is ready for edits, while the original file remains intact.

4.6 Close

This selection will allow you to save and close the active, open run. The TNM program remains running. If data has been entered or changed, TNM will prompt you to save your data prior to closing that run.

4.7 Import

TNM will allow you to import a STAMINA 2.0/OPTIMA or a **DXF** file.

4.7.1 Import STAMINA 2.0-input file. This selection will allow you to import a STAMINA 2.0 input file into TNM (see Figure 7). Importing STAMINA 2.0 files is a completely automated process, but there are three items you should be aware of: (1) to import STAMINA shielding factors, be sure to select the check box in the import window; and (2) STAMINA alpha factors are not imported since TNM uses an entirely new methodology for computing ground effects (see Appendix D and Reference 1); and (3) files produced by modified versions of STAMINA 2.0 are not compatible with TNM's import function.

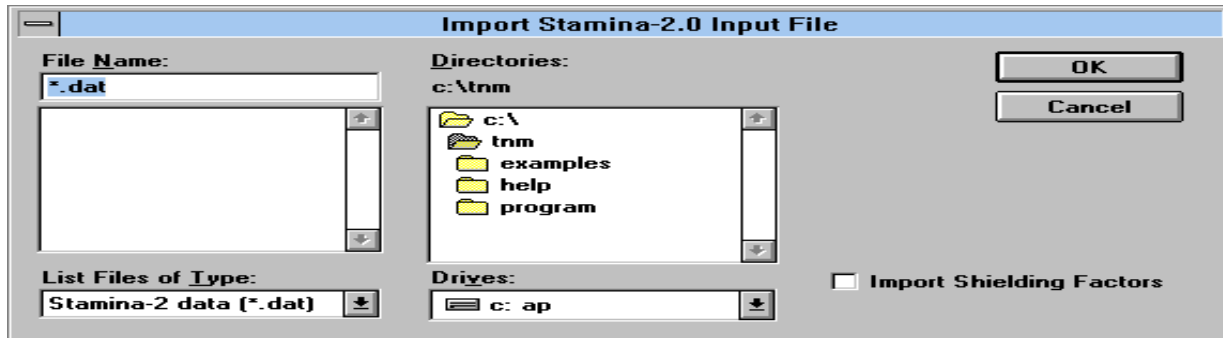


Figure 7. Import STAMINA 2.0-input file.



TNM imports shielding factors from your STAMINA files as adjustment factors (see Section 8.4.4). Typically, shielding factors in STAMINA files were used to account for things such as building row and tree zone effects. However, you may choose not to import them, but model building rows and tree zones explicitly in TNM. You may wish to input/edit TNM adjustment factors for model calibration to account for Parallel Barrier degradations between receiver-roadway pairs and propagation effects not calculated by TNM Version 1.0 -- for example, atmospheric effects.

4.7.2 Import DXF file. This selection will allow you to import a DXF file into TNM (see Figure 8). DXF is a Computer-aided Design (CAD) file format created by AutoDesk for the AutoCAD[®] software as a means of creating files that other CAD programs (e.g., Intergraph MicroStation[®]) can read, allowing CAD files to be interchanged from one program to another. They are created within a CAD program by using that CAD program's DXF-Export function.

There are two methods of importing a DXF file:

- 1.The file can be imported such that all objects and their associated attributes are preserved. Following DXF file import, convert DXF objects to TNM objects (see Section 8.16); and
- 2.If the user selects the check box, "Import as Background," TNM will import the DXF as a graphical depiction, commonly referred to as a "background" or "wallpaper." Everything that TNM can display, but which cannot be converted is imported as DXF Background. The primary purpose of importing a DXF file as Background would be to aid in the digitizing process.

When you import for conversion (i.e., not as Background), DXF labels and other text are placed in the DXF Background, which is not normally displayed by default. To view labels, you must turn select Show/Hide in the View menu, then check the “DXF Background” check box in the “Show Objects” column (see Section 6.2).



Figure 8. Import DXF file.



TNM has built into its software called TGCAD, Version 5, which is built around the AutoCAD® Release 10/11 and MicroStation® Version 4 DXF format. If your CAD program exports a later version/release DXF format, there may be some problems in reading all of the drawing elements into TNM. By saving DXF drawings in AutoCAD® as Version 10 or 11, or MicroStation® 4, some of the newer items may be converted into items that TNM can understand and be able to import properly. The following table shows the items TNM Version 1.0 can and cannot import.

DXF Import Items

DXF Item	Import object for conversion	Import as Background
Point	No	No
Line	Yes	Yes
3D-Line	Yes	Yes
Polyline	Yes *	No
Arc	Yes **	Yes
Circle	Yes **	Yes
Insert	Yes ***	Yes
Text	Yes ***	Yes
Blocks	Yes ***	Yes
Dimension Labels	Yes ***	Yes
(Others)	No	No
(Unknown)	No	No

- * Polylines are imported if the polyline or any of its vertices are complex, i.e., curve-fit, spline-fit, mesh, or polyface mesh.
- ** Arcs and circles are converted into a series of straight segments.
- *** As stated above, when you import for conversion, DXF labels and other text are placed in the DXF Background, which is not normally displayed by default. To view labels, you must turn select Show/Hide in the View menu, then check the "DXF Background" check box in the "Show Objects" column (see Section 6.2).



DXF layers. For large DXF files, you may want to “freeze” DXF file layers and import, then convert the files, incrementally. This is because TNM creates intermediate objects during import that can take up memory and slow down the program. A possible work-around is to freeze layers in your CAD program so that TNM will ignore data in that layer, which will effectively trim the file down during TNM import. You then convert the necessary data, go back to your CAD program, freeze the layer just converted, and then unfreeze a different layer for import and conversion into TNM. This method will help in dealing with large DXF files. (Consult your CAD program manual for details on CAD layers).

4.8 Print Preview

For the active TNM graphical view, this selection may be used to preview how the graphics will look on a printed page. Note: Only graphical views and output tables can be printed. Input dialogs are used exclusively for input entry.

4.9 Print

This selection is used to print graphical views and tables. Note: Only graphical views and output tables can be printed. Input dialogs are used exclusively for input entry. Further, if you would like to print an output table to a file, use the Export function in the Tables menu (see Section 13.5).

The TNM print function is an adaptation of the standard Microsoft® Print function. The current printer is displayed at the top of the dialog box. You can change printers by using the SETUP button, which connects you to the standard Microsoft® File//Print Setup dialog box. Print Setup will allow you to select the desired paper orientation and size. Note: Consult Microsoft® documentation to connect printers to your Windows system.

4.10 Print Setup

This selection allows you to set the desired printer, as well as set various printing options, e.g., paper orientation and size. Note: Consult Microsoft® documentation to connect printers to your Windows system.

4.11 Set Print Scale

This selection allows you to setup a ruler unit equal to a map distance (e.g., one inch equals 50 m). This scale capability is activated by clicking on the box just below the “fit to page” box (an "!" will appear in the box). You can check the scale by using the File//Print Preview function. If a set scale is not entered, TNM will automatically set a scale such that the view shown in the active window is maximized for printing on one sheet.

4.12 Exit

This selection will allow you to save and close an open run. If data has been entered or changed, TNM will prompt you to save your data prior to exiting the program.

5. EDIT MENU

This section describes the changes you can make to your graphical views and input dialogs.



Save your file. If you edit/add input after calculating, TNM will warn you that prior results will be lost, and asks if you wish to make the change or not. This is because TNM works with multiple files, not just a single file, and, thus, will not be able to change/add input, and then File, Save As. Changing most types of input data (with the exception of barrier costs, additional costs, receiver existing level, impact criteria level, noise reduction goal, and substantial increase) will invalidate previously calculated sound level results. If you wish to save the old results, then calculate new ones with input changes, save the previous file, then use File, Save As to change to a new file name. Thus, the original files with the original results remains intact.



Sections 5.1 through 5.6 outline edit options which can be performed in both the active graphic view and the input dialog boxes.

5.1 Undo



Tool Bar:


This selection allows you to reverse the last edit operation performed. Currently, TNM is only capable of reversing the very last edit operation, as compared with several sequential operations.

5.2 Cut



Tool Bar:

This selection is used to move a cell(s) in an input dialog or input object(s) in a graphical view:


1. Select the desired cell(s)/object(s) (see Section 5.5).
2. Select Cut in the Edit menu or click the Cut button on the Tool Bar.
3. Place the cursor using the mouse or arrow keys in the desired dialog cell or view coordinates to move to. If you are moving a block of cells, place the cursor in the top left corner of the block of cells you want to move to. Select Paste in the Edit menu or click .

5.3 Copy



Tool Bar:

This selection is used to copy a cell(s) in an input dialog or input object(s) in a graphical view:

1. Select the desired cell(s)/object(s) (see Section 5.5).
2. Select Copy in the Edit menu or click the Copy button on the Tool Bar.
3. Place the cursor using the mouse or arrow keys in the desired dialog cell or view coordinates to move to. If you are moving a block of cells, place the cursor in the top left corner of the block of cells you want to move to. Select Paste in the Edit menu or click . Note: You can copy a cell to a block of cells by highlighting a block of cells to copy to.
4. To repeat copying the selected cell(s)/object(s), repeat Step 3.

5.4 Paste



Tool Bar:

This selection is used to place previously selected cell(s) to be moved (see Section 5.2) or copied (see Section 5.3) into their desired cell(s).

5.5 Select

You may use the keyboard or mouse to select input dialog cells and graphical view objects (see Table 5). In addition, TNM provides several sub-menu options for selecting graphical view objects (see Table 6). Note: All selected cell(s)/object(s) are highlighted in gray. If you selected incorrectly, see Section 5.6 to deselect. (Note: ---- denotes “Not Applicable” or “No Action Required.”)

Table 5. Keyboard/Mouse Options for Selecting.

Keyboard	Mouse	Action	Comments
Arrow keys	Left button	Select one cell	This method of selecting is available for input dialogs.
Shift + Arrow keys	Left button+drag mouse	Select multiple cells	In graphical views, hold down the left mouse button and drag the mouse (the mouse becomes a hand) to create a rectangle enclosure about desired objects. It may be helpful to Zoom Out (see Section 6.4) to see the entire object.
---	Double click left button	Select an entire roadway, barrier, or zone	This method of selecting is available for graphical views.

Table 6. Menu Options for Selecting in Graphical Views.

Menu Option	Action	Comments
<u>E</u> verything	Select everything in the active graphical view	----
All <u>I</u> nside Rectangle	Select everything within a user-drawn rectangle enclosure	Hold down the left mouse button and drag the mouse (the mouse becomes a hand) to create a rectangle enclosure about desired objects. It may be helpful to Zoom Out (see Section 6.4) in your active view to see the entire object.
All <u>O</u> utside Rectangle	Select everything outside a user-drawn rectangle enclosure	Hold down the left mouse button and drag the mouse (the mouse becomes a hand) to create a rectangle enclosure about desired objects. It may be helpful to Zoom Out (see Section 6.4) in your active view to see the entire object.
All of One <u>T</u> ype	Select all of one type of a TNM input object in the active graphical view	Type includes roadways, receivers, barriers, building rows, terrain lines, ground zones, tree zones, contour zones, and DXF objects.

5.6 Deselect

You may use the mouse or sub-menu options to deselect input dialog cells and graphical view objects (see Table 7). (Note: --- denotes “Not Applicable” or “No Action Required.”)

Table 7. Mouse/Sub-Menu Options for Deselecting.

Keyboard	Mouse	Sub-Menu Option	Action	Comments
<ESC>	Click left button at a blank spot within the active window	Everything	Deselect everything	Key option will close the active input dialog.
---	---	All of One Type	Deselect all of one type of a TNM input object in the active graphical view	Type includes roadways, receivers, barriers, building rows, terrain lines, ground zones, tree zones, contour zones, and DXF objects.



Sections 5.7 through 5.15 outline edit options which can be performed in the active graphic view only.

5.7 Move

Note: The Move capability is not a menu option - it is only available in the Plan View using the Ctrl key and a mouse. This selection is used to graphically relocate a selected object, or portions of an object, to a new location, i.e., XY coordinates (to change an object's Z coordinates, you must use that object type's input dialog). To move an object:

1. Select the object (see Section 5.5).
2. While holding down the Ctrl key, click the left mouse button while pointing to anywhere on the object, and drag the object to the new location.

To move a segment within an object:

1. Select the segment (see Section 5.5).
2. While holding down the Ctrl key, click the left mouse button while pointing to the middle of the segment, and drag the segment to the new location.

To move a point of an object:

1. Select a segment containing the point you wish to move.
2. While holding down the Ctrl key, click the left mouse button while pointing to the point you wish to move, drag the point to the new desired location.



This Move function is helpful when adjusting the positions of any DXF imported roadways. Imported DXF roadways are typically brought into TNM with roadway coordinates at the

edge of pavement. Use the Move function to offset each edge of pavement to the center of the roadway.

5.8 **Add Point Within Segment**

This selection adds a point exactly in the middle of a selected segment in the active graphical view window. It may be helpful to zoom in on the segment prior to adding a point (see Section 6.3). To add a point at a different position, you may use this selection and edit the point's coordinates in the input dialog, or you may use the Interpolate tool in the Tool Bar (see Section 3.1.5).

5.9 **Subdivide Segment**

This selection divides a selected segment into a user-specified number of segments. You must pre-select a segment. It may be helpful to zoom in on the segment prior to subdividing a segment (see Section 6.3).

5.10 **Combine Two Objects**

This selection combines two objects of the same type (e.g., two roadways). You must pre-select the end segments of two objects. TNM will allow the user to select from which of the two objects the default settings for the combined object will be borrowed. This menu option is unavailable until you have done so. To combine two segments within a single object, see Section 5.14 or 5.15. It may be helpful to zoom in on the segments to help discern the segment start point from the end point (see Section 6.3).

5.11 **Divide an Object in Two**

This selection divides a selected object into two objects at the start point of a selected segment. You must pre-select the desired segment. This menu option is unavailable until you have done so. It may be helpful to zoom in on the segment prior to dividing the object (see Section 6.3).

5.12 **Reverse Direction**

This selection reverses the direction of a selected roadway(s) and/or barrier(s). Ordinarily, roadway direction is insignificant with traffic being uniform along each segment. However, this selection is useful when you want to input a traffic-control device onto the proper end, i.e., the end point of the roadway, but the roadway was created in the wrong direction. You must pre-select the desired roadway(s) and/or barrier(s). This menu option is unavailable until you have done so. It may be helpful to zoom in on the roadway prior to reversing direction (see Section 6.3).

5.13 **Delete Entire Object**

This selection is used to delete (Note: The Del key is not functional in TNM) an entire object(s) in the active graphical view. You must pre-select the desired object(s). This menu option is unavailable until you have done so. You will be prompted as to whether you're sure you want to delete the selected

object. If so, select Yes. To reverse a deletion, select Undo (see Section 5.1). It may be helpful to zoom in on the object prior to deleting an object (see Section 6.3).

Note: Segments of objects cannot be deleted using this menu option. There are work-arounds to delete a segment: (1) to delete the first or last segment, see Sections 5.14 or 5.15, respectively; (2) to delete middle segments, see Section 5.10 to divide the object into two at start point of the segment to be deleted, then see Section 5.13 to delete the start point.

5.14 Delete Start Point

This selection deletes the start point of a selected segment of an object. If the start point of the selected segment is the first segment of the object, this effectively deletes the first segment of the selected object. You must pre-select the desired segment. This menu option is unavailable until you have done so. It may be helpful to zoom in on the segment prior to deleting the start point (see Section 6.3). Note: This selection may also be used to combine two segments within a single object.

5.15 Delete End Point

This selection deletes the end point of a selected segment of an object. If the end point of the selected segment is the last segment of the object, this effectively deletes the last segment of the selected object. You must pre-select the desired segment. This menu option is unavailable until you have done so. It may be helpful to zoom in on the segment prior to deleting the end point (see Section 6.3). Note: This selection may also be used to combine two segments within a single object.



Sections 5.16 through 5.19 outline edit options which can be performed in the input dialogs only.

5.16 Insert Row

This selection inserts a blank row above the row where the cursor is located in an input dialog. This additional row and associated point will automatically be assigned the attributes of the other points in that object, e.g., if the object is a roadway, that point will be assigned the pavement type associated with the other points in that roadway.

5.17 Append Row

This selection places a blank row after the last row of an input dialog. This new row and associated point will automatically be assigned the attributes of the other points in that object, e.g., if the object is a roadway, that point will be assigned the pavement type associated with the other points in that roadway. This selection is also used when entering new input data via an input dialog (i.e., non-graphically). For example, if a roadway input dialog is used to create a new roadway, the dialog initially does not contain any blank rows. A blank row will need to be appended for every desired point. An easy way around this is to graphically create a dummy roadway with the desired number of segments using a mouse, then edit the dummy coordinates to exact coordinates in the input dialog.

5.18 Delete Row

This selection deletes the row where the cursor is located in an input dialog. Note: This selection is also an easy way to combine segments within a single object.

5.19 Collapse/Expand Spreadsheet Columns

Each input dialog is actually a large spreadsheet that has been broken down into several spreadsheet pages, or tabs, in order to group similar input information in an organized and readable format. As in commercially available spreadsheets, you may change any column's width by using the mouse to click, hold, and drag the column edge to a new position. As part of this capability, you may also hide an entire column(s). This selection is used to: (1) make all the input dialog's unhidden columns fit on the first tab; or (2) expand all columns back to the original various tabs. Note: This menu item does not affect TNM Table columns. Table columns are permanent and cannot be changed. However, table "rows" may be hidden or shown by selecting Hide Rows or Show All Rows, respectively, in the Tables menu (See Section 13.4).

6. VIEW MENU

This section describes the different, available, TNM graphical views (see Section 6.1). These views provide a helpful tool during barrier design (see Table 8). Within these views, the types and aspects of those objects to be shown or hidden (see Section 6.2) can be selected.

In addition, TNM provides many options for manipulating the various graphical views, such as zoom, pan, and rotate (see Sections 6.3 through 6.7). These options are summarized in Table 9. Several shortcut keys using the keyboard or mouse also are available for some of these view-manipulation options. These are shown in Table 10 on the following page. (Note: ---- denotes “Not Applicable” or “No Action Required.”)



Table 8. Purpose of TNM graphical views.

View	General purpose	Concurrently use	For this purpose
<u>P</u> lan view	Digitize coordinates. Look at everything in plan.	Input dialogs Input tables	To input text To observe multiple input objects at the same time
<u>R</u> oadway profile	Digitize roadway Z coordinates.	Roadway input dialog Roadway input table	----
<u>S</u> kew section	Investigate breaks in lines of sight between roadways and receivers.	Plan View	To locate skew section
<u>P</u> erspective view	Look at everything in perspective, especially barrier shapes as you input barrier heights.	Plan View	----

Table 9. Manipulation of TNM graphical views using the main menu.

To cause this	Menu item	And then	TNM will then
Zoom in	<u>V</u> iew, Zoom <u>I</u> n	Draw a rectangle.	Zoom in to fill the screen with your rectangle.
Zoom out	<u>V</u> iew, Zoom <u>O</u> ut	----	Zoom out by approximately 25 percent.
Locate an item in all views (selected in all views)	<u>V</u> iew, <u>C</u> enter View by Item	----	Center the selected item in the graphical view. You must have only one item selected.
Pan	<u>V</u> iew, <u>P</u> an <u>L</u> eft (or <u>R</u> ight, etc.)	----	Pan the view left (or right, etc.) by approximately 25 percent.
Rotate	<u>V</u> iew, <u>R</u> otate <u>C</u> lockwise (or <u>C</u> ounter- <u>C</u> lockwise)	----	Rotate the entire view clockwise (or counter-clockwise) by approximately 15 degrees.
Show everything	<u>V</u> iew, <u>F</u> ull	----	Zoom out or in, as needed, to fill the screen with your full input.
Get rid of unwanted line remnants	<u>V</u> iew, <u>R</u> edraw View	----	Redraw the view.

Table 10. Manipulation of graphical views.

To cause this	Do this	TNM will then
Zoom in	Press PgUp.	Zoom in by approximately 25 percent.
Zoom out	Press PgDn.	Zoom out by approximately 25 percent.
Pan	Press an arrow key, or	Pan the entire view in the arrow's direction by approximately 25 percent.
Pan	 Hold the left mouse button down for 2 seconds. After the cursor changes to  , then drag the mouse.	Pan the entire view by the amount you dragged the mouse.
Rotate a Perspective or Barrier View	Press Ctrl+Arrow	Rotate the entire view in increments of approximately 15 degrees.

6.1 New View

6.1.1 Plan View. A plan view is a graphical display of input objects from a viewpoint as if looking down from above (see Figure 9). TNM provides several ways to manipulate the view, i.e., by zooming, panning, and rotating (see Section 6.3 through 6.7).

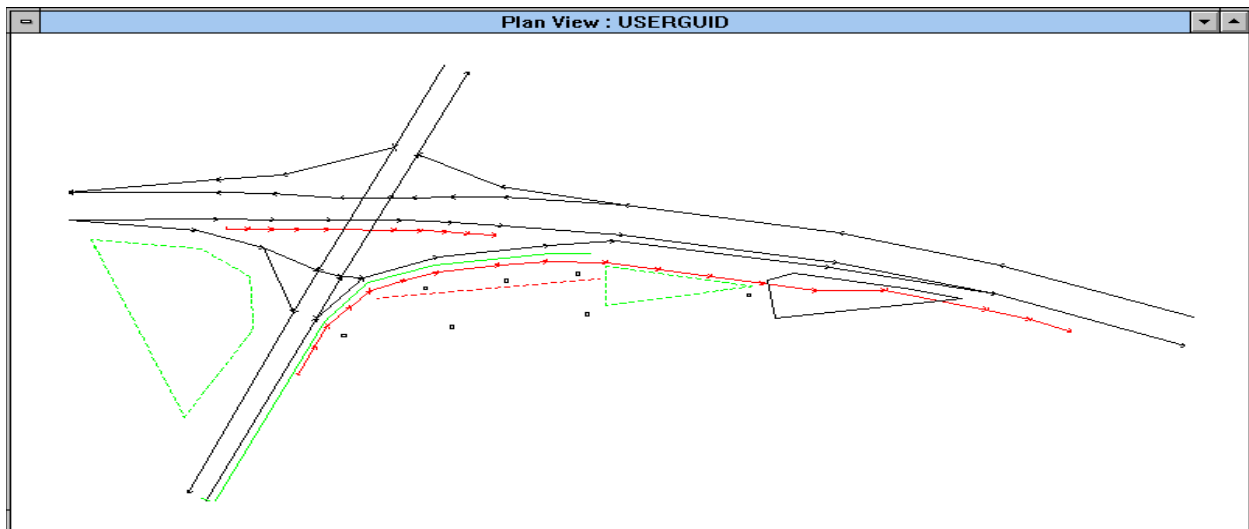


Figure 9. Plan view.

6.1.2 Roadway Profile. A roadway profile displays an elevation view of a user-selected roadway (see Figure 10). You must pre-select the desired roadway in the Plan View. This menu option is unavailable until you have done so. TNM provides several ways to manipulate the view, i.e., by zooming, panning, and rotating (see Section 6.3 through 6.7).

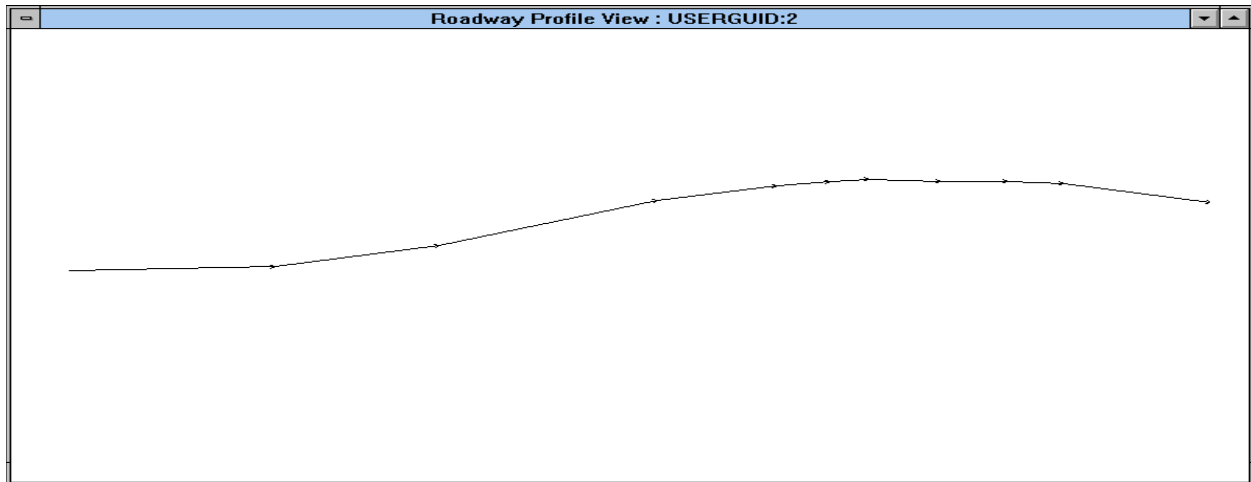



Figure 10. Roadway profile view.

6.1.3 Skew Section. A skew section illustrates a cross-sectional area within the Plan View from a viewpoint normal to the ground plane (see Figure 11). You define the desired area by drawing a single, cutting line across objects in the Plan View (Note: The entire object must be displayed within the Plan View for it to be selected). Specifically, to create a skew section:

1. Select **V**iew, **N**ew View, **S**kew Section in the main menu. TNM then displays pop-up instructions on how to create the cut across a section.
2. Press the space bar to acknowledge the instructions. The cursor then changes to a sawing tool, .
3. Depress the left mouse button and click the mouse at two points to create the cut. A new window is displayed with the newly created skew section. TNM provides several ways to manipulate the view, i.e., by zooming, panning, and rotating (see Section 6.3 through 6.7).

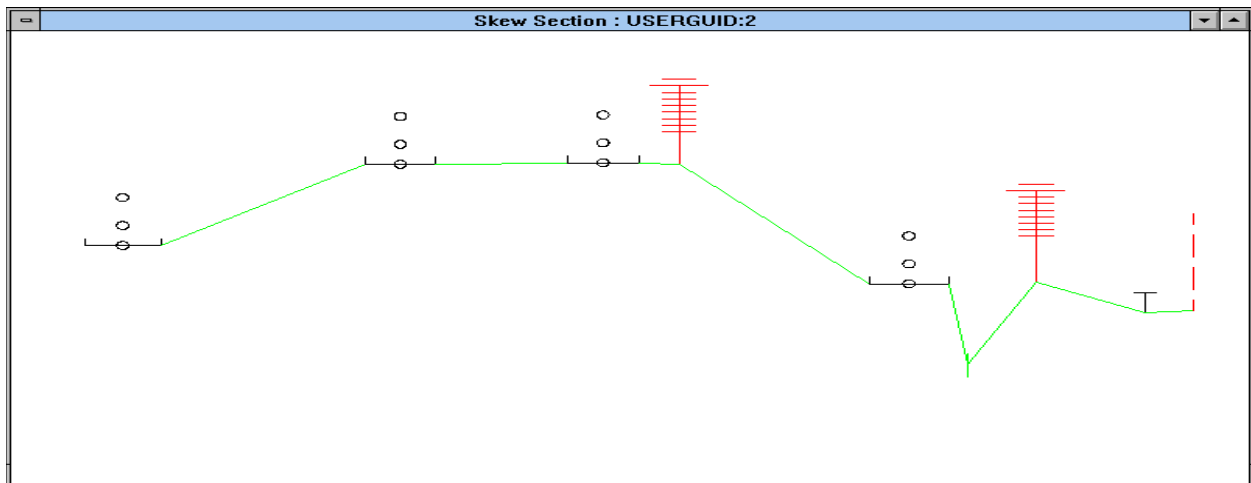


Figure 11. Skew section.

6.1.4 Perspective View. A perspective view is essentially the Plan View from a perspective viewpoint (see Figure 12). TNM provides several ways to manipulate the view angle and area, i.e., by zooming, panning, and rotating (see Section 6.3 through 6.7).

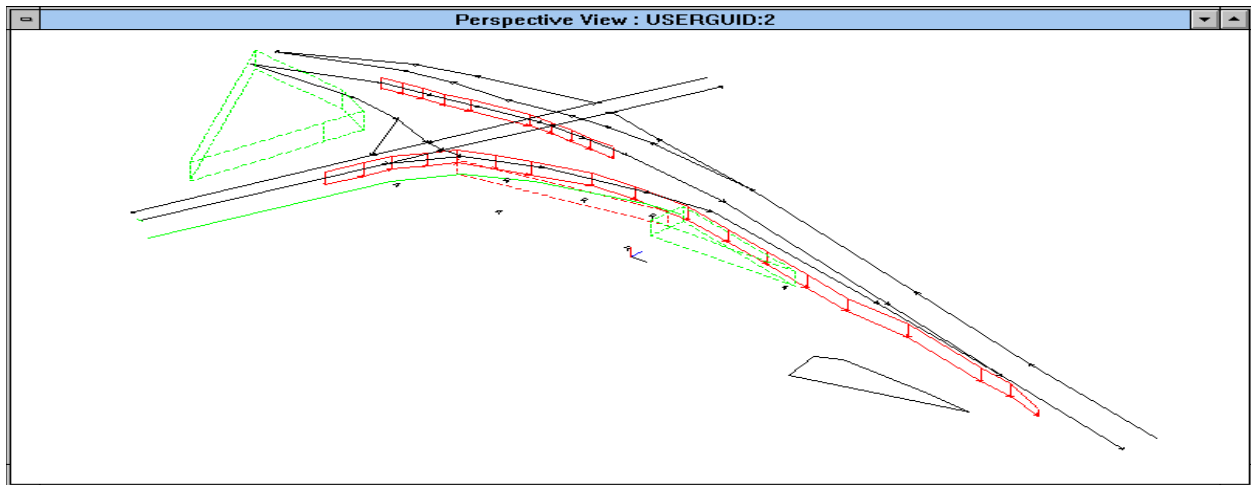


Figure 12. Perspective view.

6.2 Show/Hide

For all graphical views, any of TNM's input objects, as well as the aspects of those objects (i.e., object name, or text, and point numbers), may be selected to be shown or hidden. This option is very helpful in keeping complex cases from appearing cluttered and difficult to read.



Dealing with text/labels: If text or point numbers are not displayed after Show/Hide check boxes have been “checked,” there are several possible reasons why:

- TNM is not set up to draw text. If so, check your computer's “TGLINK” setting:
 1. Open up a DOS command prompt and type the word “set.” This will list all your computer environment variables.
 2. Look for TGLINK and check that the directory it specifies (e.g., TGLINK=C:\TNM\PROGRAM) exists and contains the file, *txt.dsc* (see Section 1.5.1 for a complete list of TNM files and their default directory locations). If TGLINK is not present, find out where *txt.dsc* is, and then add the following line to your *Autoexec.bat* file: “Set TGLINK=[directory],” where [directory] is the place where *txt.dsc* is located.
- The expected text was on a frozen DXF layer. If so, consult your CAD program manual on how to “unfreeze” DXF layers.
- The DXF Background check box is not checked in the “Show Objects” column. If so, turn on this layer by selecting Show/Hide in the View menu, then check the “DXF Background” check box in the “Show Objects” column.

6.3 Zoom In



Tool Bar:

This selection will magnify everything within a user-drawn rectangular enclosure. When the Zoom-In function is invoked, the cursor changes to a magnifying glass. To create the rectangular enclosure, depress the left mouse button at an imaginary corner of the desired enclosure area and drag the mouse across the desired area. A rectangle will appear. Continue dragging the mouse until all desired objects are encompassed by the rectangle. Note: The entire object/segment must be enclosed within the rectangle for it to be selected. It may be helpful to Zoom Out (see Section 6.4) in your active view to see all desired objects. You may repeat this process until the display reaches your desired magnification or reaches TNM's graphical capability limit.

For a quick zoom-in, press the PgUp key. The display will magnify 25 percent about the center of the view. This "center" may be changed. The view may be re-centered about a user-selected object (see Section 6.5), or simply depress the left mouse button until the cursor becomes a cross, then drag the cursor to a new center position.

6.4 Zoom Out



Tool Bar:


This selection will reduce everything in the current view by 25 percent. This can also be done by simply pressing the PgDn key. You may repeat this process until the displays reaches your desired reduction or reaches TNM's graphical capability limit.

6.5 Center View by Item

This selection centers all open Plan and Perspective views about a user-selected TNM object/segment. To center the view by an item, select the item, then select Center View by Item in the View menu.

6.6 Pan

Panning shifts the viewing window in a user-selected direction by approximately 25 percent to see portions of your drawing which are currently outside the current viewing area. Panning may be done to the Left, Right, Up, and Down.

This can also be done by using either the arrow keys, Windows scroll bars, or mouse. To pan using the mouse, hold down the left mouse button until the cursor looks like this:  . Then, drag the mouse to the new desired center position and release the mouse button.

6.7 Rotate

This selection rotates the entire view approximately 15 degrees. Rotating may be done Clockwise or Counter-clockwise. The user may also rotate a view using the keyboard: The Ctrl and left or right arrow keys will rotate the view clockwise or counter-clockwise, respectively.

In addition, for Perspective Views, the view can be rotated in all directions by using the Ctrl and arrow keys, or the Clockwise, Counter-clockwise, and Up and Down selections within the View, Rotate menu option.

6.8 Full View

This selection automatically zooms in or out the view window, as needed, so that all input objects can be seen. However, this selection does not take into account recent editing or deletions resulting in an incorrect redrawn view. Use Recompute View Extents (see Section 6.9) to recompute the active run's coordinate extents, prior to selecting Full View.

6.9 Recompute View Extents

This selection automatically recomputes the coordinate extents of the active run. Because Full View (see Section 6.8) does not account for recent editing or objects that have been deleted, use this selection to recompute where all existing TNM object coordinates extents lie, then select Full View (see Section 6.8).

6.10 Redraw View

This selection refreshes, or redraws, the view. This is helpful after a bit of editing has been done, and unwanted line remnants remain in the view.

6.11 Move Tool Bar

This selection will reposition the tool bar to one of three positions: (1) horizontally across, below the Menu Bar; (2) vertically down the left edge of the TNM screen; and (3) vertically down the right edge of the TNM screen.

7. SETUP MENU

To begin a TNM run, you must first provide setup information that pertains to the full run. Figure 13 shows the work flow involved.

As shown, during setup you first enter your user information and preferences. The arrows to the left of the setup rectangle remind you of this. Also as part of setup, you register plan sheets and other XY-coordinate input on the digitizer, so that TNM knows their scale and orientation. The figure shows three methods of digitizer registration -- typed coordinates, data already entered, and match line -- along with symbolic reminders of these methods.

The remainder of this section describes the following setup processes in the figure:

- Run Identification;
- General;
- Defaults for Objects (see Section 8.1); and
- Digitizer registration of Plan, DXF Background, and Profile.

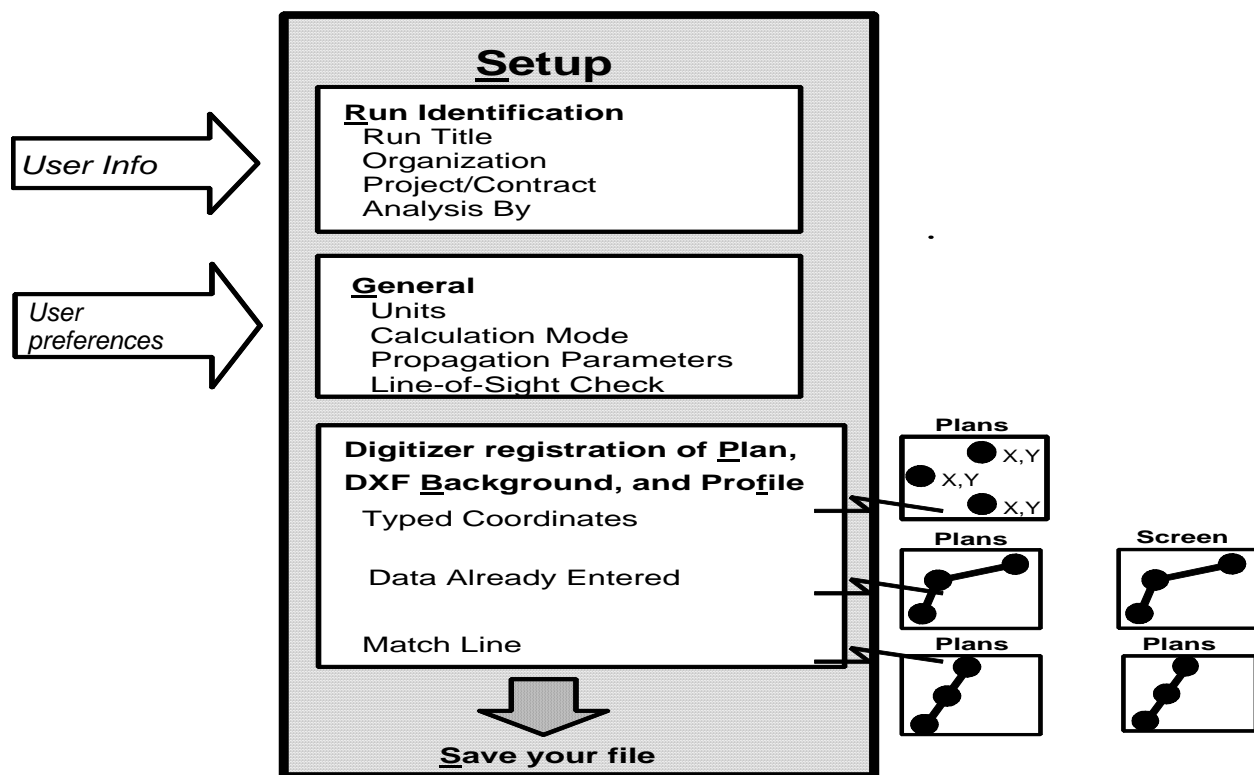


Figure 13. Setup: Work flow.

7.1 Run Identification

Run identification appears on all your printouts, in the header of all tables and in the title box of all graphics. In brief, it consists of the following:

- Run Title;
- Organization;
- Project/Contract; and
- Analysis By.

To enter run identification:

1. Select Setup, Run Identification in the main menu (see Figure 14).

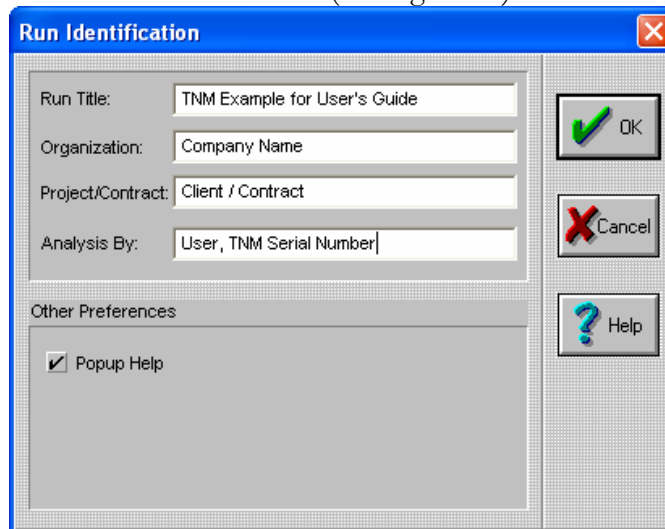


Figure 14. Run identification.

2. Enter the following information to identify your run:

- Run Title: This is the run's full name, which TNM includes on all printouts. It is an expanded version (up to 42 characters) of the run's file name (up to 8 characters);



Note: While extended run names may be acceptable in Windows 95, TNM was designed for Windows 3.1, and, therefore, must be limited to eight-character run names.

- Organization: The organization performing the analysis;
- Project/Contract: The project or contract under which the analysis is being performed;
- Analysis By: Enter your name and TNM registration number; and
- Popup Help: TNM Version 1.0 sometimes pops up brief help information. Once you no longer need these pop-up helps, then uncheck the Popup Help box by clicking on it with the mouse.



See Appendix A for FHWA policy related to run identification.

7.2 General

General input includes user preferences that affect TNM calculations. In brief, it consists of the following:

- Input and Display Units;
- Traffic Entry Type;
- Propagation Parameters; and
- **Line-of-Sight** Check.

To enter general input:

1. Select Setup, General in the main menu (see Figure 15).

Figure 15. General.

2. Enter the following general input:

- Input and Display Units (Metric or English): You can switch units back and forth, whenever you wish. When you switch, TNM converts absolutely everything to the new set of units. To switch units, click on the down arrow to the right of the units box and select Metric or English.
- Traffic Entry Type: L_{Aeq1h} Hourly (hourly A-weighted **equivalent sound level** with hourly traffic input), L_{Aeq1h} Percent (hourly A-weighted equivalent sound level with hourly traffic entered on a percent-vehicle-type basis), L_{dn} (**day-night average sound level**), and L_{den} (**Community Noise Equivalent Level**). To switch traffic type, click on the down arrow to the right of the traffic type box and select.
- Propagation Parameters: Generally leave relative humidity and temperature at their standard default values of 50 percent and 20EC, respectively. They have very little effect upon calculations. Also, choose a default ground type from among the entries in the pull down list. TNM will assume this default ground type everywhere, except (1) within roadway widths, and (2) inside the ground zones that you input. To select a default ground type, click on the down arrow to the right of the ground type box and select.



See Appendix A for FHWA policy related to relative humidity and temperature.

- **Line-of-Sight Check Parameters:** When entering barrier input or analyzing barriers, you can ask TNM to perform a line-of-sight check (see Section 10.7). Enter the subsource height and distance limit you wish for this supplementary feature. The subsource height is the height of the source you'll be checking line-of-sight to, e.g., exhaust stacks for heavy trucks, the distance limit is the maximum distance between receiver, and subsource height for the path to be included in the line-of-sight check.



See Appendix A for FHWA policy related to line-of-sight check.

7.3 Digitizer Registration of Plan, DXF Background, and Profile

The standard method of entering XY coordinates is to digitize them. Alternatively, you may type them into input dialog boxes or you may import them with DXF files or with STAMINA 2.0/OPTIMA input files. Even more simply, you may sketch them freehand with the mouse on your computer screen. However, freehand XY coordinates are generally too imprecise for sound-level computations.

If you digitize XY coordinates, you need to tell TNM the coordinate system of the plan sheets on your digitizer tablet. To do this, you "register" each plan on your digitizer. Whenever you replace, reorient, or move a plan sheet, you must register again so that TNM knows of the change.

You will register the digitizer often during input. For maximum flexibility, TNM Version 1.0 has three registration methods, which are summarized in Table 11. The remainder of this section describes the three registration methods in detail.

Table 11. Digitizer registration methods and when to use them

Registration method	When to use	Details
Typed Coordinates	You must use this method the very first time you register a TNM run. For highest accuracy, use this method all the time.	This is the initial way that TNM sets up its coordinate system for your run. Its use all the time will guarantee a complete and accurate match, throughout your input, with a fixed coordinate system. This method is available for registering your Plan or DXF Background.
Data Already Entered	When you re-register a prior sheet or shift a sheet somewhat on your digitizer. Also when you register a new sheet that has three (widely-spaced) points on it already entered.	This is the fastest way to register, although it is not available too often. This method also guarantees a complete and accurate match with a fixed coordinate system. This method is available for registering your Plan or roadway Profile.
Match Line	Sometimes when your "just-finished" sheet has a match line to your next sheet.	This is the easiest way to work from sheet to adjacent sheet. However, as you work from sheet to sheet, the coordinates of your input will slowly drift away from those of a fixed coordinate system and thereby slowly "skew" your coordinates relative to reality. Generally this is acceptable, because a slow skew over large distances will not distort sound-level predictions. However, see the warning that follows. This method is only available for registering your Plan.



Once you register by match line, do not later revert to typed coordinates. If you do, you will introduce a bias error into your coordinate systems.



Registration tolerance. For all three registration methods, TNM requires that you enter one more point than is truly needed to determine the plan sheet's coordinate system. TNM requires internal consistency among all points, within a built-in tolerance, before it accepts your registration. You cannot adjust the built-in tolerance value.

16-Button digitizer puck. If you are using a 16-bit digitizer puck, the button functions are:



Button	Function
0 (upper left)	Main digitizing button;
F (lower right)	Toggle Snap mode on/off;
3 (upper right)	Finish digitizing current input object (same as double-clicking);
D	Delete last digitized point;
A	Switch to "alph-numeric mode" to enter Z coordinates;
0 through 9	Z coordinates;
B	Backspace during Z coordinates digitization;
C	Clear entire Z coordinates; and
E	Enter Z coordinates.



See Appendix A for FHWA policy related to digitizer registration.

To Register by Typed Coordinates: This method is available for registering your Plan or DXF Background.

1. Select Setup, Register Plan (or Register DXF Background), Typed Coordinates in the main menu. TNM will display a registration dialog (see Figure 16) and a pop-up help box.

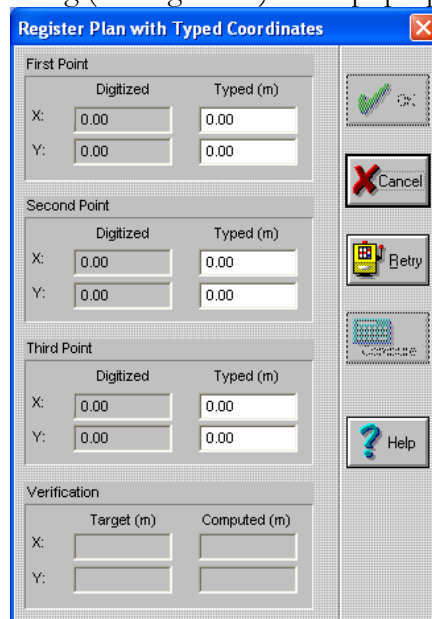







Figure 16. Typical registration dialog.



2. With your digitizer puck, click precisely on three widely spaced points. These can be any three points, as long as you know their exact coordinates. Before each click, a small puck icon on the computer screen will show you which point (first, second, or third) you are about to digitize.
3. Type the X and Y coordinates of these three points, *in the same order*, into the dialog box.
4. Select Compute in the dialog box. TNM will then compute the expected coordinates of your third point from those of your first and second points. It will show you its computed coordinates in the dialog help box (under Verification, Computed), directly alongside your typed coordinates (under Verification, Target). If the computed and target coordinates are similar enough, in your judgment, select  in the dialog box.
5. If not, then select  (Note: All coordinates will be reset to zero) and return to Step 2.

To Register with Data Already Entered: This method is available for registering your Plan or Roadway Profile (see Section 6.1.2 to open a Roadway Profile view).

1. Select Setup, Register Plan (or Register Profile), Data Already Entered in the main menu. TNM will display a pop-up help box.
2. On the computer screen, click precisely on three widely spaced points of any type. Note: It might be helpful to turn on the Snap tool by selecting  in the Tool Bar. Before each click, a small puck icon on the computer screen will show you which point (first, second, or third) you are about to digitize. TNM will display a registration dialog.
3. On the digitizer, click precisely on the same three points, in the same order.
4. Select Compute in the dialog box. TNM will then compute the expected coordinates of your third point from those of your first and second points. It will show you its computed coordinates in the dialog help box (under Verification, Computed), directly alongside your typed coordinates (under Verification, Target). If the computed and target coordinates are similar enough, in your judgment, select  in the dialog box.
5. If not, then select  (Note: All coordinates will be reset to zero) and return to Step 2.

To Register with Match Line: This method is only available for registering your Plan.

1. Select Setup, Register Plan, Match Line in the main menu. TNM will display a registration dialog and a pop-up help box.
2. With your digitizer puck, click on three distinct, widely spaced points along a match line. These can be any three points, as long as you can locate them precisely on the second plan's match line, as well. Before each click, a small puck icon on the computer screen will show you which point (first, second, or third) you are about to digitize.

3. Replace your plan sheet with another one that contains the same match line and the same three distinct points. Then with your digitizer puck, click on the same three points, in the same order, on the new plan sheet.
4. Select Compute in the dialog box. TNM will then compute the expected coordinates of your third point from those of your first and second points. It will show you its computed coordinates in the dialog help box (under Verification, Computed), directly alongside your typed coordinates (under Verification, Target). If the computed and target coordinates are similar enough, in your judgment, select  in the dialog box.
5. If not, then select  (Note: All coordinates will be reset to zero) and return to Step 2.

8. INPUT MENU

Within FHWA TNM[®], after Setup you then enter all input for a given run. This section first discusses TNM default objects and then each input type, including their default values and constraints, in detail. Additional input details appear in Appendix B. Figure 17 shows the work flow for Input. In regard to Figure 15, the following should be kept in mind:

- **Project materials and input types:** During input, you enter all information from your project plans, profiles, sections, topography, maps, aerial photographs, and traffic. In Figure 17, the arrows to the left of the setup rectangle remind you of this. From these materials, you enter the following TNM input types: Roadways, Receivers, Barriers, Building Rows, Terrain Lines, Ground Zones, Tree Zones, and Contour Zones.
- **Input order:** Figure 17 shows TNM input types from top to bottom within the shaded rectangle. The order of input is generally not important, with a few obvious exceptions. For example, you must enter roadways before traffic. In general, you will enter input of all types from a single plan sheet and then will proceed to the next plan sheet to enter its input. The order in the figure is suggested, but not required, for each of these plan sheets.



In the figure, traffic input is shown last. It is far easier to enter traffic at the end, after all roadways are already entered. Last-minute traffic entry, roadway by roadway, is often required because traffic is often available only at the last minute on highway projects.

Input tables and graphics document your input, both on the screen and on hard copy. They are shown to the right of the rectangle in the figure.

- **Input check:** TNM Version 1.0 has an extensive set of checks for input consistency. You may find it most convenient to periodically "check input" (select Input, Input Check in the main menu) as you enter it. In any case, TNM automatically checks input as its first step in calculating sound levels.

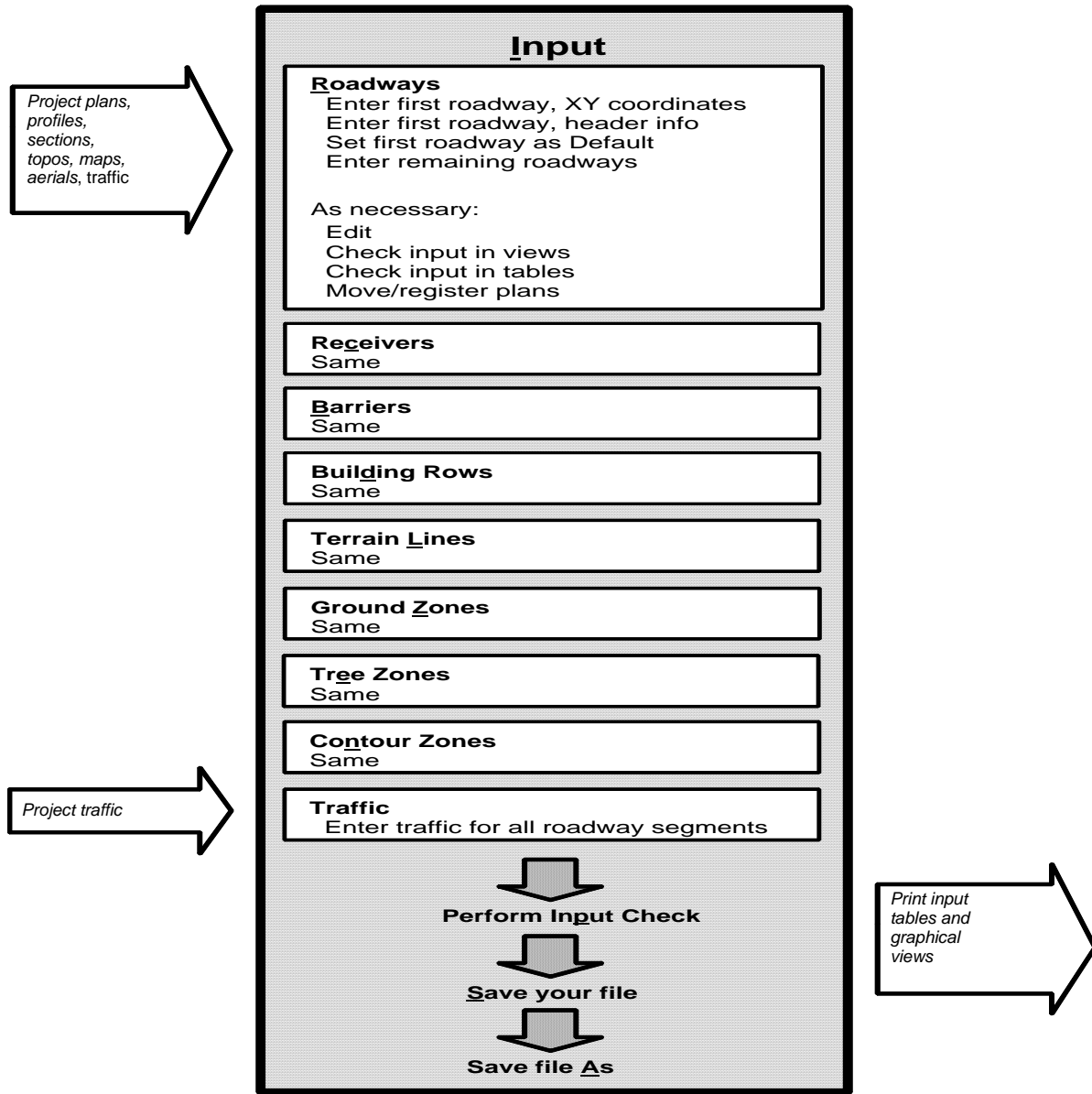


Figure 17. Input: Work flow.

8.1 TNM Default Objects

TNM Version 1.0 has built-in default values for every parameter of every input type. However, you may want to change some of these built-in defaults. Once you have entered an object with the new values, then you can tell TNM to use that object for defaults, instead of its built-in values.



For example, you might first input a roadway with your desired values of roadway width and pavement type. Then you might wish all subsequent roadways to have these same values, as defaults. If so, then you would set that roadway as your default roadway. Your subsequent roadways will inherit most of the default roadway's parameters, including roadway Width, Pavement Type, On Structure, Speed Constraint, Control Device, and Vehicles Affected (%). Note: Roadway coordinates are not inherited.

TNM provides two methods for designating a default object: (1) graphically from the Plan View; or (2) using Setup. The default process applies to all input types.



TNM defaults affect subsequent input, not past input. TNM default objects only work "forward in time." They do not travel backwards in time. In other words, defaults affect only subsequent input objects, not ones you have already entered. All of your past input is safe from change. For this reason, you may change defaults from time to time as you input. For example, you can set a mainline roadway as your default roadway and then input other mainlines. Then you can change to an on-ramp default to input other on-ramps.

To designate a default object (described here for roadways, but applicable to all object types) graphically from the Plan View:

1. Open both the run's Plan View and the roadway input dialog.
2. In the Plan View, digitize the first roadway's XY coordinates.
3. Enter header information in the input dialog. Only header input is needed at this time, before you set this roadway as the default.
4. Set this roadway as the default roadway, as follows:
 - Select it in the Plan View. No other object may be selected at the same time.
 - Select Input, Set Default Object from the main menu.With Roadway #1 as the default, its header values flow down to all subsequent roadways.
5. Digitize/enter all remaining roadway input.
6. Whenever you wish, you may set a different roadway as the default roadway.

To designate a default object (described here for roadways, but applicable to all object types) using Setup:

1. Open both the run's Plan View and the roadway input dialog.
2. In the Plan View, digitize the first roadway's XY coordinates.
3. Enter all other header information in the input dialog. Only header input is needed at this time, before you set this roadway as the default.
4. Select Setup, Defaults for Objects from the main menu (see Figure 18).

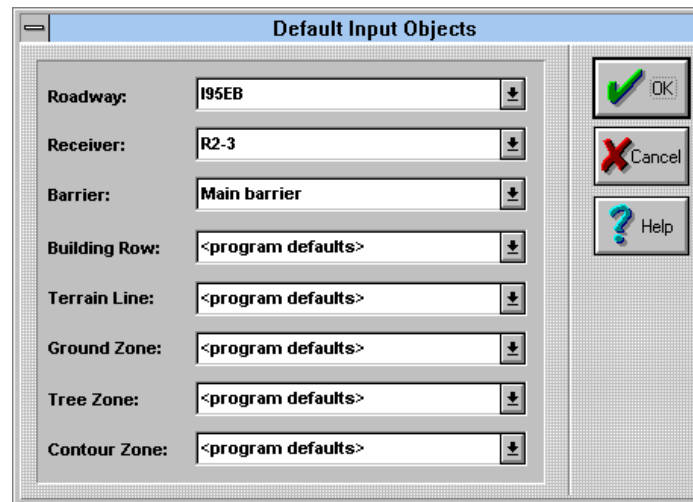



Figure 18. List of current default input objects.

5. Set this roadway as the default roadway, as follows:
 - Select it in the Roadway pull-down list, by clicking on the down arrow next to the roadway box.
 - Click  to exit.



Note that this dialog box allows you to choose defaults, in one operation, for all input types. However, you must know an object's name to choose defaults by this method.

6. Digitize/enter all remaining roadway input.
7. Whenever you wish, you may set a different roadway as the default roadway.

8.2 Overview of Input

8.2.1 Input types. TNM Version 1.0 has the following input types:

- **Roadways (and their traffic):** Roadway traffic is TNM's source of sound **energy**. Roadways can also shield receivers from other roadways or can be on structure, so that other roadway sound passes under them, unshielded.
- **Receivers:** TNM calculates and prints out sound levels at your input receivers.
- **Barriers:** TNM barriers are either walls or berms that intervene between roadways and receivers to reduce sound levels. TNM perturbs barrier heights, so you can decide heights later and learn the resulting sound levels.
- **Building Rows:** TNM building rows are long rows of buildings, with gaps, that intervene between roadways and receivers to reduce sound levels.

- **Terrain Lines:** TNM terrain lines define where the terrain is located, both horizontally and vertically. Where terrain lines protrude through lines-of-sight, they reduce sound levels just as do intervening berms. Where they do not protrude, they locate the ground vertically relative to lines-of-sight.
- **Ground Zones:** TNM ground zones define the type and acoustical characteristics of intervening ground, wherever the ground differs from your chosen default ground type.
- **Tree Zones:** TNM tree zones consist of long, wide regions of heavy woods and vegetation that intervene between roadways and receivers, thereby reducing sound levels.
- **Contour Zones:** TNM contour zones define areas where you wish TNM to compute sound level contours.

8.2.2 Input methods. You can enter XYZ coordinates in several ways, as summarized in Table 12:

Table 12. Input methods for TNM coordinates.

Input method for coordinates	Relevant coordinates	Details	Registration required?
Digitize from plan sheets or aerial photos	XY	TNM needs to know the XY coordinate system of your plan sheet or aerial photo: first upon initializing a plan sheet, then as you shift it on the digitizer, and then if you change sheets.	Yes
	Z	With a 16-button digitizer puck, you may enter Z coordinates directly from the digitizer, at the same time as you digitize XY coordinates. See hint below.	Already registered for XY coordinates
Digitize from roadway profiles	Z	TNM needs to know the horizontal (for example, station number) and Z coordinate system of your roadway profile.	Yes
Import as DXF background (see Section 4.7)	XY	TNM needs to know the XY coordinate system of the DXF background, just like it would a plan sheet or aerial photo. A DXF background has only lines on it, like a plan sheet, rather than DXF coordinate information.	Yes
Import as DXF objects (see Section 4.7)	XYZ	TNM automatically knows the coordinates of all DXF objects. However, you may want to change the coordinates system from the CAD system's to your own.	No, but you may want to
Type into input dialogs	XY	A last resort. Use only if you have no digitizer and no access to DXF files.	No
	Z	The normal method of entering Z coordinates, unless you import DXF objects, or digitize roadway Z coordinates from profiles.	No



Enter Z coordinates as you digitize. Just after you click on a point to digitize its XY coordinates, press the “A” button on the digitizer puck (see Section 7.3). A Z-coordinate window is shown on the screen. Still at the digitizer, enter the point's Z coordinate with the puck numerals, 0 through 9. You must include two decimal digits. For example, to enter 120, press 12000. The value 120.00 will be displayed. If you pressed 120, only, 1.20 will be displayed. If needed, use the following buttons to edit the Z coordinate: “B” to backspace or “C” to clear. Press the “E” button to enter the coordinate. Then proceed to the next point.

8.3 Roadways

Roadway traffic is TNM's source of sound energy. This section concerns its input. See Appendix B for summary tables of all roadway input variables. Figure 19 shows several TNM roadways in plan and skew views.

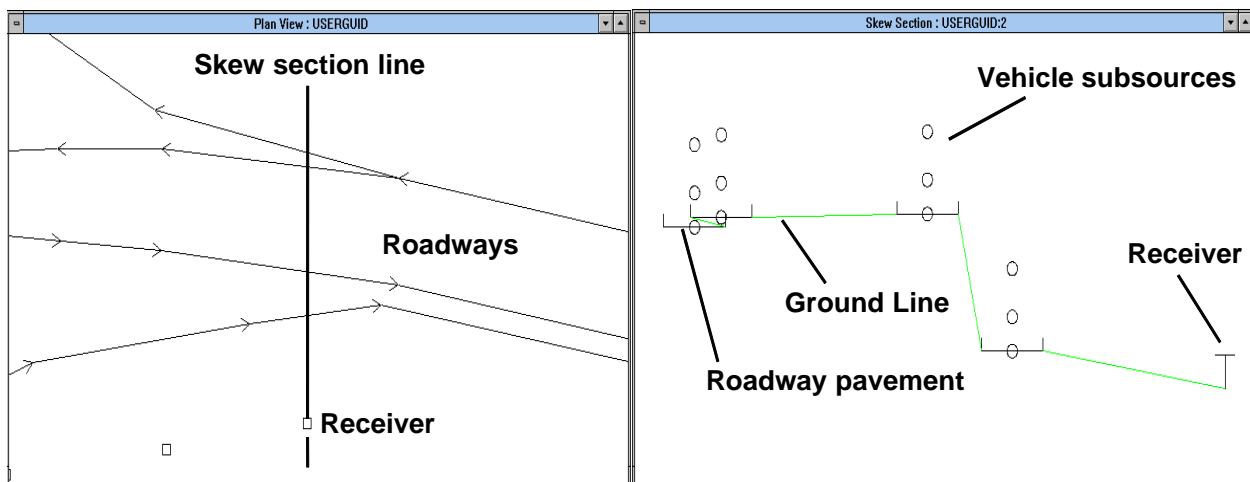



Figure 19. TNM roadways in plan and skew views.

To enter a complete set of roadways and set defaults (details later):

1. Open both the run's Plan View and the roadway input dialog.
2. In the Plan View, digitize the first roadway's XY coordinates.
3. Enter all other header information in the input dialog. Only header input is needed at this time, before you set this roadway as the default.
4. Set this roadway as the default roadway (see Section 8.1).
5. Digitize/enter all remaining roadway input.
6. Whenever you wish, you may set a different roadway as the default roadway.

8.3.1 Coordinates. Every roadway point has three coordinates: X, Y and Z, where Z is the ground elevation of the roadway.

To digitize the XY coordinates of a roadway:

1. Click on the roadway tool in the TNM Tool Bar. 
2. Digitize the XY coordinates of all roadway points, in the direction of traffic flow. Then click again on the roadway tool to turn it off, or double-click on the last XY point.



Intersections. In general, do not allow roadways to intersect any other type of TNM input. Most such intersections are not allowed by TNM Version 1.0. In addition, do not digitize roadways inside of tree zones. To assist you, TNM detects and reports all unallowed intersections during Input, Input Check (see Section 8.15).





Direction of flow. You must digitize roadways in the direction of traffic flow, and must therefore separate two-way traffic into two roadways, one in each direction. TNM slows down heavy trucks and increases their noise emissions on upgrades. If you digitize against traffic flow, heavy trucks will slow and get louder on downgrades, instead. In addition, TNM accelerates vehicles away from traffic-control devices, which it locates at start points of roadways. If you digitize against traffic flow, TNM will locate these devices at the wrong end of your roadway and will decelerate traffic as it approaches the control device. Both of these reverse-traffic situations will produce incorrect sound levels. If you have no **grades** (up or down) and also no traffic-control devices, you can safely ignore this warning without incorrect results. To reverse the direction of traffic for a roadway or a roadway segment, see Section 5.12.



Roadway XY coordinates. When digitizing roadways, try to match curves in the Plan View within plus or minus 2 m (6 ft) or so. This will almost always ensure that distances between roadway segments and receivers are precise to within plus or minus 10 percent (plus or minus 1 decibel). With no nearby receivers, you may relax this precision. In addition, always try to maintain approximately the correct roadway length on tight curves, by "straddling" the actual roadway centerline with your straight-line-segment approximation within TNM. Concerning Z coordinates, Section 8.3.3 discusses the need for additional roadway points to adequately match the vertical roadway coordinates.

3. If you wish, combine portions of the same actual roadway into one continuous TNM roadway. You will end up with a roadway in portions whenever it appears on several different plan sheets.



To digitize the Z coordinates of a roadway (Note: To type-in coordinates, see Section 8.3.2):

1. Select a roadway in the Plan View and then open its Roadway Profile, by choosing View, New View, Roadway Profile in the main menu. The roadway points in the profile correspond to those in your Plan View, but strung out straight. These are the points you entered to best match the roadway's horizontal curves.
2. Place a roadway profile sheet on the digitizer and register it with "Data Already Entered" (see Section 7.3).
3. To digitize the Z coordinates of existing roadway points: Select  and  in the Tool Bar. Move the puck horizontally to match an existing point, then vertically to the roadway's proper

elevation (Z coordinate). Click the puck to cause the Z coordinate of the existing roadway point to jump vertically to its digitized value.




Roadway Z coordinates. When entering roadway Z coordinates, try to approximate vertical coordinates within plus or minus 0.3 m (1 ft) or so. This will ensure that the vertical relation between roadways and nearby barriers is precise enough for proper barrier calculation. With no nearby barriers, you may relax this precision to plus or minus 1 m (3 ft) or so. Even without nearby barriers, roadway Z coordinates are still important to TNM propagation.

- To add additional roadway points, in order to match the roadway's vertical curves more precisely, turn off  and  in the Tool Bar. On the digitizer, click on any additional roadway points you wish, in any order. This will insert new points within the roadway with their proper XYZ coordinate.

8.3.2 General Input. Roadway general input consists of the following:

- Roadway name and width;
- Point names and numbers;
- Point coordinates, if they have not been digitized or imported;
- Pavement type; and
- Whether or not the roadway segment is on structure.

To enter general roadway input:

- Select **Input, Roadways** in the main menu. TNM will open the roadway input dialog.
- Select  on the roadway input dialog (see Figure 20).

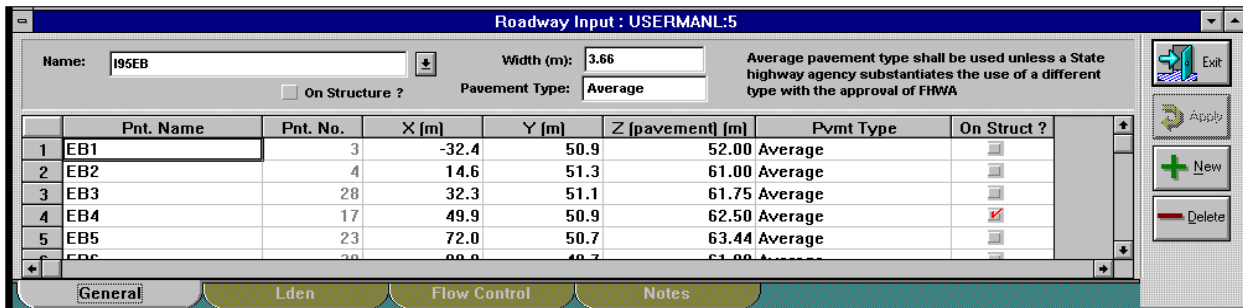


Figure 20. Roadway input: General tab.

- Enter the roadway's name and width in the header of the input dialog.



Roadway widths and resulting roadway edges. Roadway widths/edges serve two purposes in TNM Version 1.0: (1) They ensure that sound propagation from roadway to receiver begins over pavement; and (2) Even if roadway edges do not interrupt any lines-of-sight, they do locate the ground plane vertically, which is important to sound propagation. In that sense, roadway edges are automatic TNM terrain lines.

Note that roadway width cannot be varied from segment to segment. If a roadway width changes substantially, you must end one TNM roadway and begin another with the new width.



Roadway widths. The skew section of Figure 17 shows several roadways with overlapping widths. Such overlap might occur with parallel mainline roadways or when a ramp merges with a mainline. In the skew section, TNM draws a ground line from roadway edge to roadway edge, without regard to their overlap. During calculation, however, TNM smoothes out this ground line as shown by the added heavier line in the figure. Because of this smoothing, overlapping roadways are calculated correctly. Note that TNM's ground-line smoothing changes during calculation, depending upon which roadway's sound is being calculated.

When you set roadway widths, do not try to avoid overlap or to exactly match up edges of parallel roadways. Instead, try to actually guarantee overlap, so that TNM does not insert an unwanted gap in the roadway pavement. In addition, (1) set the width of the right-most roadway to approximate the right edge of pavement, and (2) set the width of the left-most roadway to approximate the left edge of pavement. You do not have to be overly precise in locating these pavement edges. Plus or minus 3 m (10 ft) is precise enough.

4. Enter the pavement type in the header of the input dialog. This parameter flows down to newly entered roadway segments. It also flows from the default roadway's header (see Section 8.1) to the header of subsequent roadways.

TNM Version 1.0 contains the following pavement types:

- Dense-graded asphaltic concrete (DGAC);
 - Portland cement concrete (PCC);
 - Open-graded asphaltic concrete (OGAC); and
 - Average: A composite pavement type consisting of data for DGAC and PCC combined.
-

Pavement type affects sound emissions from TNM vehicles. Use "average" pavement in nearly all situations. To change pavement types, you must enter the acronym for the new type explicitly, e.g., DGAC, rather than selecting it from a pull down list.





See Appendix A for FHWA policy related to pavement type.

5. Click the on-structure box in the header of the input dialog if most of the roadway is on structure. This parameter flows down to newly entered roadway segments. It also flows from the default roadway's header to the header of subsequent roadways.
-




Roadways on structure. When one roadway intervenes between another roadway and a receiver, it acts like an intervening barrier. It also helps to locate the ground plane vertically during TNM's calculation of sound propagation. However, if the roadway is on an elevated structure, it no longer truly intervenes, because sound can pass under it. For this reason, you must tell TNM which roadway segments are on structure. During TNM calculations, on-structure intervening roadways are ignored, i.e., they neither act like barriers nor help locate

the ground plane vertically. However, they are still noise sources. Pavement edges of an on-structure roadway only affect its own sound, not the sound from other roadways.

6. You may type/edit any point's coordinate in the spreadsheet.
7. Change the pavement type, if necessary, of individual roadway segments. In addition, click the on-structure box if the segment is on structure -- or unclick this box if it is improperly checked.
8. Click  along the right edge of the input dialog to apply your changes.
9. Click  along the right edge of the input dialog to exit.

8.3.3 Additional roadway points. When you first digitize a roadway, you include enough points to adequately match curves in the Plan View. However, sometimes additional points are needed to adequately match vertical roadway coordinates -- that is, to adequately match the roadway profile. You can determine this by locating the digitized points on a roadway profile sheet, connecting them with straight-line segments, and noting how well the straight-line segments match the actual profile.

If additional points are needed to match the roadway's profile:

1. In the Plan View, subdivide the relevant roadway segment into an appropriate number of portions (see Section 5.9).
2. Select Input, Roadways in the main menu, to return to the roadway input dialog. Then type in Z coordinates and other input for the new points. Then click  .

8.3.4 Traffic. TNM has five built-in vehicle types:

- Automobiles: all vehicles with two axles and four tires -- primarily designed to carry nine or fewer people (passenger cars, vans) or cargo (vans, light trucks) -- generally with gross vehicle weight less than 4,500 kg (9,900 lb);
- Medium trucks: all cargo vehicles with two axles and six tires -- generally with gross vehicle weight between 4,500 kg (9,900 lb) and 12,000 kg (26,400 lb);
- Heavy trucks: all cargo vehicles with three or more axles -- generally with gross vehicle weight more than 12,000 kg (26,400 lb);
- Buses: all vehicles designed to carry more than nine passengers; and
- Motorcycles: all vehicles with two or three tires and an open-air driver/passenger compartment.

If you wish to add your own "user-defined" vehicle type to TNM's built-in types, see Section 8.11. Section 8.11 discusses use of your user-defined vehicles, once you have entered their acoustic emission characteristics.



Traffic mode. Under Setup, you choose a traffic mode for your run's calculations, from among the following:

- L_{Aeq1h} : hourly **A-weighted** equivalent sound level (1HEQ);
- L_{Aeq1h} : hourly A-weighted equivalent sound level (1HEQ) expressed in percent;
- L_{dn} : day-night average sound level (DNL); and
- L_{den} : Community Noise Equivalent Level (CNEL), where “den” stands for day/evening/night.

You must enter and edit all traffic in that same mode here. If you enter traffic in some other mode, TNM will ignore it during calculation. In particular for L_{Aeq1h} , you cannot enter some traffic as volumes and other traffic as percentages. Note: TNM’s Input Check module will produce errors if the traffic percentages in each column do not add up to 100 percent.



Copy/paste. You can copy/paste traffic into the traffic-choice spreadsheet from an independent spreadsheet program. You must make sure, however, that vehicle types are spelled properly, including capitalization. If they are not, TNM will not accept them.

To enter traffic volumes/speeds for L_{Aeq1h} Hourly:

1. Select Input, Roadway in the main menu.
2. Select **L_{Aeq1h} Hourly** on the roadway input dialog (see Figure 21).

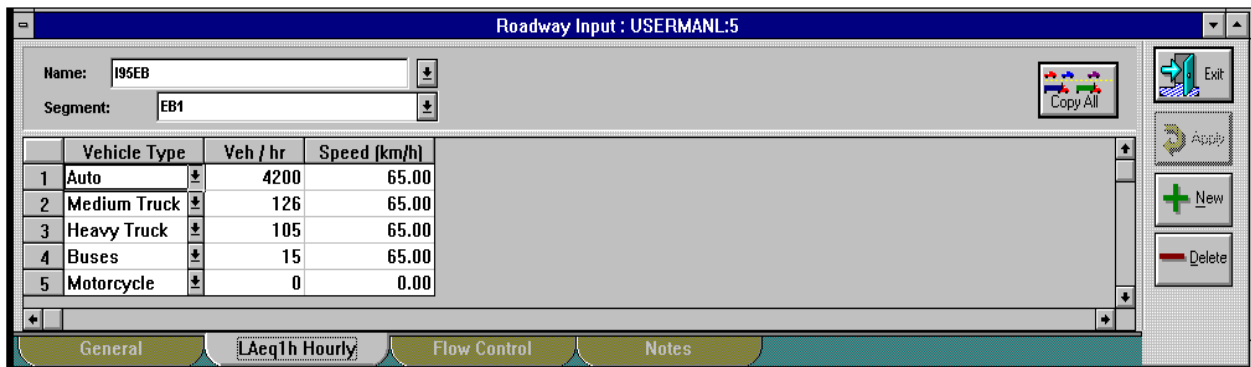





Figure 21. Roadway input: Traffic tab (L_{Aeq1h} Hourly).

3. Select a roadway segment, either in the header’s pull down list or by clicking on it in the Plan View. Then for each vehicle type in the spreadsheet, enter the hourly volume and speed for that roadway segment.
4. If you wish, apply the spreadsheet’s traffic to the entire roadway by clicking  in the dialog’s header.
5. When done entering traffic for the segment, click  along the right edge of the input dialog to apply your changes.
6. Click  along the right edge of the input dialog to exit.

To enter traffic percentages/speeds for L_{Aeq1h} :

1. Select Input, Roadway in the main menu.

2. Select **LAeq1h Percent** on the roadway input dialog (see Figure 22).

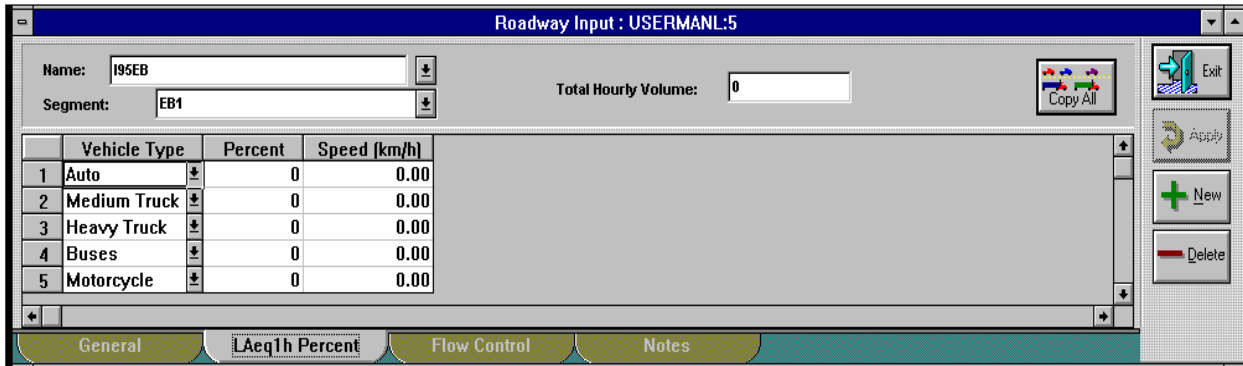





Figure 22. Roadway input: Traffic tab (L_{Aeq1h} Percent).

3. Select a roadway segment, either in the header's pull down list or by clicking on it in the Plan View. Then enter total hourly volume in the header of the dialog box. Then for each vehicle type in the spreadsheet, enter the percentage for that vehicle type, plus speed.



Percentages. Percentages within each column must add up to 100 percent.

4. If you wish, apply the spreadsheet's traffic to the entire roadway by clicking  in the dialog's header.
5. When done entering traffic for the segment, click  along the right edge of the input dialog to apply your changes.
6. Click  along the right edge of the input dialog to exit.

To enter traffic for L_{dn}:

1. Select Input, Roadway in the main menu.
2. Select **Ldn** on the roadway input dialog (see Figure 23).

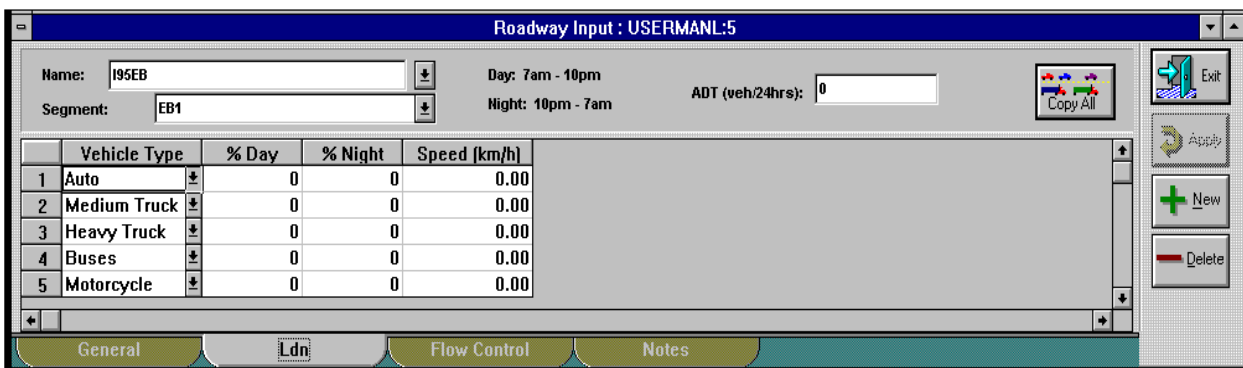





Figure 23. Roadway input: Traffic tab (L_{dn}).


3. Select a roadway segment, either in the header's pull down list or by clicking on it in the Plan View. Then enter the average daily traffic (ADT) in the header of the dialog box. Then for each vehicle type in the spreadsheet, enter the percentage for that vehicle type, plus speed.



Percentages. Percentages within each column must add up to 100 percent.

4. If you wish, apply the spreadsheet's traffic to the entire roadway by clicking  in the dialog's header.
5. When done entering traffic for the segment, click  along the right edge of the input dialog to apply your changes.
6. Click  along the right edge of the input dialog to exit.

To enter traffic for L_{den} :

1. Select Input, Roadway in the main menu.
2. Select  on the roadway input dialog (see Figure 24).

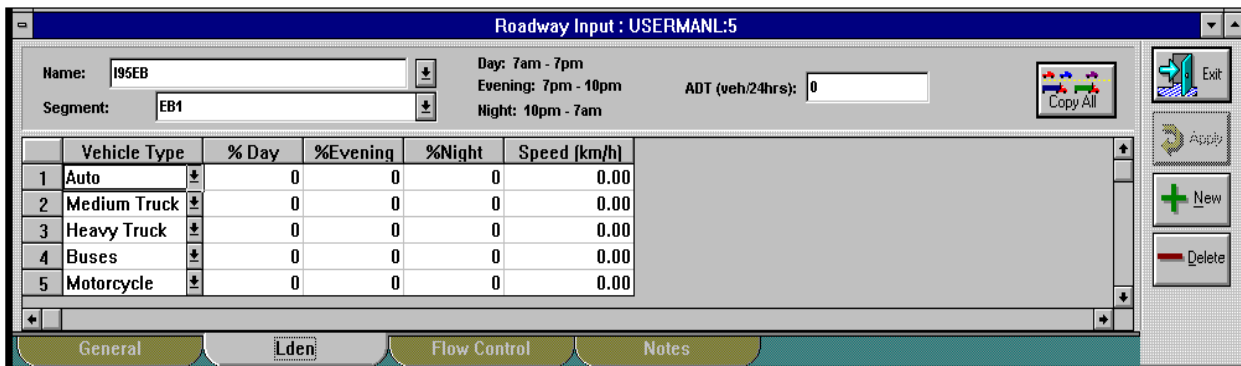





Figure 24. Roadway input: Traffic tab (L_{den}).

3. Select a roadway segment, either in the header's pull down list or by clicking on it in the Plan View. Then enter the average daily traffic (ADT) in the header of the dialog box. Then for each vehicle type in the spreadsheet, enter the percentage for that vehicle type, plus speed.



Percentages. Percentages within each column must add up to 100 percent.

4. If you wish, apply the spreadsheet's traffic to the entire roadway by clicking  in the dialog's header.
5. When done entering traffic for the segment, click  along the right edge of the input dialog to apply your changes.
6. Click  along the right edge of the input dialog to exit.

8.3.5 Flow control. TNM Version 1.0 computes the acoustical effect of the following traffic-control devices:

- Stop signs;
- Toll booths;
- Traffic signals; and
- On-ramp start points.

At a traffic-control device, TNM reduces vehicle speeds to your "speed constraint," for your "percentage of vehicles affected," and then accelerates this percentage of vehicles away from the device. Acceleration continues until the vehicles come back up to your input speed, or until they reach the end of that TNM roadway. As vehicles accelerate, their noise emissions increase as compared to cruising vehicles at the same speed.

To enter roadway flow-control input:

1. Select Input, Roadway in the main menu.
2. Select **Flow Control** on the roadway input dialog (see Figure 25).

	Pnt. Name	Pnt. No.
1	EB1	3
2	EB2	4
3	EB3	28
4	EB4	17
5	EB5	23
	EB6	28

Figure 25. Roadway input: Flow control tab.

3. If the roadway begins with a traffic-control device, select the type of device from the pull down list in the header of the input dialog. In addition, enter the device's speed constraint and the percentage of vehicles it affects. TNM always puts the traffic-control device at the roadway's start point.





The speed constraint is generally zero for all devices except on-ramp start points, where vehicles sometimes enter the on-ramp without completely stopping first. A reasonable start speed for such on-ramps is 16 km/hr (10 mph). In general, 100 percent of vehicles are affected by all devices except traffic signals, which generally catch only a portion of vehicles on their red phase.



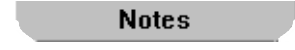


Roadways too short. TNM Version 1.0 stops computing vehicle speeds for accelerating vehicles at the endpoint of the traffic-device's roadway. For the subsequent roadway, TNM begins anew with that roadway's input speeds. In other words, TNM does not link speeds from one roadway to the next. If you know that vehicles will continue to accelerate past the endpoint of the traffic-device roadway, you must extend this roadway to allow continuing

acceleration. For example, if heavy-truck acceleration will continue past the physical merge point of an on-ramp with the mainline, extend the on-ramp past this physical merge point, parallel to the mainline, so that heavy trucks will be back up to speed before leaving the on-ramp roadway. Refer to the TNM Technical Manual for more detail.

4. Click  along the right edge of the input dialog to apply your changes.
5. Click  along the right edge of the input dialog to exit.

8.3.6 Notes. As with all input types, you may enter notes to remind yourself of particular characteristics of roadways or their points/segments.

To enter roadway notes:

1. Select Input, Roadways in the main menu.
2. Select  on the roadway input dialog (not shown).
3. If desired, type a roadway note in the header of the dialog box.
4. If desired, type a note about individual points or segments in the relevant spreadsheet row.
5. Click  along the right edge of the input dialog to apply your changes.
6. Click  along the right edge of the input dialog to exit.

8.4 Receivers

TNM calculates and prints out sound levels at your input receivers. If you want sound level contours, in addition to sound levels at your input receivers, you must select Contours in the main menu. Your input receivers are entirely separate from TNM contours. This section concerns receiver input. See Appendix B for summary tables of all receiver input variables. Figure 26 shows several TNM receivers in plan and skew views.

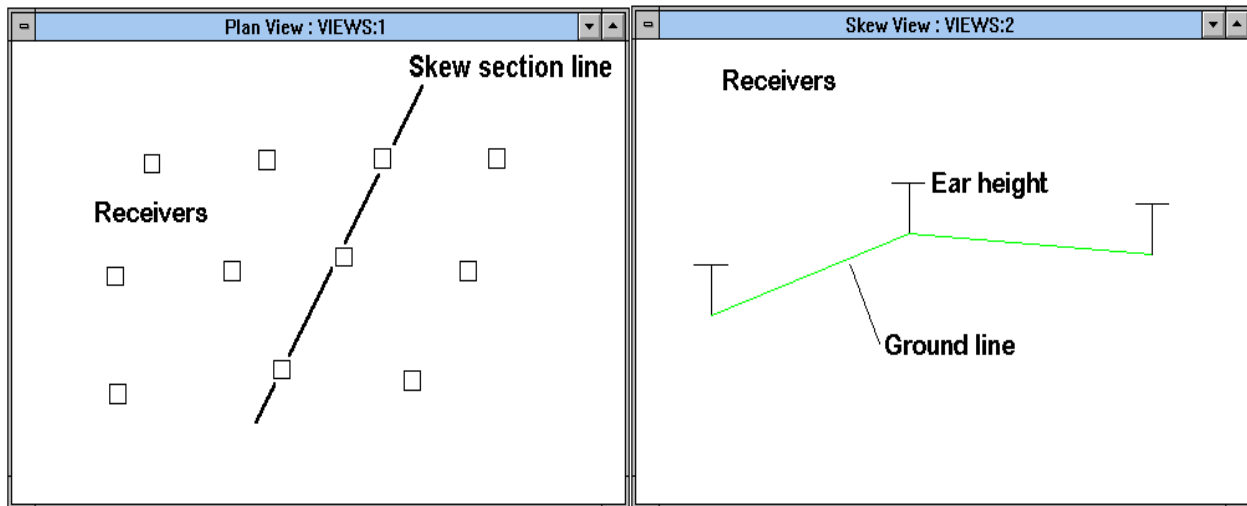



Figure 26. TNM receivers in plan and skew views.

To enter a complete set of receivers and set defaults (details later):

1. Open both the run's Plan View and the receiver input dialog.
2. In the Plan View, digitize the first receiver's XY coordinates.
3. Enter all other header information in the input dialog. Only header input is needed at this time, before you set this receiver as the default.
4. Set this receiver as the default receiver (see Section 8.1).
5. Digitize/enter all remaining receiver input.
6. Whenever you wish, you may set a different receiver as the default receiver.

8.4.1 Coordinates. Every receiver has three coordinates: X, Y and Z, where Z is the ground elevation at the base of the receiver.

To digitize the XY coordinates of a receiver:

1. Click on the receiver tool in the TNM header.  This tool will remain on as you digitize multiple receivers, until you click it again to turn it off.
2. Digitize the XY coordinates of the receiver.




Intersections In general, do not allow receivers to intersect any other type of TNM input (Note: Because roadway coordinates are placed at the center of the roadway's width, receivers should not be placed within 1/2 the distance of the roadway's width from the roadway). However, receivers stacked on top of each other, such as multiple microphones on a mast to represent 1st, 2nd, and 3rd floor receivers for example, are allowed. To model a microphone on top of a barrier, such as a reference microphone, you must offset your receiver position in the horizontal plane by a minimum 0.1 ft. To assist you, TNM detects and reports all unallowed intersections during Input, Input Check (see Section 8.15).

8.4.2 General input. Receiver general input consists of the following:

- Receiver name and coordinates, if they have not been digitized or imported;
- Receiver height above the ground; and
- Number of dwelling units represented by that single TNM receiver.

To enter general receiver input:

1. Select Input, Receivers in the main menu. TNM will open the receiver input dialog.
2. Select  on the receiver input dialog (see Figure 27).

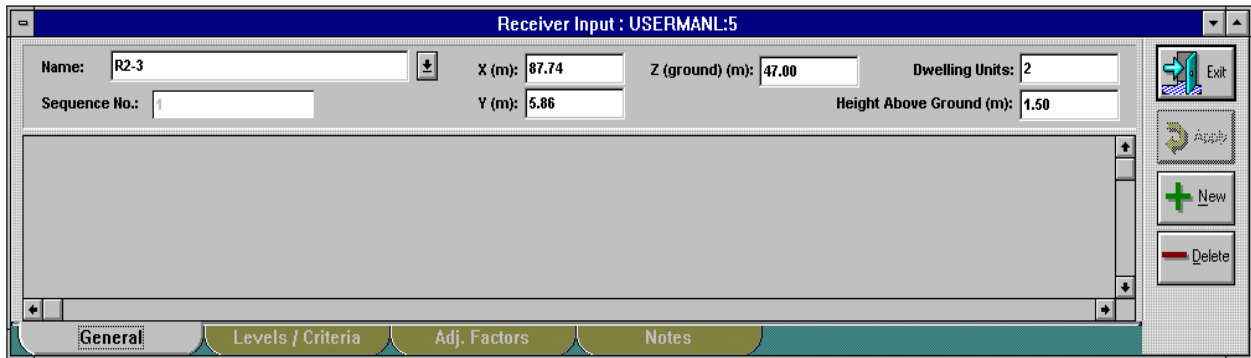



Figure 27. Receiver input: General tab.

3. Enter the receiver's name and its height above ground in the header of the input dialog. In addition, if you wish cost-effectiveness output, enter the number of dwelling units that this receiver represents. (The receiver's height above ground and dwelling units flow from the default receiver's header to the header of subsequent receivers.)
4. Enter the receiver's Z (ground) in the header of the input dialog. TNM automatically combines the receiver's Z (ground) with its height above ground, to determine the receiver's ear height for calculation.

5. Click  along the right edge of the input dialog to apply your changes.

6. Click  along the right edge of the input dialog to exit.

8.4.3 Levels and criteria. TNM allows you to enter the following sound levels and criteria:

- Existing level (dBA);
- Substantial increase (dB): computed minus existing;
- Impact Criteria Level (dBA); and
- Noise Reduction Goal (dB).

To enter receiver levels/criteria input:

1. Select Input, Receivers in the main menu.
2. Select **Levels / Criteria** on the receiver input dialog (see Figure 28).

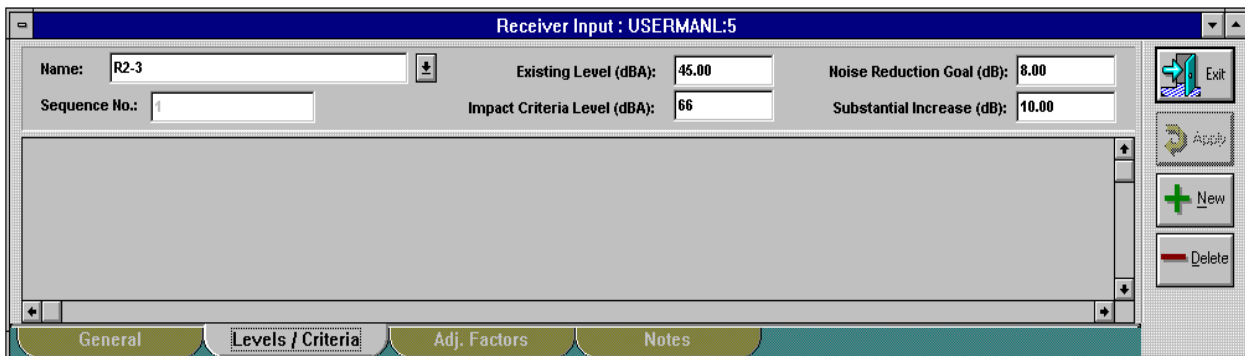


Figure 28. Receiver input: Levels/Criteria tab.

- If you wish TNM to compute noise impact, enter Existing Level, Substantial Increase, and Impact Criterion Level in the header of the input dialog.





See Appendix A for FHWA policy related to these parameters.

- Existing Level: This is the baseline for judgment of relative noise impact -- that is, impact due to a substantial increase in sound level.
- Substantial Increase: This is the criterion for judgment of relative noise impact. In its results table, TNM tallies a receiver as "impacted, substantial increase," if its calculated sound level minus its existing level is greater than this criterion.
- Impact Criteria Level: This is the criterion for judgment of absolute noise impact -- that is, impact due to speech interference and other matters not dependent upon existing noise levels. In its results table, TNM tallies this receiver as "impacted, L_{Aeq1h} ," if its calculated sound level equals or exceeds this criterion.

For assessments of impact, TNM calculates sound levels with all barriers set to their zero height. In other words, impact is assessed without noise barriers.

- If you wish TNM to compute cost-effectiveness parameters for your noise barriers, enter the noise reduction goal in the header of the input dialog.

In its results table, TNM tabulates each receiver's calculated sound level minus this noise reduction goal. This difference changes automatically as you choose different perturbed barrier heights.


- Click  along the right edge of the input dialog to apply your changes.
- Click  along the right edge of the input dialog to exit.

8.4.4 Adjustment factors. Adjustment Factors are sound level adjustments in dB that are added to the sound levels calculated by TNM. TNM imports shielding factors from your STAMINA files as adjustment factors. Typically, shielding factors in STAMINA files were used to account for things such as building row and tree zone effects. However, you may choose not to import them, but model building rows and tree zones explicitly in TNM. You may wish to input/edit TNM adjustment factors for model calibration to account for Parallel Barrier degradations between receiver-roadway pairs and propagation effects not calculated by TNM Version 1.0 -- for example, atmospheric effects.



See Appendix A for FHWA policy related to adjustment factors.

To enter adjustment factors for each receiver/roadway-segment combination:

- Select Input, Receivers in the main menu.
- Select  on the receiver input dialog (see Figure 29).

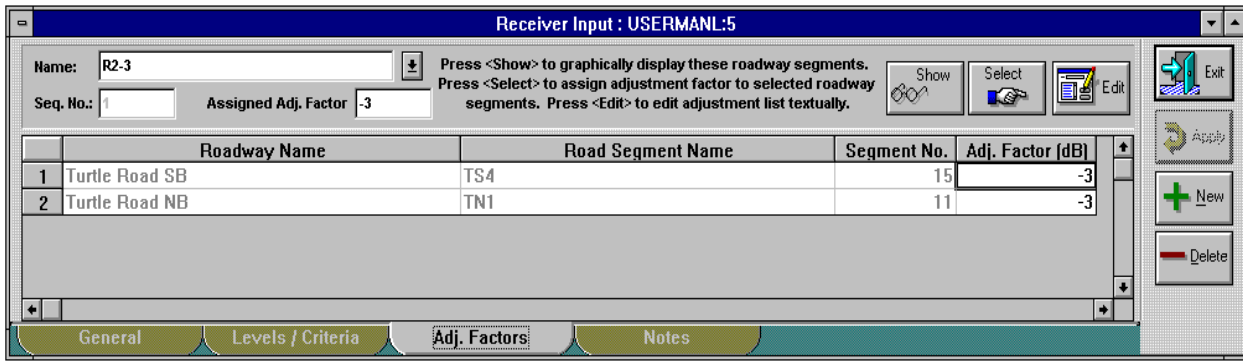






Figure 29. Receiver input: Adjustment Factor tab.


3. Enter a Default Assigned Adjustment Factor in the header of the input dialog. In the next several steps, you will assign this factor to selected roadway segments.





Adjustment factors are added. TNM adjustment factors are algebraically added, not subtracted, from calculated sound levels. Therefore, if you want adjustment factors to reduce calculated sound levels -- say for attenuations that TNM Version 1.0 does not calculate -- you must enter them as negative numbers.

4. Click  along the right edge of the input dialog, because in the next step you will be leaving the input dialog.
5. In the Plan View, select those roadway segments you wish for this value of the adjustment factor to be applied.
6. Back in the input dialog, click  in the header. TNM will then assign the default adjustment factor to your selected roadway segments and will list them all in the spreadsheet portion of the input dialog.
7. To assign a different adjustment factor to different roadway segments, loop back to Step 3.
8. Click  along the right edge of the input dialog to apply your changes.
9. Click  along the right edge of the input dialog to exit.

To show which roadway segment(s) are assigned a specific receiver:

1. While still in the receiver input dialog, select the desired receiver whose assigned roadways or roadway segments you would like to “show.”
2. Click  in the header of the input dialog. In the Plan view, TNM will highlight the appropriate roadways and/or roadway segments that are assigned to the receiver.

To remove a roadway segment from the adjustment-factor list:

1. While still in the receiver input dialog, click  along the right edge of the dialog, because in the next step you will be leaving the input dialog.
2. Click  in the header of the input dialog. TNM will display the edit dialog for receiver adjustment factors (see Figure 30).

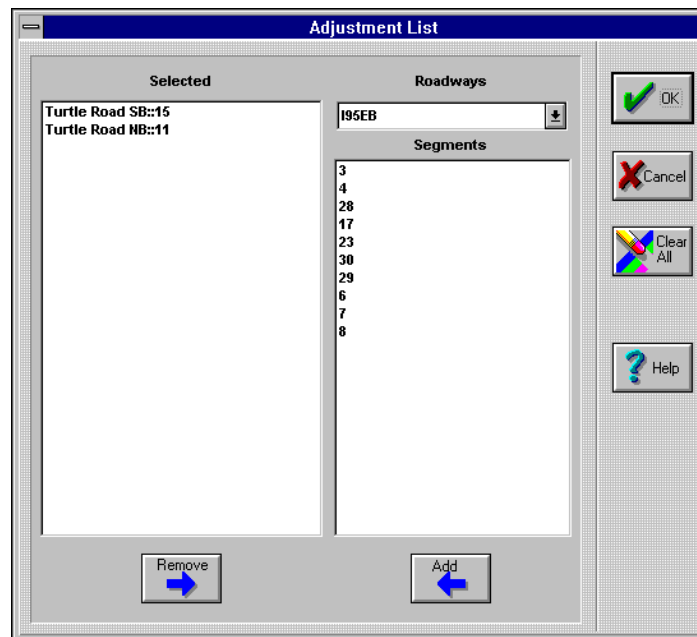









Figure 30. Receiver adjustment factors: Edit dialog.

3. Select one or more roadway segments in the left-most list.
4. Click  under this list. TNM will then remove these segments from the receiver-adjustment list. To remove all segments for a given roadway from the receiver adjustment list, click  on the right edge of the list.
5. Click  along the right edge of the dialog. TNM will return you to the receiver input dialog.
6. Click  along the right edge of the input dialog to apply your changes.
7. Click  along the right edge of the input dialog to exit.

8.4.5 Notes. As with all input types, you may enter notes to remind yourself of particular characteristics of receivers.

To enter receiver notes:

1. Select **I**nput, **R**eceivers in the main menu.
2. Select **Notes** on the receiver input dialog (not shown).
3. If desired, type a note in the header of the dialog box for each receiver name.
4. Click  along the right edge of the input dialog to apply your changes.
5. Click  along the right edge of the input dialog to exit.

8.5 Barriers

TNM barriers are either walls or berms that intervene between roadways and receivers to reduce sound levels. For the purposes of barrier design, TNM allows you to perturb barrier heights up and down, so you can decide specific heights later and then quickly determine the resulting sound levels. Within TNM, you may also place a wall barrier on top of a berm barrier, as described below. This section concerns barrier input. See Appendix B for summary tables of all barrier input variables. Figure 31 shows several TNM barriers in plan and skew views.

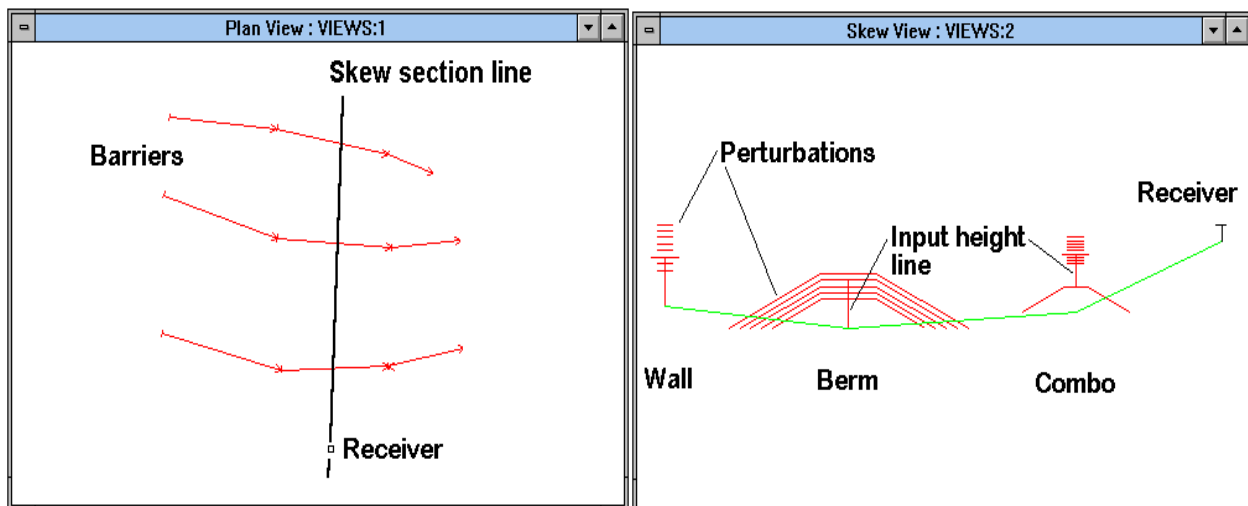


Figure 31. TNM barriers in plan and skew views.

To enter a complete set of barriers and set defaults (details later):

1. Open both the run's Plan View and the barrier input dialog.
2. In the Plan View, digitize the first barrier's XY coordinates.
3. Enter all other header information in the input dialog. Only header input is needed at this time, before you set this barrier as the default.
4. Set this barrier as the default barrier (see Section 8.1).
5. Digitize/enter all remaining barrier input.
6. Whenever you wish, you may set a different barrier as the default barrier.

8.5.1 Coordinates. Every barrier point has three coordinates: X, Y and Z, where Z is the ground elevation at the base of the barrier.

To digitize the XY coordinates of a barrier:



1. Click on the barrier tool in the TNM header.
2. Digitize the XY coordinates of all barrier points. Then click again on the barrier tool to turn it off, or double-click on the last XY point.



Intersections. In general, do not allow barriers to intersect any other type of TNM input. Most such intersections are not allowed by TNM Version 1.0. To assist you, TNM detects and reports all unallowed intersections during Input, Input Check (see Section 8.15).



Barrier XY coordinates. When digitizing barriers that lie along roadways, try to match the straight-line segments you used for roadway digitizing. In that manner, you will preserve the relative horizontal distance between roadway and barriers, which is important to calculations. Try to maintain this relative roadway/barrier distance to within approximately 10 percent. With no nearby roadways or receivers, you may relax this barrier XY precision.

In addition, do not digitize gaps in barriers where no gaps actually occur. Unwanted gaps allow far more sound energy through them than the gap size would suggest.

8.5.2 General input. Barrier general input consists of the following:

- # Barrier name and type (wall or berm);
- # Barrier perturbation increment, plus the number of perturbations up and number down;
- # Barrier base height, minimum height and maximum height;
- # Point coordinates, if they have not been digitized or imported;
- # Height of each point above the ground; and
- # Each point's perturbation increment, plus the number of perturbations up and down.

To enter general barrier input:

1. Select Input, Barriers in the main menu. TNM will open the barrier input dialog.
2. Select **General** on the barrier input dialog (see Figure 32).

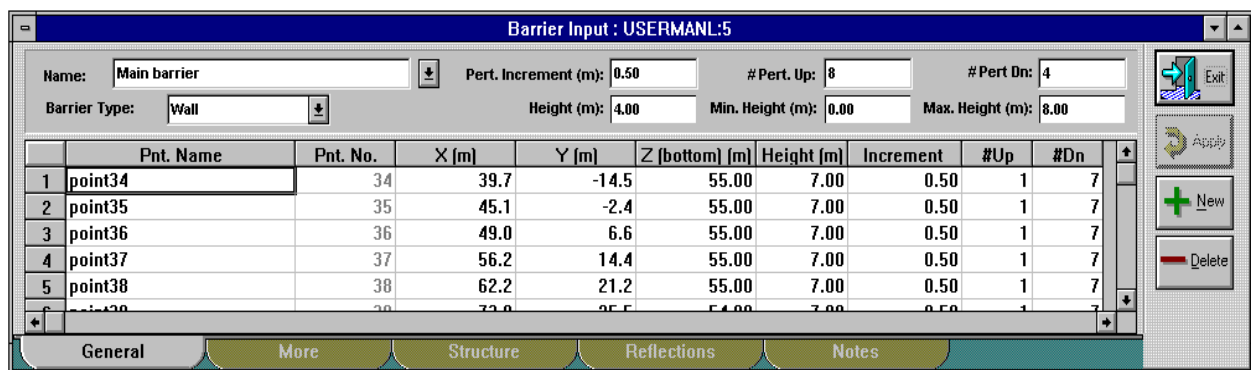


Figure 32. Barrier input: General tab.

3. Enter the barrier's name and select its type from the pull-down list in the header of the input dialog.

TNM Version 1.0 has two barrier types, walls and berms, each with slightly different input as described below. Both can be perturbed up and down from their input heights, so that TNM can calculate sound propagation for a series of height possibilities all in the same calculation run. After all acoustics are calculated, then you can request quick results for any particular combination of perturbed heights.

In addition, you can construct "combination" barriers by placing a wall barrier directly on top of a berm barrier, as described below.

4. Enter the barrier's minimum and maximum heights in the header of the input dialog. (These two parameters flow from the default barrier's header to the header of subsequent barriers.)

During its input check, TNM perturbs all barriers up and down, as you have requested. It then checks and reports on any downward perturbations that fall below the barrier's minimum height. Similarly, it checks and reports on any upward perturbations that exceed the barrier's maximum height. These two parameters, minimum and maximum heights, are included to help you check for unwanted barrier perturbations.

5. Enter values for barrier height, perturbation increment, number of perturbations up, and number of perturbations down. (These four parameters flow down to newly entered barrier points. They also flow from the default barrier's header to the header of subsequent barriers.)
6. Type each point's Z (bottom) in the point's spreadsheet row.
7. Enter the height of each barrier point in the point's spreadsheet row.



Barrier-point heights. When entering barrier-point heights for barriers that lie along roadways, try to preserve the relative elevation between the roadway and the barrier top. This is important to barrier calculations. Try to maintain this relative roadway/barrier elevation to within approximately 0.3 m (1 ft). With no nearby roadways or receivers, you may relax this barrier precision to approximately plus or minus 1 m (3 ft). Even without nearby barriers, barrier-top heights are still important to TNM propagation.

8. Modify the following parameters: perturbation increment (Increment column), number of perturbations up (#Up column), and number of perturbations down (#Down column) for each barrier segment in the segment's spreadsheet row. (These parameters flow down to newly entered barrier points. They also flow from the default barrier's header to the header of subsequent barriers.)
-



Run-time. The number of perturbations your barriers have can greatly affect run-time. In general, it is recommended that barrier perturbations be no smaller than 1 ft, especially during initial design. When a close-to-final design has been developed, you may want to create a new run with perturbations smaller than 1 ft. However, keep in mind that a 1-ft change in barrier height will typically have a very small effect on sound level, usually less than 0.5 dB.



Fixed-height barriers. If you enter a value of 0 for all of the perturbation parameters (Increment, #Up, and #Down), TNM will designate the particular barrier as a fixed-height barrier.

Figure 33 is a side view of a perturbed barrier. The bottom heavy line along the barrier is the barrier's bottom. You input this bottom line by entering a Z (bottom) coordinate for each barrier point. The top heavy line is the barrier's input-height line. You input this input-height line by entering a height for each barrier point. Each barrier segment is then perturbed as shown. You input these perturbations by entering three parameters for each barrier segment: (1) perturbation height, (2) number of perturbations up, and (3) number of perturbations down. In the input-dialog spreadsheet, you enter these perturbations on each segment's start point row. The last barrier point needs no entries for these parameters.

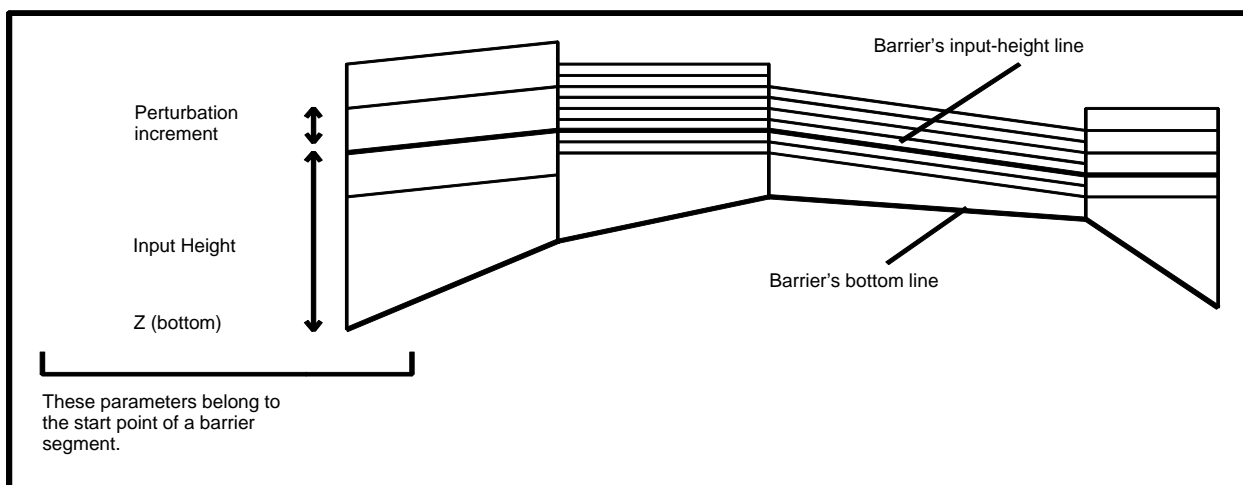





Figure 33. Barrier perturbations: Vertical side view of a barrier.

9. Click  along the right edge of the input dialog to apply your changes.
10. Click  along the right edge of the input dialog to exit.

8.5.3 More barrier input.

- TNM allows the following additional barrier input:
- # Unit costs
 - # For berms: Top width and slope.

To enter "more" barrier input:

1. Select Input, Barriers in the main menu.
2. Select  on the barrier input dialog (see Figures 34 and 35).

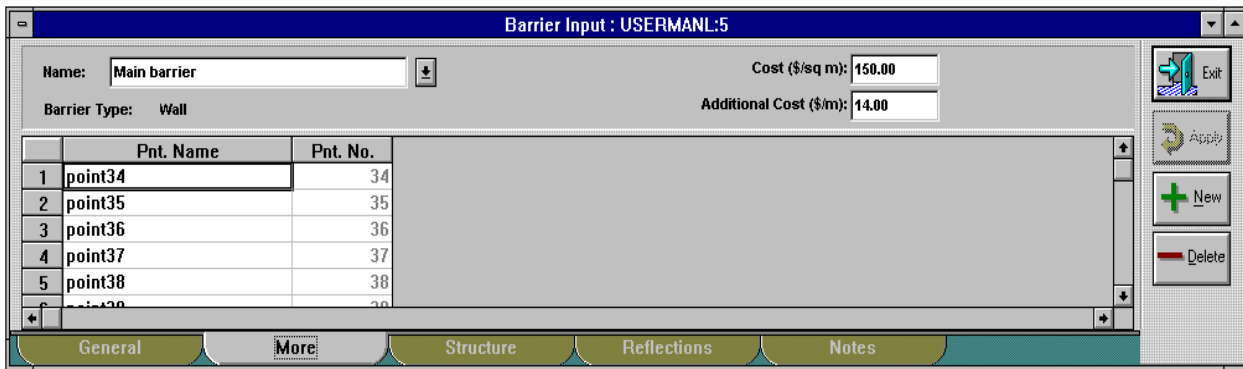


Figure 34. Barrier input: "More" tab for wall barriers.

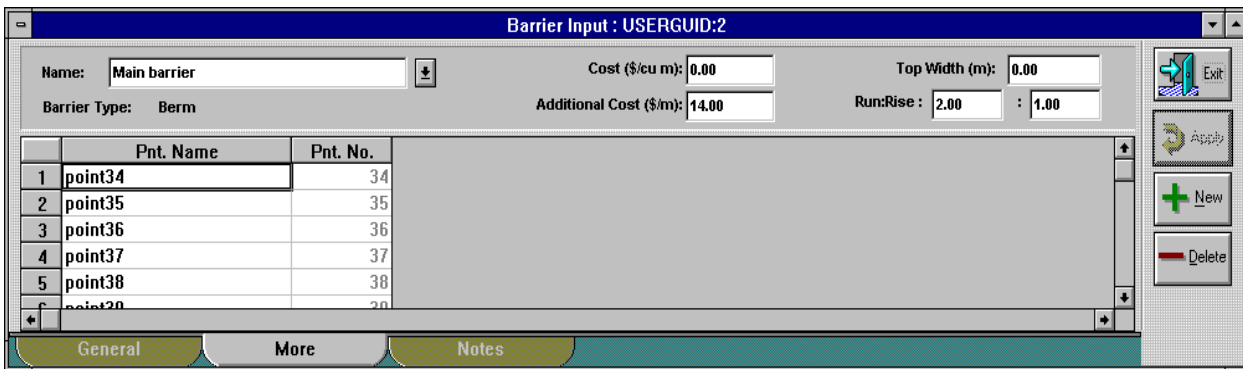


Figure 35. Barrier input: "More" tab for berm barriers.

3. If you wish TNM to compute barrier costs, then enter the barrier's unit cost and additional cost in the header of the input dialog. (These two parameters flow from the default barrier's header to the header of subsequent barriers.)

TNM Version 1.0 includes two unit costs for barriers: (1) the cost per unit area (per cubic volume for berms), and (2) an additional cost per linear foot. TNM computes total barrier cost from both, combined. A barrier's cost per unit area (or unit volume) often includes material costs, which are generally proportional to area (or volume). However, other costs are sometimes more proportional to barrier length -- for example, costs of the barrier's engineering design, clearing and grubbing, and landscaping. You can choose how to use these two cost parameters -- either one, or both.



4. For berm barriers, enter the Side Slope (Run:Rise) in the dialog header. The skew section of Figure 39 shows these two parameters. (These two parameters flow from the default barrier's header to the header of subsequent barriers.)



Side slopes of berms are measured as Run:Rise -- that is, horizontal: vertical. For example, if you walk down a two-to-one (2:1) berm in the steepest direction, for every distance of two that you progress horizontally you will descend a distance of one vertically. When you construct a skew section perpendicular to a berm barrier, the barrier's side slope in the section will agree with your input value. However, when you construct a section at an angle to the barrier, the skew section will "stretch out" the side slope so that it looks less steep than your input value.




Berm Top Width. TNM Version 1.0 applies a default value of 0 to berm top widths. You may change this value; however, it is recommended that you use the default. TNM has shown some apparent anomalies in the diffraction algorithms for berms with a top width.

5. Click  along the right edge of the input dialog to apply your changes.
6. Click  along the right edge of the input dialog to exit.

8.5.4 Barriers on structure. When a barrier is built on an elevated structure, it generally only shields receivers from adjacent roadways that are also on the structure. Sound from other roadways can pass under the structure, unshielded. For this reason, you must tell TNM which barrier segments are on structure and which roadway segments they shield. During TNM calculations, on-structure barriers are ignored for all non-shielded roadways. They neither block lines-of-sight nor help locate the ground plane vertically for that source/receiver combination.

To enter "structure" barrier input:

1. In the Plan View, select a set of barrier segments that all shield the same set of roadway segments.
2. Also select the roadway segments that they shield.
3. Select Input, Structure Barriers in the main menu.
4. Click  to confirm.

To graphically see which barrier segments shield which roadway segments:

1. Select Input, Barriers in the main menu.
2. Select **Structure** on the barrier input dialog. "On Struct?" will be checked for each barrier segment that is on structure (see Figure 36).

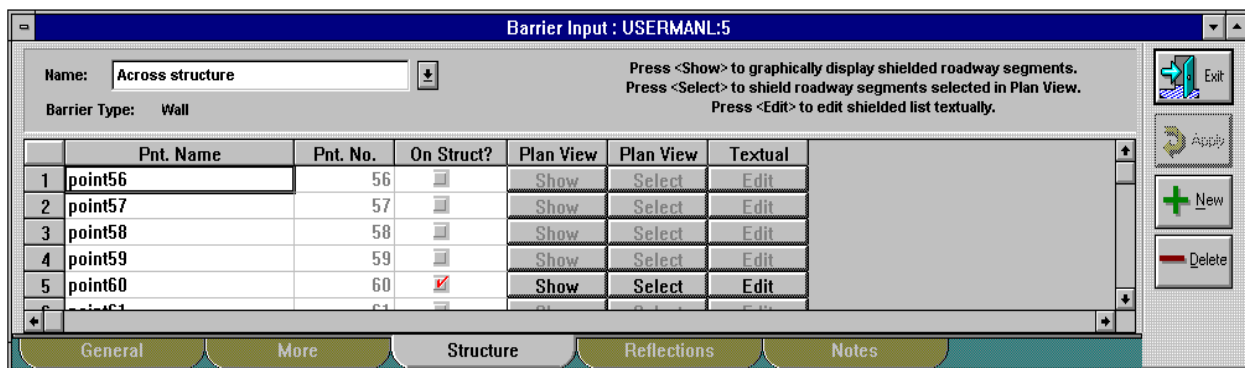
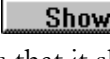








Figure 36. Barrier input: Structure tab.



3. For each on-structure barrier segment, click . In the Plan View, TNM will highlight that barrier segment and all the roadway segments that it shields.

4. Click  along the right edge of the input dialog to apply your changes.
5. Click  along the right edge of the input dialog to exit.

To select a roadway segment(s) to be shielded by a barrier segment(s):

1. Select Input, Barriers in the main menu.
2. Select  on the barrier input dialog.
3. In the dialog header, select the desired barrier in the Name pull-down list.
4. In the Plan view, use the mouse to select the desired roadways or roadway segments to be shielded.
5. In the dialog, click  for those barrier segments that will shield the selected roadways or roadway segments.
6. Click  along the right edge of the input dialog to apply your changes.
7. Click  along the right edge of the input dialog to exit.

To remove a shielded roadway segment from the current barrier's shielded list:

1. Select Input, Barriers in the main menu.
2. Select  on the barrier input dialog.
3. For the desired on-structure segment, click . TNM will display the edit dialog for structure barriers (see Figure 37).

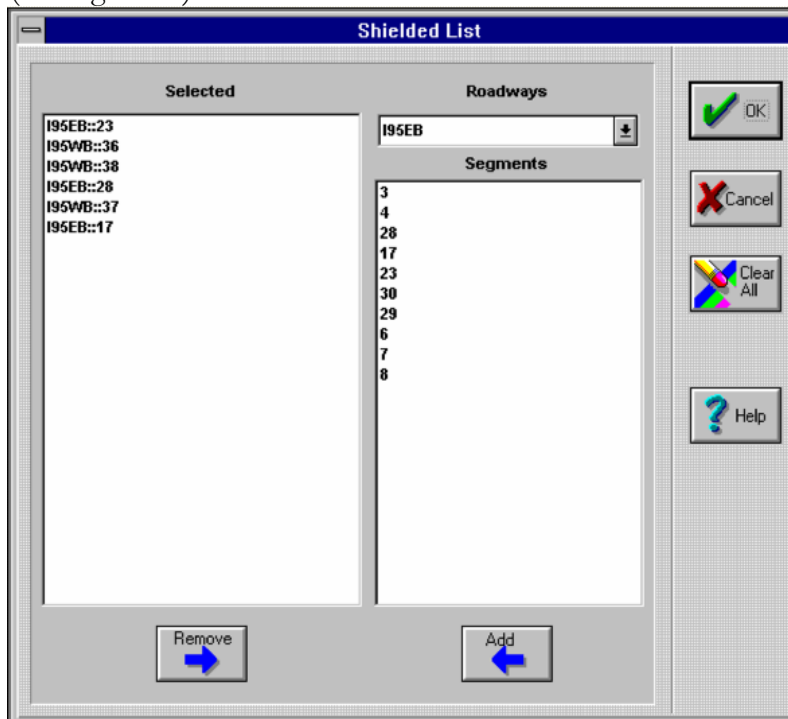







Figure 37. Structure barriers: Edit dialog.


4. Select one or more roadway segments in the left-most list.
5. Click  under this list. TNM will then remove these segments from the shielded-roadway list. The structure barrier will no longer shield them. To remove all segments from the shielded-roadway list, click  on the right edge of the list.
6. Click  along the right edge of the dialog. TNM will return you to the barrier input dialog.
7. Click  along the right edge of the input dialog to apply your changes.
8. Click  along the right edge of the input dialog to exit.

8.5.5 Reflective and Absorptive Barriers. To designate a barrier as reflective or absorptive, you enter a **noise reduction coefficient** (NRC) for appropriate barrier segments. For pre-designed noise-barrier systems, NRCs are available from the barrier manufacturer. For generic materials, NRCs are available in standard textbooks. TNM converts your NRC into one-third octave-band **sound absorption** coefficients and then absorbs reflected sound based upon these coefficients.



Important Reflections, i.e., a single reflection from a barrier to receivers on the opposite side of a roadway, are not implemented in TNM Version 1.0. As a result, the columns, “Reflections ?” and the associated next three columns are grayed out and not available for selection/editing.

To enter Noise Reduction Coefficients for barriers:

1. Select Input, Barriers in the main menu.
2. Select  on the barrier input dialog (see Figure 38).

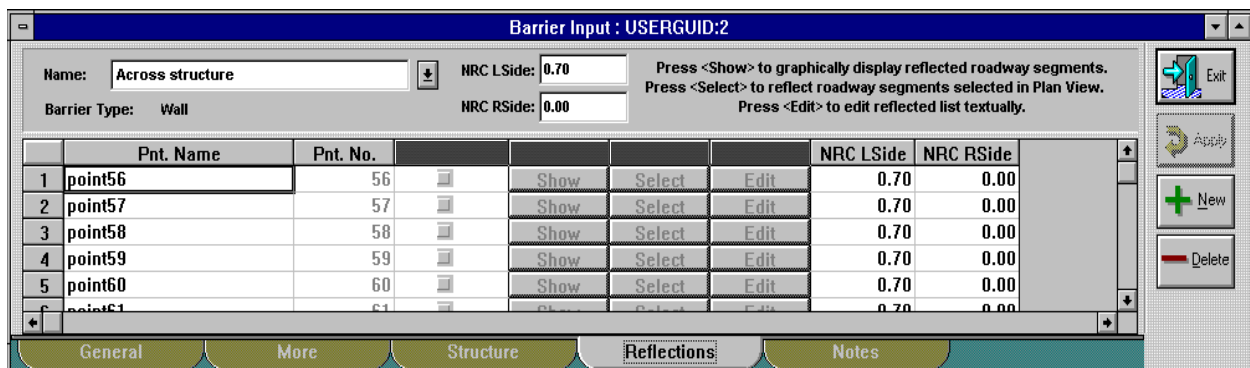


Figure 38. Barrier input: Reflections tab.

3. Enter Noise Reduction Coefficients for the barrier segment's left and right side (NRC LSide and NRC RSide) in each relevant row of the dialog's spreadsheet. NRCs range from 0.00 to 0.95, in steps of 0.05.






Each barrier has a left and right side, depending upon the direction you input it. As you walk along the barrier in the direction of input, the left side of the barrier is to your left, the right side to your right. In all graphical views, TNM draws barriers as arrows, to show their input direction and thereby their left and right sides. You may have to zoom in on a barrier to see the arrows.



See Appendix A for FHWA policy related to Noise Reduction Coefficients.

8.5.6 Notes. As with all input types, you may enter notes to remind yourself of particular characteristics of barriers or their points/segments.

To enter barrier notes:

1. Select **I**nput, **B**arriers from the main menu.
2. Select  on the barrier input dialog (not shown).
3. If desired, type a barrier note in the header of the dialog box.
4. If desired, type a note about individual points or segments in the relevant spreadsheet row.
5. Click  along the right edge of the input dialog to apply your changes.
6. Click  along the right edge of the input dialog to exit.

8.5.7 Combination wall/berm barriers. Within TNM Version 1.0 you may place a wall barrier on top of a berm barrier, to make a combo barrier. When you do this, however, you must make sure of the following:

- You must "snap" the all the points of the wall barrier and the berm barrier together, when you digitize (see Section 3.1.5), i.e., the X and Y coordinates for both barriers must be identical.
- The bottom edge of your wall barrier must have exactly the same Z (bottom) coordinates as the top edge of your berm. Numerically, each point's Z (bottom) for the wall must equal Z (bottom) + Height for the berm.
- Your berm barrier cannot have perturbations, either up or down.
- Your wall barrier cannot perturb below the top of the berm barrier.

Note: TNM will produce input check errors if the above conditions were not followed. Figure 39 shows a wall barrier directly on top of a berm barrier.

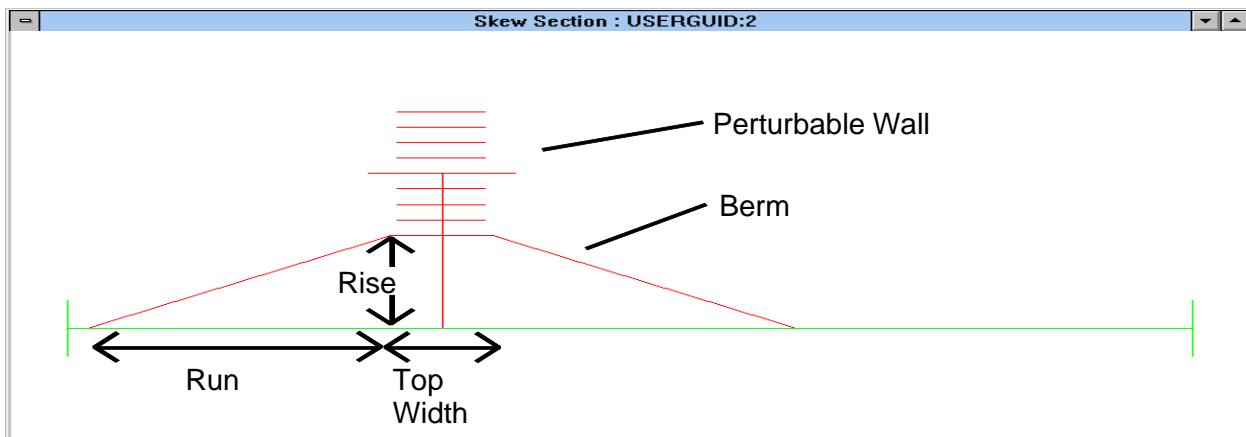


Figure 39. TNM wall barrier on top of a berm barrier.

8.6 Building Rows

TNM building rows are long rows of buildings, with gaps, that intervene between roadways and receivers, like barriers, to reduce sound levels. Unlike barriers, however, a portion of the sound energy penetrates through building-row gaps, thereby making them less effective than comparable-height barriers. Think of building rows as barriers with gaps. This section concerns building-row input. See Appendix B for summary tables of all building-row input variables. Figure 40 shows several TNM building rows in plan and skew views.

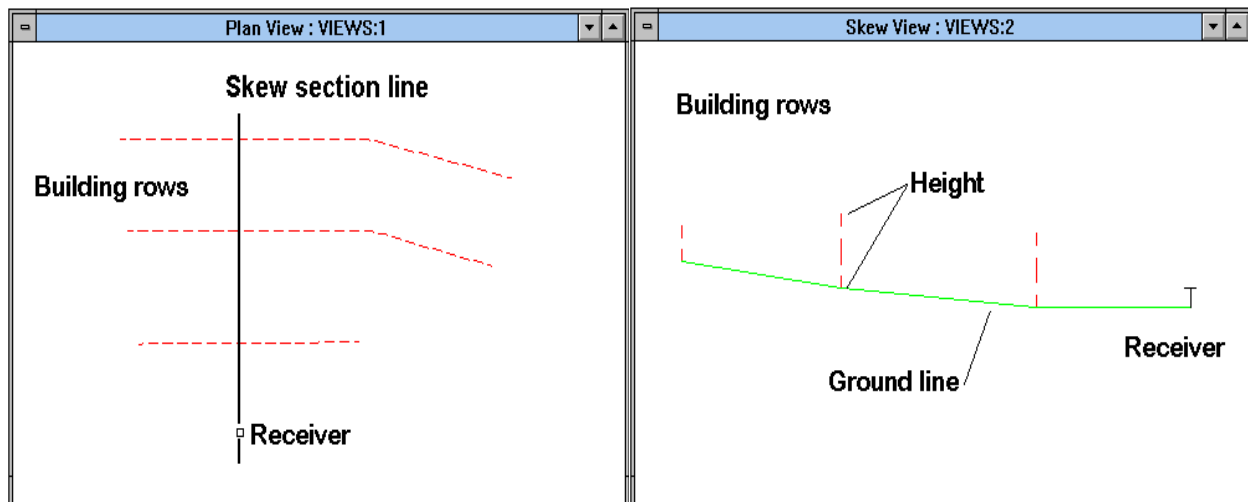


Figure 40. TNM building rows in plan and skew views.


To enter a complete set of building rows and set defaults (details later):

1. Open both the run's Plan View and the building row input dialog.
2. In the Plan View, digitize the first building-row's XY coordinates.
3. Enter all other header information in the input dialog. Only header input is needed at this time, before you set this building row as the default.

4. Set this building row as the default building row (see Section 8.1).
5. Digitize/enter all remaining building-row input.
6. Whenever you wish, you may set a different building row as the default building row.

8.6.1 Coordinates. Each building-row point has three coordinates: X, Y and Z, where Z is the ground elevation at the base of the building row.

To digitize the XY coordinates of a building row:

1. Click on the building-row tool in the TNM header. 
2. Digitize the XY coordinates of all building-row points. Then click again on the building-row tool to turn it off, or double-click on the last XY point.



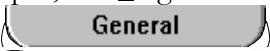
Intersections. In general, do not allow building rows to intersect any other type of TNM input. Most such intersections are not allowed by TNM Version 1.0. To assist you, TNM detects and reports all unallowed intersections during Input, Input Check (see Section 8.15).

3. If you wish, combine portions of the same actual building row into one continuous TNM building row. You will end up with a building in two portions whenever it appears on several different plan sheets.

8.6.2 General input. Building-row general input consists of the following:

- Building-row name;
- Building-row average height and building percentage; and
- Point coordinates, if they have not been digitized or imported.

To enter general building-row input:

1. Select Input, Building Rows in the main menu. TNM will open the building-row input dialog.
2. Select  on the building-row input dialog (see Figure 41).

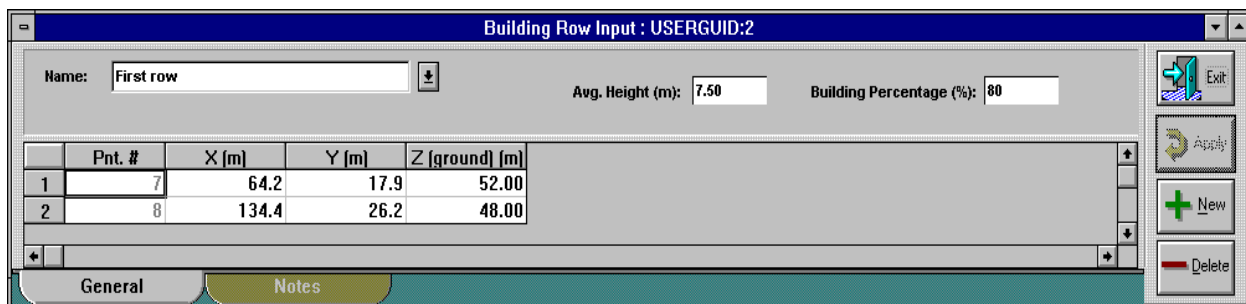


Figure 41. Building-row input: General tab.

- Enter the building row's name, its average height, and its building percentage in the header of the input dialog. (Average height and building percentage flow from the default receiver's header to the header of subsequent receivers.)

When a building row intervenes between roadway and receiver, TNM **diffracts** a portion of the sound energy over the top of the buildings. For this portion, TNM needs to know the building-row average height. Another portion of the sound energy penetrates through the gaps in the building row. For this portion, TNM needs to know the "building percentage" along the row. "Building percentage" is the length of actual building structure along the row, divided by the full length of the row -- then converted to a percentage.

Note that height and percentage of building rows cannot be varied from segment to segment. If these two parameters change substantially, you must end one TNM building row and begin another. You do not have to be overly precise in these two parameters. Plus or minus 2 m (6 ft) is precise enough for average height, as long as most buildings are within a story of one another. For building percentage, it is not necessary that building spacing be highly regular.


Building row or barrier? TNM Version 1.0 does not allow you to enter a building percentage greater than 80 percent. If your building percentage is greater than this, use a noise barrier instead of a building row.




Building-row gaps. TNM Version 1.0 does not account for the actual location of gaps along a building row. For this reason, it predicts average results behind the building row -- that is, average of locations directly behind gaps and locations directly behind building structures. If you wish more precise results, you must input each individual building structure as a separate TNM barrier.






- Enter each point's Z (ground) in the point's spreadsheet row.

- Click  along the right edge of the input dialog to apply your changes.

- Click  along the right edge of the input dialog to exit.

8.6.3 Notes. As with all input types, you may enter notes to remind yourself of particular characteristics of building rows or their points/segments.

To enter building-row notes:

- Select **Input, Building Rows** in the main menu.
- Select  on the building-row input dialog (not shown).
- If desired, type a building-row note in the header of the dialog box.
- Click  along the right edge of the input dialog to apply your changes.
- Click  along the right edge of the input dialog to exit.

8.7 Terrain Lines

TNM terrain lines define where the terrain is located, both horizontally and vertically. Where terrain lines protrude vertically through lines-of-sight, they reduce sound levels just as do intervening berms. Where they lie below lines-of-sight, they locate the ground vertically relative to these lines-of-sight. Think of terrain lines as zero-height barriers without perturbations. This section concerns terrain-line input. See Appendix B for summary tables of all terrain-line input variables. Figure 42 shows several TNM terrain lines in plan and skew views.

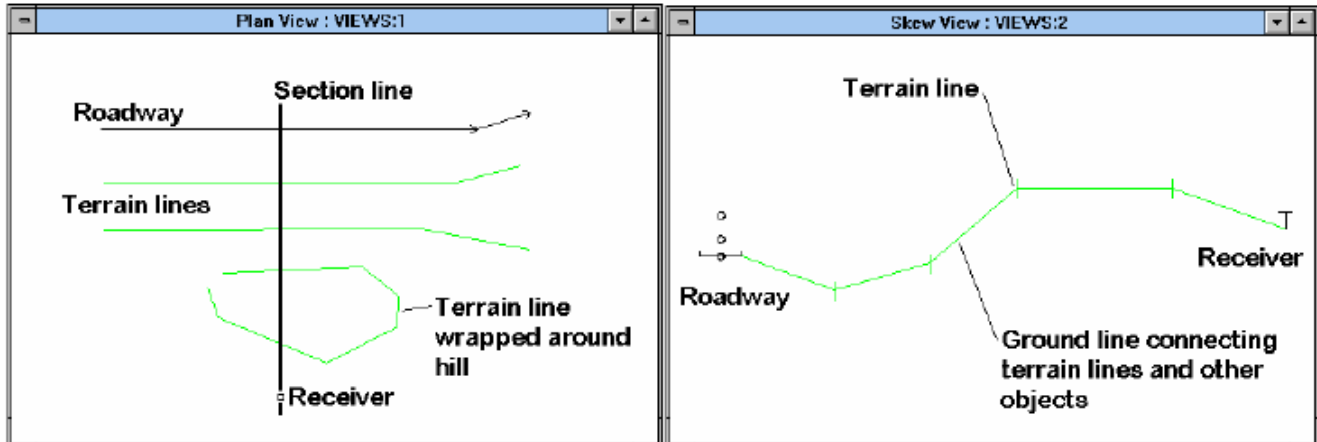



Figure 42. TNM terrain lines in plan and skew views.

8.7.1 Coordinates. Each terrain-line point has three coordinates: X, Y and Z, where Z is the ground elevation of the terrain line.

To digitize the XY coordinates of a terrain line:

1. Click on the terrain-line tool in the TNM header. 
2. Digitize the XY coordinates of all terrain-line points. Then click again on the terrain-line tool to turn it off, or double-click on the last XY point.



Intersections. In general, do not allow terrain lines to intersect any other type of TNM input. Most such intersections are not allowed by TNM Version 1.0. To assist you, TNM detects and reports all unallowed intersections during Input, Input Check (see Section 8.15).



Terrain lines. Insert terrain lines wherever you wish TNM to know the general height of the terrain between source and receiver. However, please note that small changes in terrain elevations have little effect on the overall shape of the ground and on the final sound levels. Consequently, TNM's ground-smoothing algorithm will automatically "smooth" away minor elevation changes prior to sound level calculations to reduce computation time. TNM has shown some weaknesses in the diffraction algorithms; thus, it is recommended that terrain lines be only used to locate substantial changes in terrain elevation. Typical terrain lines might lie:

- Along the bottom of deep drainage ditches that parallel the roadway
- Along the top edge of slope for depressed roadways
- Along the edge of fill for roadways on fill

- Along the ridge of an intervening hill
- Along a line of constant elevation (top of line) of an intervening hill.

In addition, it is not necessary to enter terrain lines where the Z coordinates of other input serve to define the topography:


- Z (pavement) of roadways, at the edge of pavement rather than at the roadway centerline
- Z (ground) of receivers
- Z (bottom) of barriers, including berms
- Z (bottom) + Height of berms, but at the edge of the berm top width, rather than at the berm centerline
- Z (ground) of building rows
- Z (ground) of the perimeter of tree zones.

8.7.2 General input.

Terrain-line general input consists of the following:

- # Terrain-line name
- # Point number and coordinates, if they have not been digitized or imported

To enter general terrain-line input:

1. Select **I**nput, **T**errain **L**ines in the main menu. TNM will open the terrain-line input dialog.
2. Select  on the terrain-line input dialog (see Figure 43).

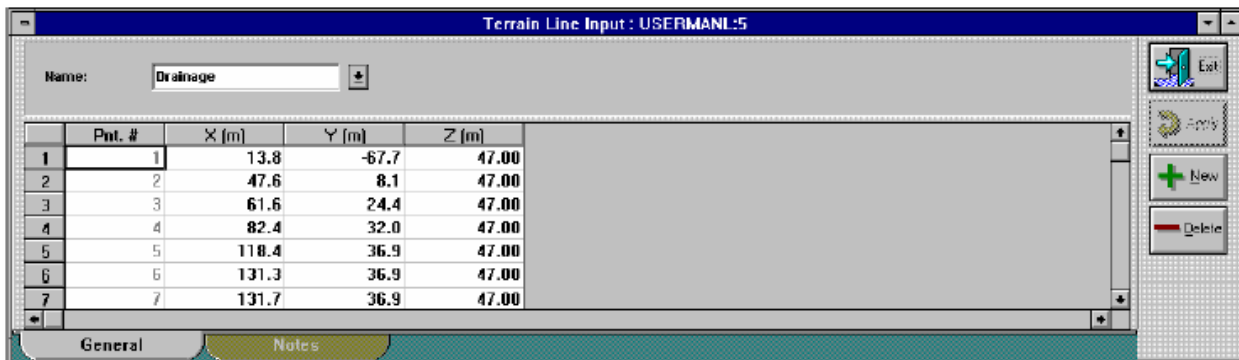






Figure 43. Terrain-line input: General tab.

3. If you wish, enter a name for the terrain line.
4. Enter each point's Z (ground) in the point's spreadsheet row.
5. Click  along the right edge of the input dialog to apply your changes.
6. Click  along the right edge of the input dialog to exit.

8.7.3 Notes.

As with all input types, you may enter notes to remind yourself of particular characteristics of terrain lines or their points/segments.

To enter terrain-line notes:

1. Select **Input**, **Terrain Lines** in the main menu.
2. Select **Notes** on the terrain-line input dialog (not shown).
3. If desired, type a terrain-line note in the header of the dialog box.
4. Click  along the right edge of the input dialog to apply your changes.
5. Click  along the right edge of the input dialog to exit.

8.8 Ground Zones

Under **Setup**, **General**, you choose a default ground type. TNM ground zones define the type of intervening ground, and therefore the **ground's** acoustical **attenuation** characteristics, wherever the ground differs from your chosen default ground type. Geometrically, a TNM ground zone consists of an area enclosed by a string of straight-line segments, connected together end-to-end. This area has no Z coordinates. It serves solely to define the type of ground. This section concerns ground-zone input. See Appendix B for summary tables of all ground-zone input variables. Figure 44 shows several TNM ground zones in plan and skew views.

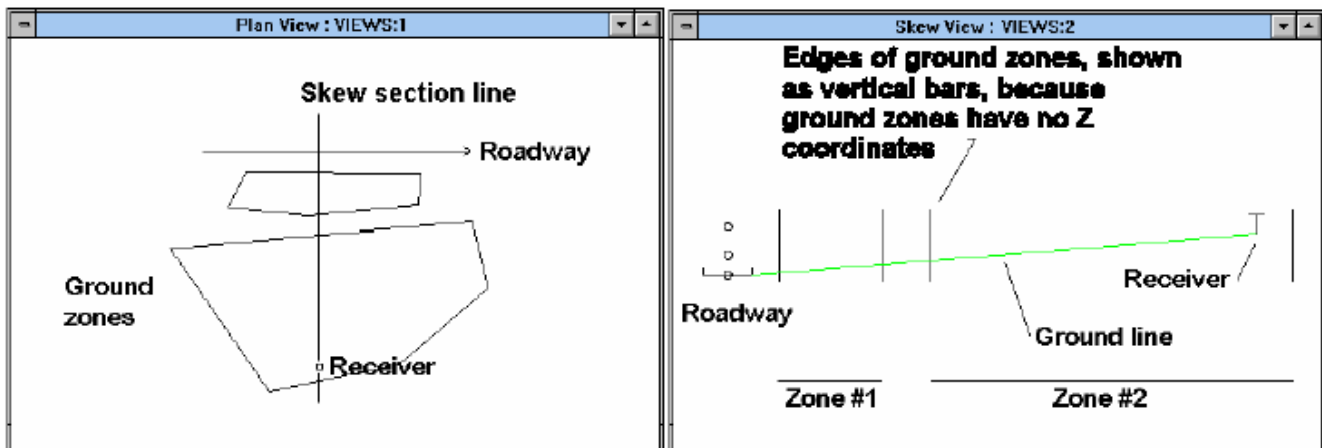



Figure 44. TNM ground zones in plan and skew views.

8.8.1 Coordinates. Each ground-zone point has only two coordinates: X and Y. Ground zones have no vertical position. For this reason, they do not define the vertical location of the ground. They serve only to define its type.

To digitize the XY coordinates of a ground zone:

1. Click on the ground-zone tool in the TNM header. 
2. Digitize the XY coordinates of all ground-zone points. Then click again on the ground-zone tool to turn it off, or double-click on the last XY point. TNM will automatically ensure that the ground zone closes on itself. You do not have to connect its endpoint to its start point.

Error!

Ground zones. Enter ground zones only where the ground differs from your ground-type default. TNM automatically sets the ground type to the default everywhere outside of your ground ZONES. In addition, only enter ground zones for relatively large patches of ground. For example, if several local streets intervene between source and receiver, enter them as ground zones if they cover a sizable fraction (20 to 30 percent or more) of the intervening ground, especially if they lie midway between source and receiver. Do not bother being too precise when locating the exact edges of ground zones. Note that TNM automatically places pavement along each roadway, depending upon the roadway's width. For this reason, ground zones are not needed to define pavement.

8.8.2 General input.

Ground-zone general input consists of the following:

- Ground-zone name
- Type of ground, or optionally a custom flow resistivity

To enter general ground-zone input:

1. Select **Input**, **Ground Zones** in the main menu. TNM will open the ground-zone input dialog.
2. Select **General** on the ground-zone input dialog (see Figure 45).

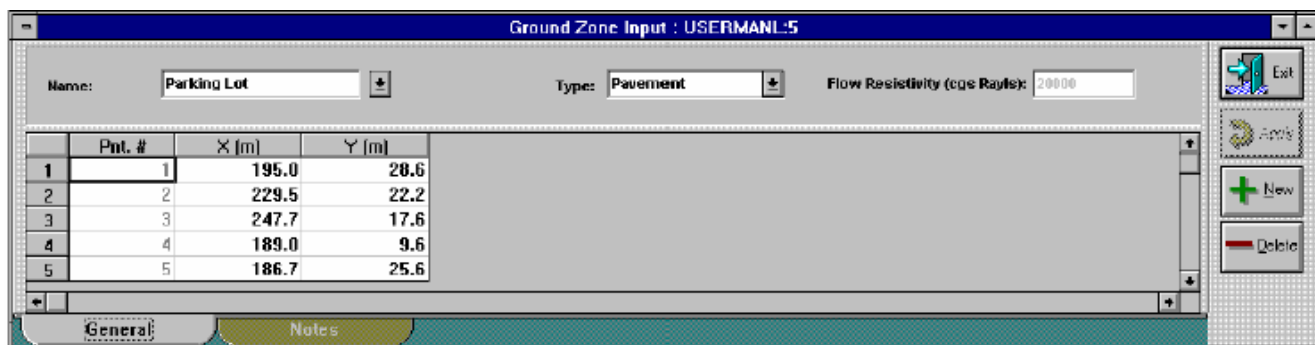


Figure 45. Ground-zone input: General tab.

3. Enter the ground-zone's name and select its type from the pull-down list in the header of the input dialog. (Ground-zone type flows from the default ground zone's header to the header of subsequent ground zones. See Section 8.1 to select this contour zone as a default.) TNM includes the following ground zone types:
 - Pavement: Asphalt or concrete surface, or any surface as hard as these (acoustically, pavement and water are treated identically);
 - Water: Large body of water, swamp, or soil that is highly saturated with water (acoustically, pavement and water are treated identically);
 - HardSoil: Hard-packed soil, including dirt roads;
 - Grvl/LooSoil: Gravel and loose soil;
 - Lawn: Well-groomed, residential-type lawn;
 - FieldGrass: Field grass (substantially sparser than lawn);
 - GranSnow: Granular snow;



- PowdSnow: Powder snow; and
- Custom.



See Appendix A for FHWA policy related to custom ground zones.

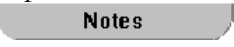




Hard and soft ground. Use TNM's Pavement ground zone type, if you would like to model a generic acoustically **hard ground** surface. Use TNM's Field grass ground zone type, if you would like to model a generic acoustically **soft ground** surface.

4. If you choose the custom ground type, enter its flow resistivity in the header of the dialog box (see Appendix B).
5. Click  along the right edge of the input dialog to apply your changes.
6. Click  along the right edge of the input dialog to exit.

8.8.3 Notes. As with all input types, you may enter notes to remind yourself of particular characteristics of ground zones.

To enter ground-zone notes:

1. Select Inter, Ground Zones in the main menu.
2. Select  on the ground-zone input dialog (not shown).
3. If desired, type a ground-zone note in the header of the dialog box.
4. Click  along the right edge of the input dialog to apply your changes.
5. Click  along the right edge of the input dialog to exit.

8.9 Tree Zones

TNM tree zones consist of long, wide regions of heavy woods and undergrowth that intervene between roadways and receivers, thereby reducing sound levels. The trees and undergrowth should obstruct vision of the traffic. Geometrically, a TNM tree zone consists of an area enclosed by a string of straight-line segments, connected together end-to-end. This section concerns tree-zone input. See Appendix B for summary tables of all tree-zone input variables. Figure 46 shows several TNM tree zones in plan and skew views.



See Appendix A for FHWA policy related to tree zones.

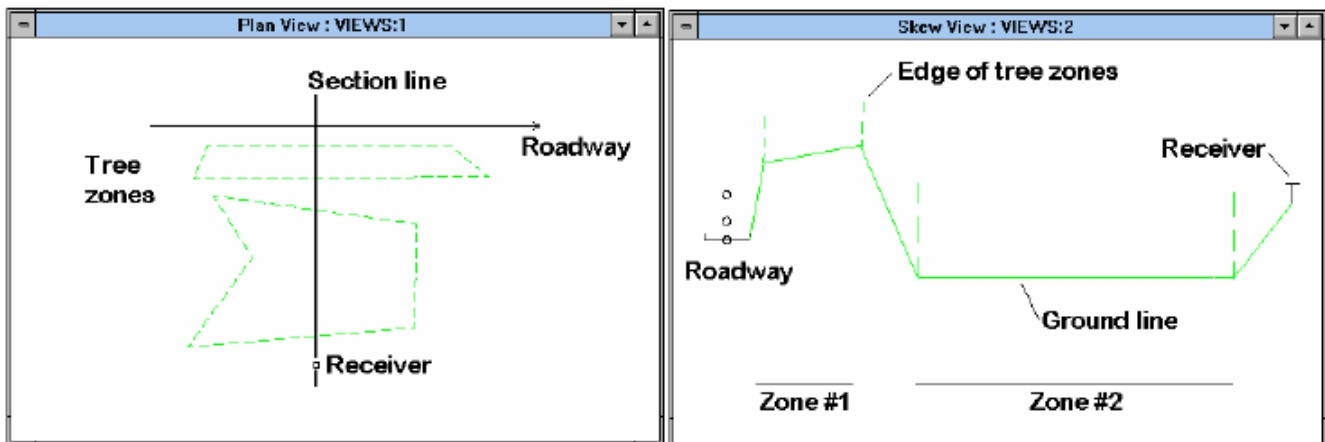



Figure 46. TNM tree zones in plan and skew views.

8.9.1 Coordinates. Each tree-zone point has three coordinates: X, Y and Z, where Z is the ground elevation at the base of the tree zone.

To digitize the XY coordinates of a tree zone:

1. Click on the tree-zone tool in the TNM header. 
2. Digitize the XY coordinates of all tree-zone points. Then click again on the tree-zone tool to turn it off, or double-click on the last XY point. TNM will automatically ensure that the tree zone closes on itself. You do not have to connect its endpoint to its start point.



Intersections In general, do not allow tree zones to intersect any other type of TNM input. Most such intersections are not allowed by TNM Version 1.0. To assist you, TNM detects and reports all unallowed intersections during Input, Input Check (see Section 8.15).




Tree zones TNM Version 1.0 computes tree attenuation per the standard of the International Standards Organization.¹² This standard requires that trees be sufficiently dense to completely block the view along the propagation path. This requires dense undergrowth as well as dense tree-top foliage. Do not include a TNM tree zone unless its vegetation is sufficiently dense.

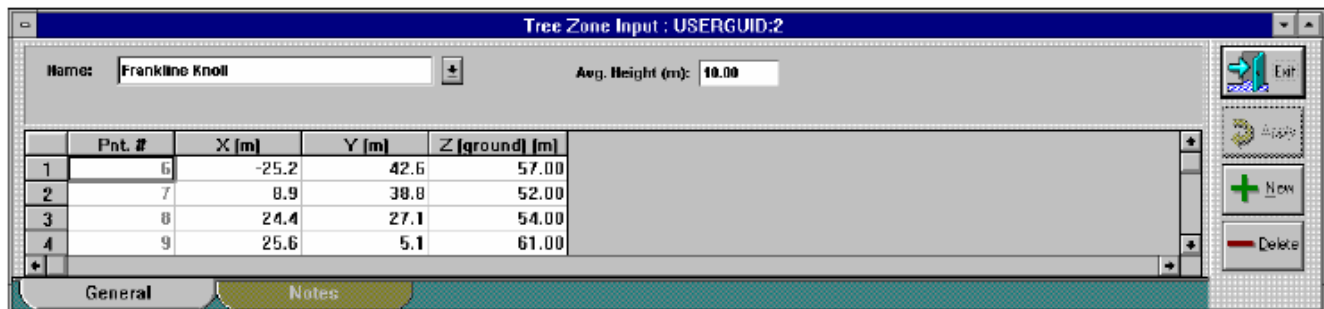
8.9.2 General input. Tree-zone general input consists of the following:

- Tree-zone name;
- Average height above the ground; and
- Z coordinate, where Z is the ground elevation at the base of the tree zone.

To enter general tree-zone input:



1. Select Input, Tree Zones in the main menu. TNM will open the tree-zone input dialog.

2. Select  on the tree-zone input dialog (see Figure 47).



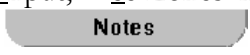


Pnt. #	X [m]	Y [m]	Z [ground] [m]	
1	6	-25.2	42.6	57.00
2	7	8.9	38.8	52.00
3	8	24.4	27.1	54.00
4	9	25.6	5.1	61.00

Figure 47. Tree-zone input: General tab.

3. Enter the tree-zone's name and its average height in the header of the input dialog. (Average Height flows from the default tree-zone header to the header of subsequent tree zones. See Section 8.1 to select this tree zone as a default.)
4. Enter the tree zone's Z coordinates.
5. Click  along the right edge of the input dialog to apply your changes.
6. Click  along the right edge of the input dialog to exit.

8.9.3 Notes. As with all input types, you may enter notes to remind yourself of particular characteristics of tree zones.

To enter tree-zone notes:

1. Select Input, Tree Zones in the main menu.
2. Select  on the tree-zone input dialog (not shown).
3. If desired, type a tree-zone note in the header of the dialog box.
4. Click  along the right edge of the input dialog to apply your changes.
5. Click  along the right edge of the input dialog to exit.

8.10 Contour Zones


TNM allows you to compute three types of contour zones: sound level contours, noise reduction contours, i.e., insertion loss contours, and level difference contours. The work-flow involved in generating contours is discussed in Section 12. Geometrically, a TNM contour zone consists of an area enclosed by a string of straight-line segments, connected together end-to-end. This section concerns contour-zone input. See Appendix B for summary tables of all contour-zone input variables.



See Appendix A for FHWA policy related to contours.

8.10.1 Coordinates. Each contour-zone point has only two coordinates: X and Y. Contour zones have no vertical position. For this reason, they do not define the vertical location of the ground.

To digitize the XY coordinates of a contour zone:

1. Click on the contour-zone tool in the TNM header. 
2. Digitize the XY coordinates of all contour-zone points. Then click again on the contour-zone tool to turn it off, or double-click on the last XY point. TNM will automatically ensure that the contour zone closes on itself. You do not have to connect its endpoint to its start point.



Intersections In general, contour zones can intersect any other type of TNM input. However, users are cautioned against the intersection of barriers and roadways (this includes a roadway's width) with contour zones. The reason is that contouring logic can break down in areas of steep noise gradients, such as exist around the ends of barriers and on roadways. To compute a contour zone about a barrier/roadway, create a contour zone in front of the barrier/roadway and behind the barrier/roadway.

8.10.2 General input. Contour-zone general input consists of the following:

- Contour-zone name;
- Contour tolerance (dB); and
- Minimum Grid Spacing and Grid Height.

To enter general contour-zone input:

1. Select **Input, Contour Zones** in the main menu. TNM will open the contour-zone input dialog.
2. Select **General** on the contour-zone input dialog (see Figure 48).

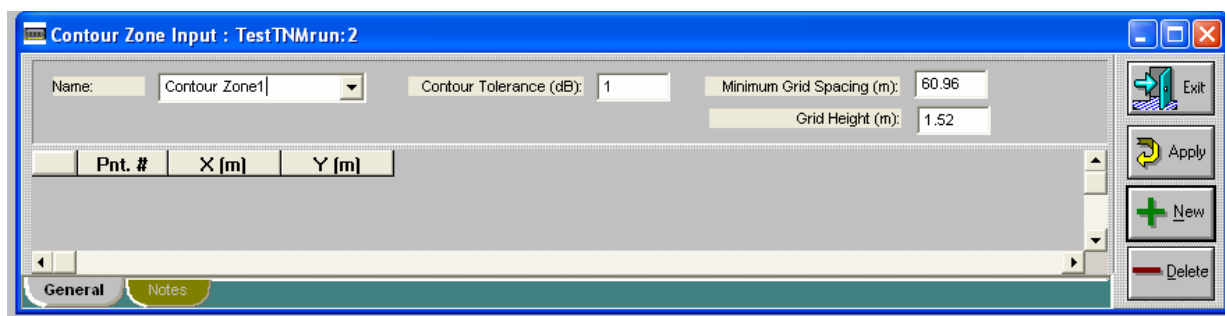







Figure 48. Contour-zone input: General tab.

3. Enter the contour-zone's name in the header of the input dialog.
4. Enter the Contour tolerance (dB) and Minimum Grid Spacing and Grid Height. Contour tolerance and grid parameters will flow down from the default contour-zone header to the header of subsequent contour zones (see Section 8.1 to select this contour zone as a default).

5. Click  along the right edge of the input dialog to apply your changes.
6. Click  along the right edge of the input dialog to exit.

8.10.3 Notes. As with all input types, you may enter notes to remind yourself of particular characteristics of contour zones.

To enter contour-zone notes:

1. Select Input, Contour Zones in the main menu.
2. Select  on the contour-zone input dialog (not shown).
3. If desired, type a contour-zone note in the header of the dialog box.
4. Click  along the right edge of the input dialog to apply your changes.
5. Click  along the right edge of the input dialog to exit.

8.11 User-defined Vehicles

You may enter up to five of your own vehicle types into TNM as supplementary types to TNM's built-in types.



See Appendix A for FHWA policy related to vehicle emission levels.

To enter a user-defined vehicle type into TNM:

1. Obtain a copy of the official TNM measurement method from FHWA, *Measurement of Highway-Related Noise*.¹³
2. In accordance with the official method, measure A-level emissions as a function of speed for your user-defined vehicle type. As required by the official method, measure under the following reference conditions:
 - Cruise throttle;
 - Level grade; and
 - Dense-graded asphalt pavement (DGAC) or Portland cement concrete (PCC).

These measurements will result in the following three parameters for your user-defined vehicle type:

- Minimum level at very low speeds;
 - Reference level at 80 km/hr (50 mph); and
 - Slope.
3. Select Input, User-defined Vehicles in the main menu (see Figure 49).

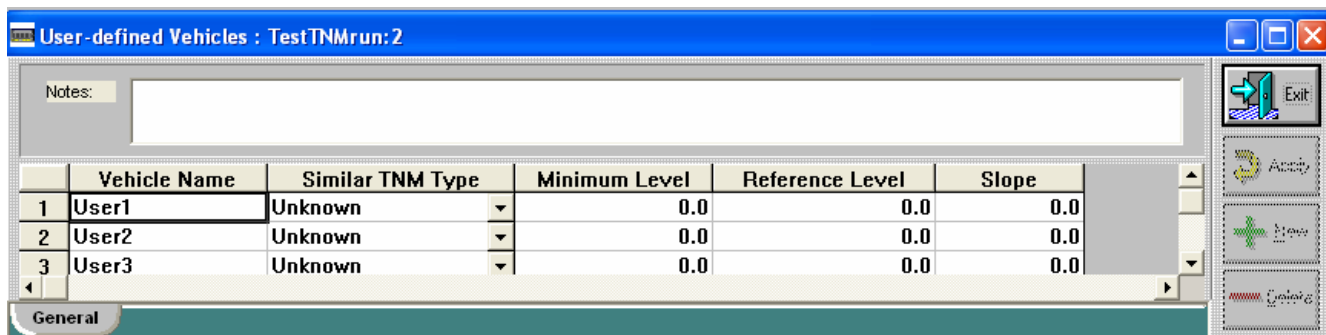


Figure 49. User-defined vehicles input: General tab.

4. Decide which TNM vehicle type is most similar to your user-defined type and select it in the Similar TNM Type pull-down menu. Base this decision upon the following factors, in this order of importance:
 - Estimated subsource heights;
 - Estimated acceleration characteristics; and
 - Estimated spectrum.
5. Enter the three parameters found in Step 2 (Minimum Level, Reference Level, and Slope). TNM will merge your three measured parameters with subsource heights, acceleration characteristics, and spectrum of the similar TNM vehicle type.

8.12 Important Reflections

Important Reflections are not implemented in TNM Version 1.0.

8.13 Structure Barriers

When a barrier is built on an elevated structure, it generally only shields receivers from adjacent roadways that are also on the structure. Sound from other roadways can pass under the structure, unshielded. To designate barrier segments that are on structure and which roadway segments they shield, see Section 8.5.4.

8.14 Adjustment Factors

When TNM calculates sound levels at a receiver from a particular roadway segment, it adds that segment/receiver's adjustment factor to its calculated result. To enter an adjustment factor for a receiver(s), see Section 8.4.4.



See Appendix A for FHWA policy related to adjustment factors.

8.15 Input Check

TNM automatically checks all your input for unallowed intersections and barrier perturbations, as its first step in Calculate. If you wish, you may tell TNM to check input periodically as you enter it.

Periodic input checks are desirable, because they catch potential input misunderstandings before you progress through all your input. Note: The Input Check selection is only available when a Plan view is active. See Appendix C for explanations of error messages.

8.16 Find DXF Path and Convert DXF Segments To

These selections are used to find a path of segments between two user-selected DXF segments (see Section 4.7 to import a DXF file), and then convert them to a TNM object (Roadway, Barrier, Building Row, Terrain Line, Ground Zone, or Tree Zone). To do so:

1. Graphically select two non-connecting segments (see Section 5.5) of a desired object.
2. Select Input, Find DXF Path in the main menu. If TNM successfully finds all the connecting segments between your desired segments, all those segments will be graphically highlighted (if TNM is unsuccessful, re-select two segments and try again).
3. Select Input, Convert DXF Segments To in the main menu, then select the desired TNM object type to convert to.
4. Repeat this process for all remaining DXF segments.



Unconverted DXF segments. Convert all desired DXF segments prior to saving and exiting TNM. Any unconverted DXF segments cannot be saved as part of your run and will be deleted prior to exit. You may, of course, re-import the DXF file later.

8.17 Renumber TNM Points

This selection is used to sequentially renumber the point numbers that TNM automatically assigns to each input object. That is, for each input object type, TNM automatically assigns each segment/object point a sequential point number. For example, you may enter a roadway with four segments, i.e., five points. TNM automatically assigns numbers 1 through 5 sequentially to these five points. If you then delete the third segment, the roadway points now numerically skip over the deleted point number and your roadway point numbers are no longer sequential. Select Input, Renumber TNM Points to renumber/reassign sequential points to each type of TNM input objects, e.g., the example roadway's three remaining segments (4 points) will be reassigned and numbered 1 through 4 (the next roadway will begin with point number 5). Because this function is not dynamically linked to the input dialogs, tables, etc., TNM will prompt you that only the Plan view should be open before continuing. After TNM has renumbered your input object points, you must close your run, then re-open it to see the new numbers reflected.

9. CALCULATE MENU

Because TNM calculations are complex and time-consuming, select Calculate after all input items have been entered and verified (see Figure 50). When Calculate is selected, TNM automatically first performs a final Input Check (see Section 8.15). TNM then computes predicted noise levels at all receivers through a series of adjustments to a reference sound level. These adjustments account for the following sound propagation factors: **divergence**; atmospheric absorption; ground characteristics and topography; barriers; rows of buildings; and areas of heavy vegetation. The reference sound level is based upon vehicle noise emission levels contained within the TNM Data Base (see Appendix F).

Once calculations are complete, and prior to proceeding with any subsequent actions, it is strongly recommended that you save the run as another filename. Once you have saved the run under another name, you may proceed with any changes, etc., to the run. The reason that this is so important is that once you have changed the input parameters associated with that run (with the exception of barrier costs, additional costs, receiver existing level, impact criteria level, noise reduction goal, and substantial increase) the output will be invalid and deleted.

After calculation, TNM automatically sets each barrier segment to its input height, computes the resulting sound levels, and then generates various results tables. As with input tables, these results tables appear on your screen and can be printed or saved on disk. If you are interested only in your barrier input heights, without perturbations, your work with TNM is complete. However, to see results of barrier segments with varying perturbations, see Section 10 to perform a Barrier Analysis.

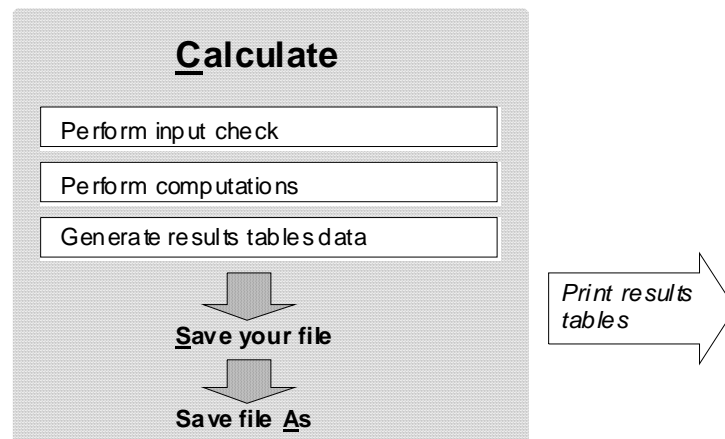


Figure 50. Calculate: Work flow.

Run-time: Unlike its predecessor, STAMINA, TNM is a Windows-based program with increased capabilities (see Appendix D for a comparison of the two programs) and complex acoustic algorithms (refer to the TNM Technical Manual). However, the model's increased capabilities and theoretical basis result in fairly extensive run-times. TNM will currently run typical studies in between 1 and 2 hours on state-of-the-art personal computers (PCs); and the more complex studies (previously unachievable with STAMINA) are expected to take no longer than an overnight run. These run-times are substantially longer than those of STAMINA. However, the notable improvements in accuracy (refer to the TNM Technical Manual), flexibility, and ease of use should more than compensate. To help reduce run-time, keep the following in mind before you select Calculate:



- (1) Barrier perturbations: The number of perturbations your barriers have can greatly affect run-time. In general, it is recommended that barrier perturbations be no smaller than 1 ft, especially during initial design. When a close-to-final design has been developed, you may want to create a new run with perturbations smaller than 1 ft. However, keep in mind that a 1-ft change in barrier height will typically have a very small effect on sound level, usually less than 0.5 dB.
- (2) Master run: You might want to enter all input into a "master" run and then split the master run into smaller sub-runs for computation:

1. Create your master run: Digitize/type all input for your full project into one "master" TNM run.
2. Create smaller sub-runs from your master run: Make a series of smaller runs (A, B, C, and so forth) from the complete set of input in the master run. To do this:
 - Save As: Save the master run under Run A's new name.
 - Delete: Selectively delete everything not needed for Run A.
 - Save file: Save Run A.
 - Open: Open the master run again, which will have all the original input.
 - Repeat for Run B, Run C, and so forth.

In this manner, you can duplicate selected portions of the master run in smaller individual runs, each relevant to a single barrier design, for actual calculation and barrier analysis.

10. BARRIER ANALYSIS MENU

After all input items have been entered, and sound levels calculated, the sound level results computed for the barriers' input heights are automatically tabulated in TNM Sound Level Results tables. At this point, you are ready to optimize your barrier design by performing a Barrier Analysis. Optimizing a barrier design requires balancing between acoustic performance and cost.

10.1 Typical Work Flow

This section provides an overview of the typical work flow for performing a barrier analysis (see Figure 51). Optimizing a barrier design involves perturbing barrier segment(s) to achieve a desired barrier insertion loss or noise reduction. Because barrier costs are a major factor in a barrier design, you may also want to monitor changes in costs at the same time. TNM dynamically links the Barrier Analysis module with TNM tables (see Section 13.1 through 13.3), so you can watch design factors, such as sound level results and barrier costs, change as you perturb barrier segments up or down to optimize your barrier design.



As stated above, TNM dynamically links the Barrier Analysis module with TNM tables. To facilitate this linkage, the Barrier view (see Figure 52) must be the active view prior to opening each results table.

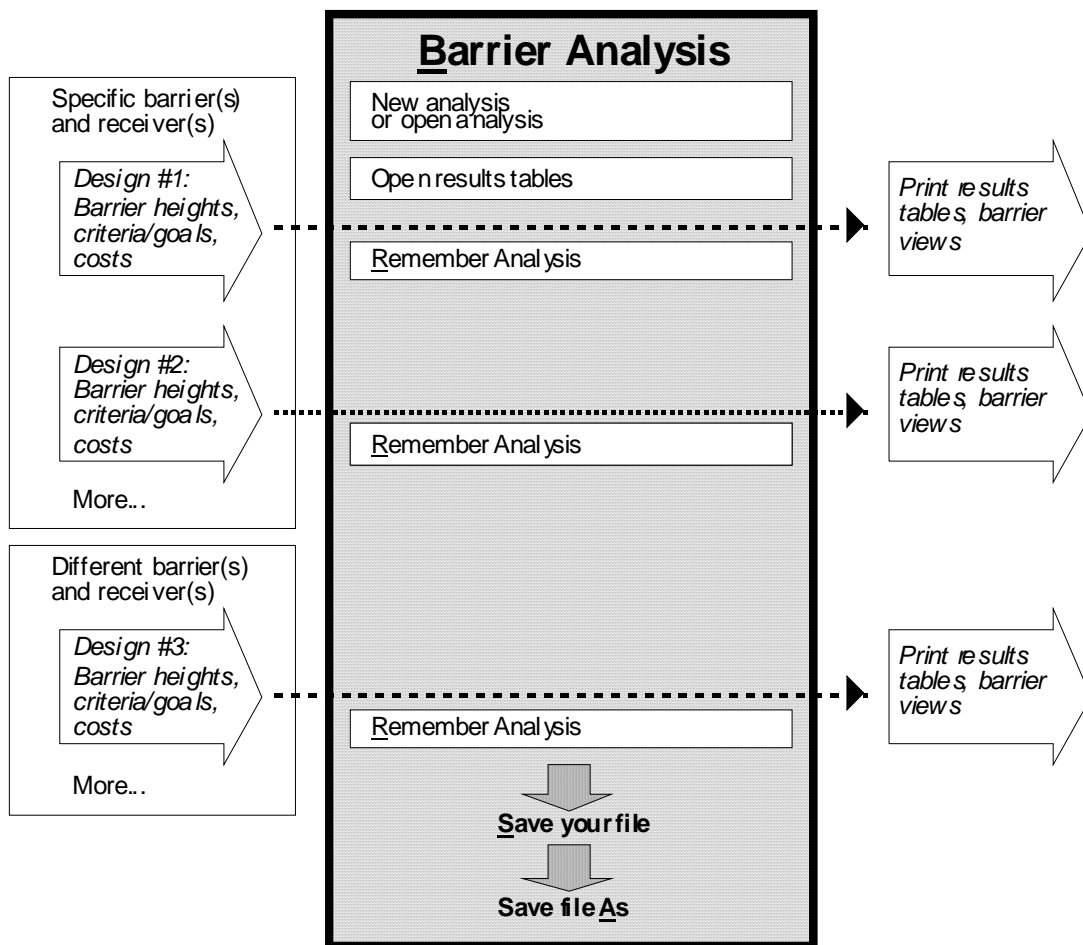


Figure 51. Barrier analysis: Work flow

To begin a barrier analysis, you may create a new analysis (see Section 10.2) or open an existing one (see Section 10.3). In doing either, TNM will open a barrier perspective view (see Figure 52).

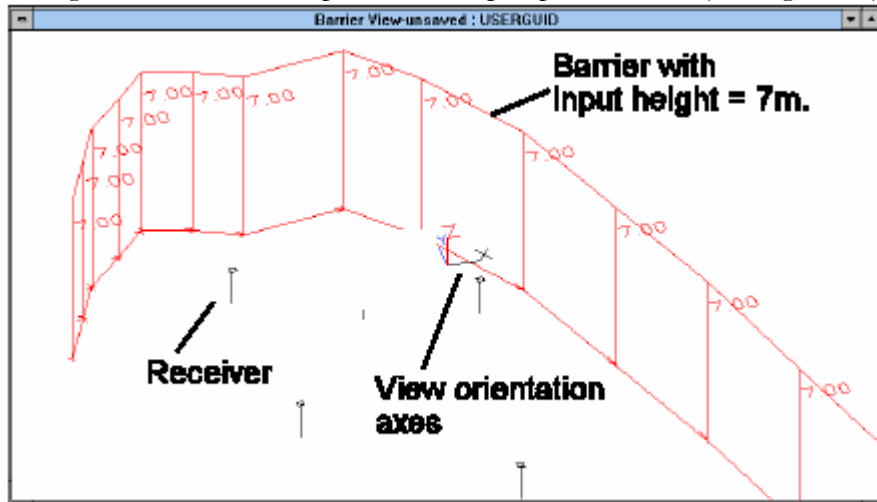


Figure 52. Barrier analysis: Barrier view.

Open a Sound Levels table and a Barrier Segment Descriptions table (see Section 13.2). To prepare the tables for easier viewing: (1) in the Sound Levels table, hide superfluous rows so that only the relevant barrier segment rows are displayed (see Section 13.4); and (2) in the Barrier Segment Descriptions table, hide all rows except the rows with "cost" in them. Tile the windows horizontally (see Section 14.3) with the perspective view for easier viewing. Zoom-in to a desired area for analysis (see Section 6.3). Rotate the view until the barriers' heights can be seen (see Section 6.7). The resultant TNM screen is shown in Figure 53.

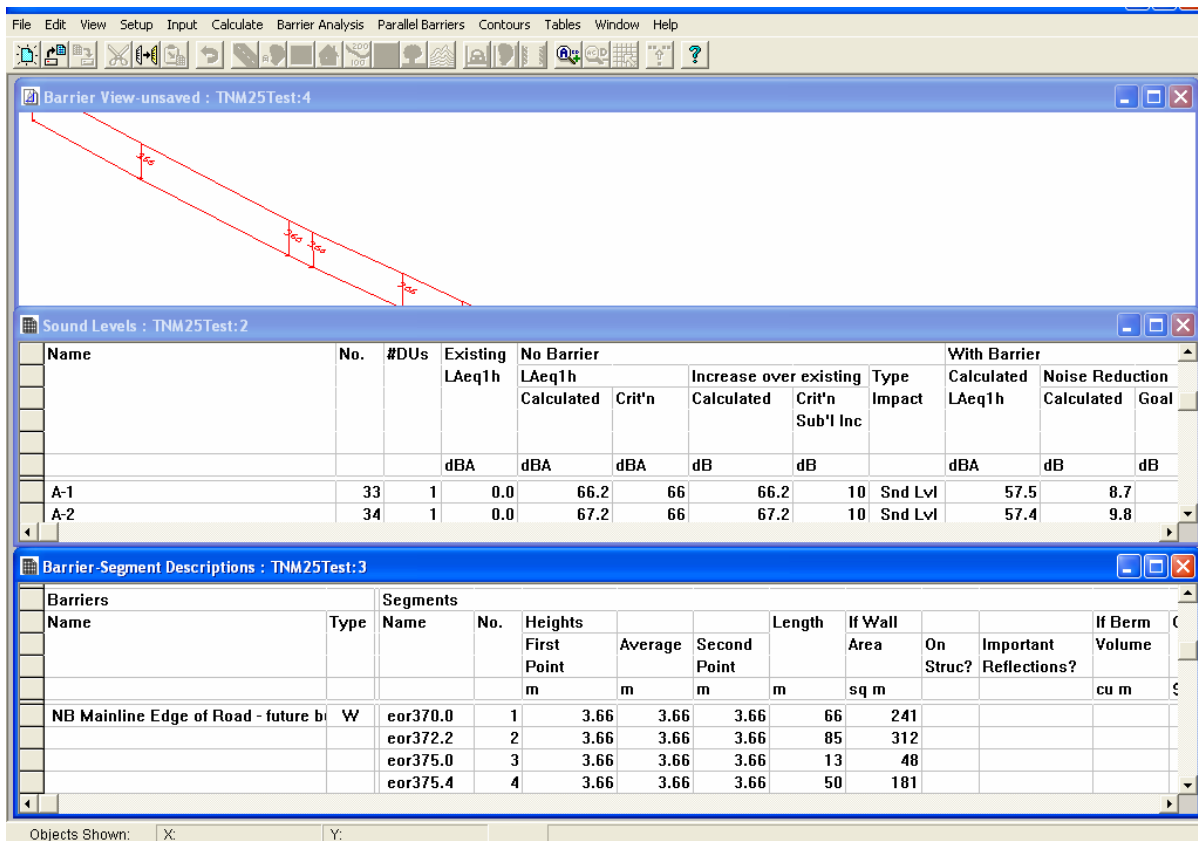


Figure 53. Graphical view of a barrier analysis.

Select a segment(s) to perturb (see Section 10.6). Perturb the selected segment(s) and watch changes in the appropriate tables occur at the same time (see Figure 54).

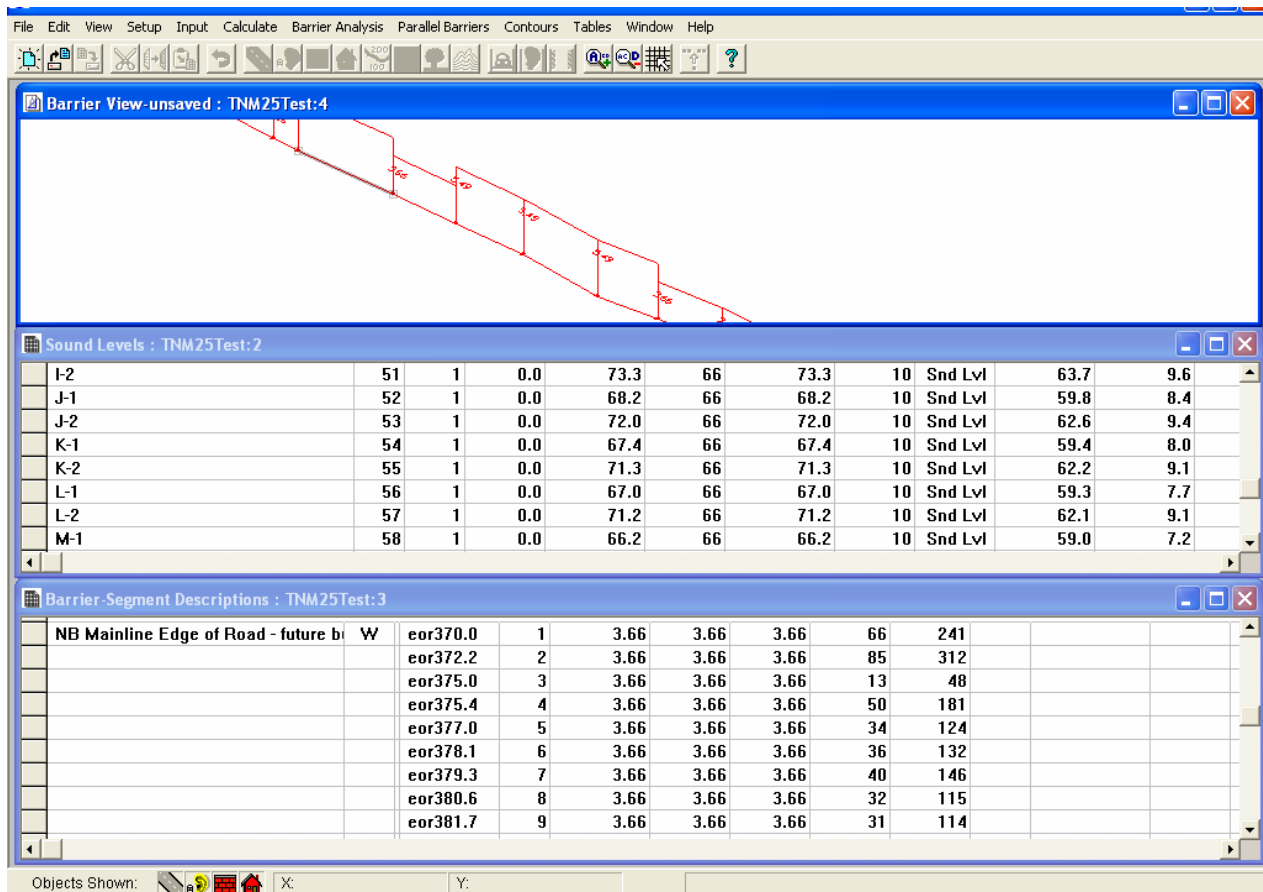


Figure 54. Resultant barrier analysis view.

When you have achieved the desired insertion loss/noise reduction for that segment, select the next segment to perturb. This process is repeated until the desired barrier design is achieved. As you experiment with different barrier heights and criteria/ goals/ costs, you may find some barrier designs of lasting interest. To save a particular barrier design within an analysis, select Remember and enter a barrier analysis name (see Section 10.4). When you save your run, all "remembered" barrier analyses are also saved.

10.2 New

To begin a new barrier analysis, first select the desired barrier(s) and receiver(s). If you try to start a new barrier analysis without previously selecting at least one barrier and one receiver, TNM will prompt you to do so. TNM then opens a new perspective view with the selected barrier(s) at their input heights and receiver(s) (see Figure 55).

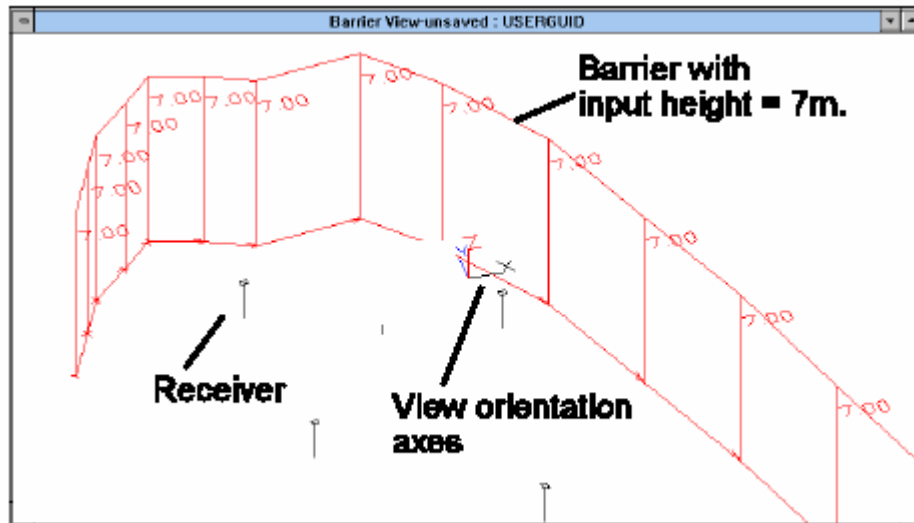


Figure 55. New barrier analysis.

10.3 Open

This selection will open a previously saved barrier analysis. When OPEN is selected, TNM will display a pop-up box with a list of available barrier analyses, if any exist. Click on the desired name and then click



. TNM then opens a barrier perspective view with the previously saved barrier analysis.

10.4 Remember and Remember As

As you experiment with different barrier heights and criteria/ goals/ costs, you may find some barrier designs of lasting interest. If you would like to save a particular barrier design within an analysis, select Remember As and enter a design name. Select Remember to save subsequent changes in your design. If you would like to make changes to a previously remembered barrier analysis, select Remember As and enter a different barrier analysis name. Note: The terms, Remember and Remember As, are used to distinguish them from the Save and Save As functions (see Section 4.4 and 4.5). Use Save or Save As to save an entire run including all "remembered" barrier analyses.

10.5 Delete

This selection allows you to delete a previously remembered barrier analysis. When this function is selected, TNM will display a list of remembered analyses to choose from.

10.6 Next Segment, Previous Segment, Perturb Up, and Perturb Down

These functions pertain to the selection of barrier segments and then perturbing them up or down (see Figure 56). TNM dynamically links the Barrier Analysis module with its Diagnosis By Barrier Segment table (see Section 13.2), so you can watch the noise levels change as you perturb barrier segments up or down to optimize your barrier design.

TNM also provides keyboard shortcuts for these functions. Segment selecting may also be invoked by using either the Shift and left/right arrow keys, or a mouse. The Shift and up/down keys are then

used to perturb barrier segments up/down, respectively. Note: If you cannot perturb your selected barriers, check your original barrier input to see if perturbations were entered. If none were entered, you will need to enter them and recalculate sound levels.

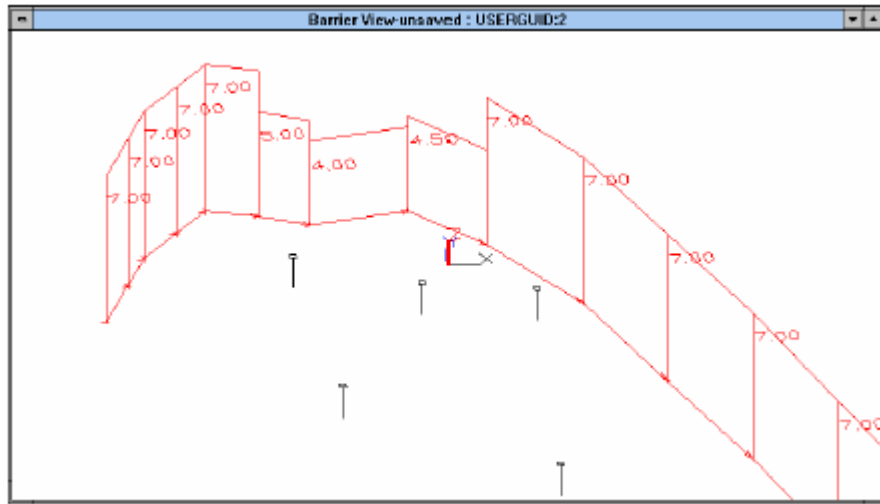


Figure 56. Select/perturb barrier segments.

10.7 Line of Sight

This function is used to determine if your selected barrier(s) break the lines-of-sight from vehicles on nearby roadways to your selected receivers. When this function is selected, TNM first displays nearby roadways. Then, TNM determines line-of-sight blockage with either green or red indicators (+). That is, where the barrier breaks line-of-sight, green indicators are displayed; and areas, where the barrier does not break line-of-sight, red indicators are displayed (see Figure 57). You can watch the line-of-sight break indicators change as you perturb barrier segments up/down. You may recall the subsource height and distance limit for the line-of-sight check are user-selectable options (see Section 7.2).

 See Appendix A for FHWA policy related to line of sight.

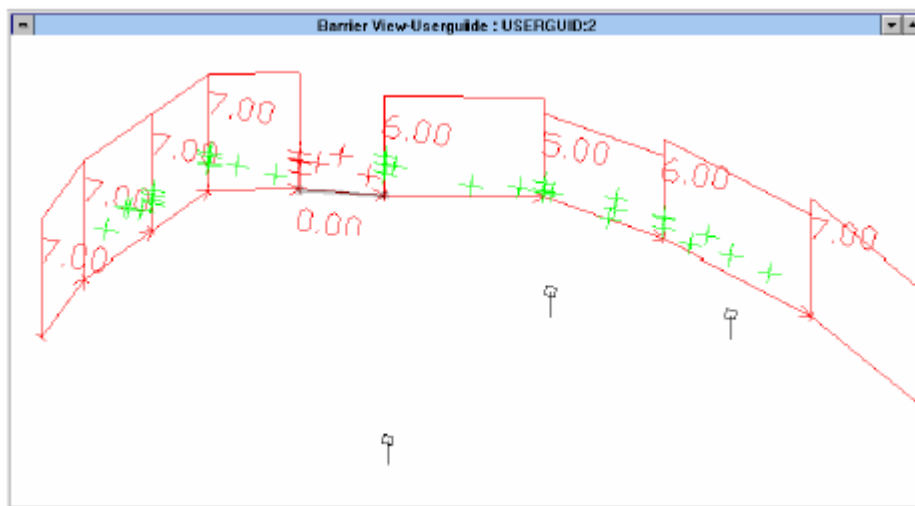


Figure 57. Perform line-of-sight check.

11. PARALLEL BARRIERS MENU

Often times, a roadway may be flanked by parallel barriers (e.g., wall barriers, berms, retaining walls, etc.), which may cause multiple reflections and barrier performance degradation. As a result, you may want to examine the effects of existing parallel barriers, or predict the effects prior to construction.



When to use this TNM capability: Research^{14,15} has shown that the magnitude of the performance degradation associated with parallel reflective noise barriers is linked to the ratio of the separation (width) between the barriers and the average height of the barriers. The following table provides recommended guidance on when to use TNM's parallel barrier analysis capability, based on width-to-height (W:H) ratio.

W:H Ratio	Max Expected Degradation (dB)	Recommendation
Less than 10:1	3 or greater	Analyze cross-section with TNM.
10:1 to 20:1	0 to 3	May want to analyze cross-section with TNM.
Greater than 20:1	No degradation	Don't bother analyzing cross-section with TNM.

Figure 58 shows the typical work flow for performing a parallel barrier analysis. To begin a parallel barrier analysis, you may create a new analysis (see Section 11.1) or open an existing one (see Section 11.2).

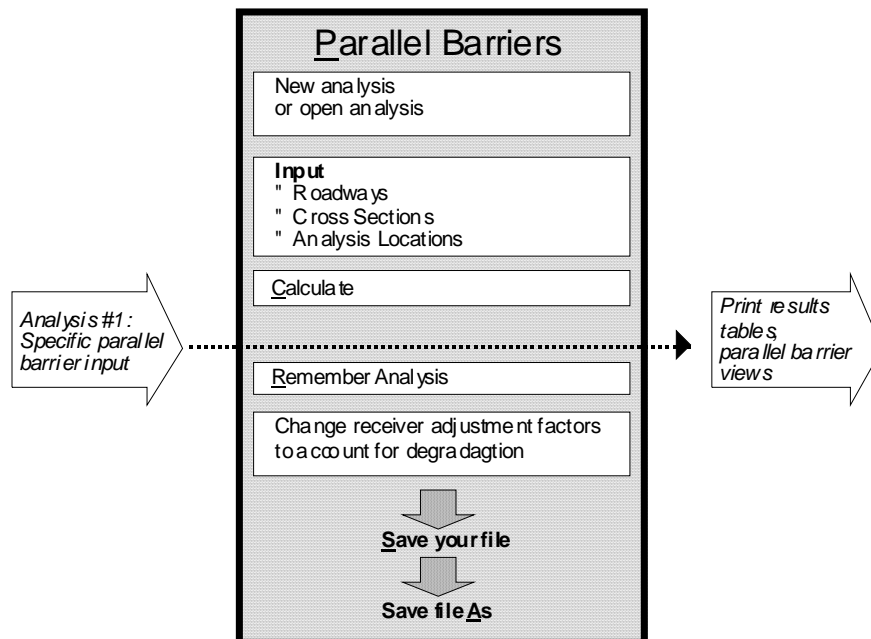



Figure 58. Parallel Barriers: Work flow.

11.1 New

To begin a new parallel barrier analysis, select Parallel Barrier, New in the main menu. In the Plan View, the mouse pointer will now change to a sawing tool, . Locate the parallel barrier cross-section to analyze. Click the left mouse button and drag a line across the desired section, then click the left mouse button again to end the line. TNM then opens a new view with the selected cross section (see Figure 59). If the view does not show at least two barriers, then either your section line did not cross at least two barriers, or one or both of your barriers have no input height. Note: For objects to be included in the cross-section, they must be completely displayed within the Plan View window.

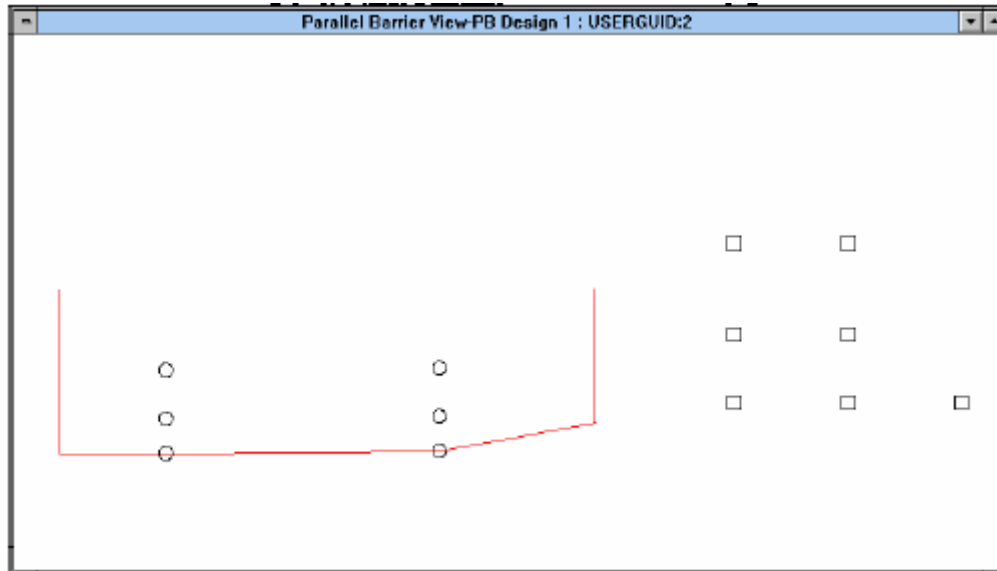


Figure 59. New parallel-barrier analysis.

Error!



When creating your new parallel barrier analysis, avoid locating the cross-section through any receivers. You will input analysis locations (parallel barrier receivers) later on (see Section 11.7).

11.2 Open

This selection allows you to open a previously saved parallel barrier analysis. When Open is selected, TNM will display a pop-up box with a list of available parallel barrier analyses, if any exist. Click on the



desired name and then click on . TNM then opens a graphical view of the analysis.

11.3 Remember and Remember As

To save a particular parallel barrier analysis, select Remember As and enter an analysis name. Select Remember to save subsequent changes in your analysis. If you would like to make changes to a previously remembered analysis, select Remember As and enter a different analysis name. Note: The terms, Remember and Remember As, are used to distinguish them from the Save and Save As functions (see Section 4.4 and 4.5). Use Save or Save As to save an entire run including all "remembered" parallel barrier analyses.


11.4 Delete

This selection allows you to delete a previously remembered parallel barrier analysis. When this function is selected, TNM will display a pop-up box with a list of remembered analyses from which to choose.

11.5 Roadways

Tool Bar: 

Roadways in parallel barrier analysis are referred to as "sources." When you create your parallel barrier analysis, any roadways that the cross section intersects will be shown in the parallel barrier analysis as three vertically aligned circles, which represent the three TNM subsource heights (a 0-m subsource height to represent tire/pavement noise for all vehicle types, a 1.5-m subsource height to represent engine/exhaust noise for all vehicle types, except heavy trucks, and a 3.6-m subsource height to represent heavy truck stack exhaust noise).


To add a roadway(s), click , or select Roadways in the Parallel Barrier pull-down menu, and place each source at the desired location(s) on the surface between the parallel barriers. To enter traffic for all sources, select Parallel Barrier, Roadways in main menu, and follow the same procedures outlined in Section 8.3.4 for entering traffic for non-parallel-barrier situations.




In most cases, traffic will not need to be input for a given parallel barrier analysis because it will be borrowed from its parent roadway in your main TNM run. Unfortunately, NRC's are not inherited from the parent roadway and will need to be re-entered. Also, many times you may approximate many lanes of traffic with just one or two main lanes. This approximation will introduce very little inaccuracies into an analysis, with the exception of a parallel barrier analysis. For parallel barrier cross sections, it is recommended that all traffic lanes be modeled in the cross section.

11.6 Cross Section


Tool Bar: 

The parallel barrier surface, defined by both barriers, the connecting roadway, and any intervening ground, is referred to in TNM as a "surface." To add a surface(s), click  select Parallel Barrier, Cross Section

in the main menu, and draw the surface using a mouse at the desired location(s). Click  to turn the surface tool off. Edit surface coordinates and enter NRC values for appropriate segments in the Parallel Barrier Cross Section input dialog. Note: There are virtually no restrictions on the characteristics of surfaces. In other words, you may simulate tilted barriers or barrier-top overhangs.

11.7 Analysis Locations

Tool Bar: 

During parallel barrier analysis, receivers are referred to as "analysis locations." To input an analysis location(s), click , or select Parallel Barrier, Analysis Location in the main menu, and place each at desired location(s) outside the surface boundary.

11.8 Calculate

After you have included all desired objects in your parallel barrier analysis, you select Parallel Barrier, Calculate in the main menu. TNM then computes the parallel-barrier degradations at your receivers. These degradations are documented in Parallel Barrier tables (see Section 13.3) and may be accounted for as receiver adjustment factors (see Section 8.4.4) during regular TNM sound level calculations.

12. CONTOURS MENU

Contours are graphical plots consisting of a smooth curve, statistically regressed through points of equal level. They are extremely useful tools for land-use planning and for the performance of high-level design projects.



See Appendix A for FHWA policy related to contours.

There are three types of contours available within TNM: (1) Sound Level Contours (see Section 12.2); (2) Noise Reduction Contours, i.e., barrier insertion-loss contours (see Section 12.3); and (3) Level Difference Contours (see Section 12.4). To create a contour zone within which TNM will calculate contours, see Section 8.10. Figure 60 shows the typical work flow for generating contours.

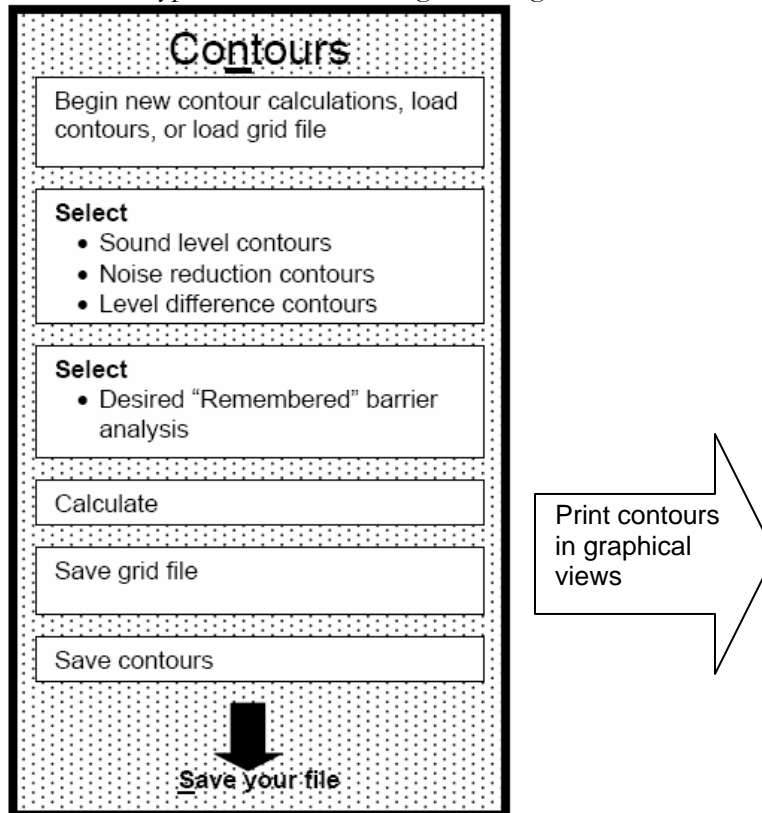


Figure 60. Contours: Work flow.



As Figure 60 shows above, you must select a “Remembered” barrier analysis, prior to continuing on to calculating contours.



To obtain contours for a “no barrier” case, you may create a “dummy” barrier with no height.

12.1 Define Contour Levels

This selection allows you to input a minimum and maximum contour level and a desired contour step level to increment within your minimum/maximum range. Note: Input of contour accuracy

parameters, such as tolerance, minimum grid spacing, and grid (receiver) height is entered in the contour zone input dialog (see Section 8.10).



Run-time: Based on user-input parameters (see Sections 8.10 and 12.1), TNM generates a grid and interpolates the ground elevation at all grid points within the user-defined contour zone. If the user inputs a large contour zone and a very small contour precision, TNM will require a longer time to generate and interpolate those grid points. It is recommended that you carefully consider the size and tolerance of the desired contour zone area prior to calculating contours.

12.2 Calculate Sound Level Contour

A Sound Level Contour displays your computed A-weighted sound levels for the defined contour zone using the user-defined range and step size (see Section 12.1). To calculate a sound level contour: (1) select a contour zone within the contour zone input dialog or by using the mouse to double-click on it in the Plan View (To create a contour zone, see Section 8.10); and (2) select **C**ontours, **C**alculate **S**ound **L**evel **C**ontour from the main menu. Note: The Plan View must be active for Calculate to be available. TNM will display a pop-up box that shows you the selected contour zone's name, and allows you to select a barrier design for contour computations. A Remembered barrier design is required because TNM needs to know what sound level results to compute contours for since contour computations will not be computed for all barrier designs, i.e., perturbation-height combinations. An example display of calculated sound level contours within your defined contour zone is shown in Figure 61.

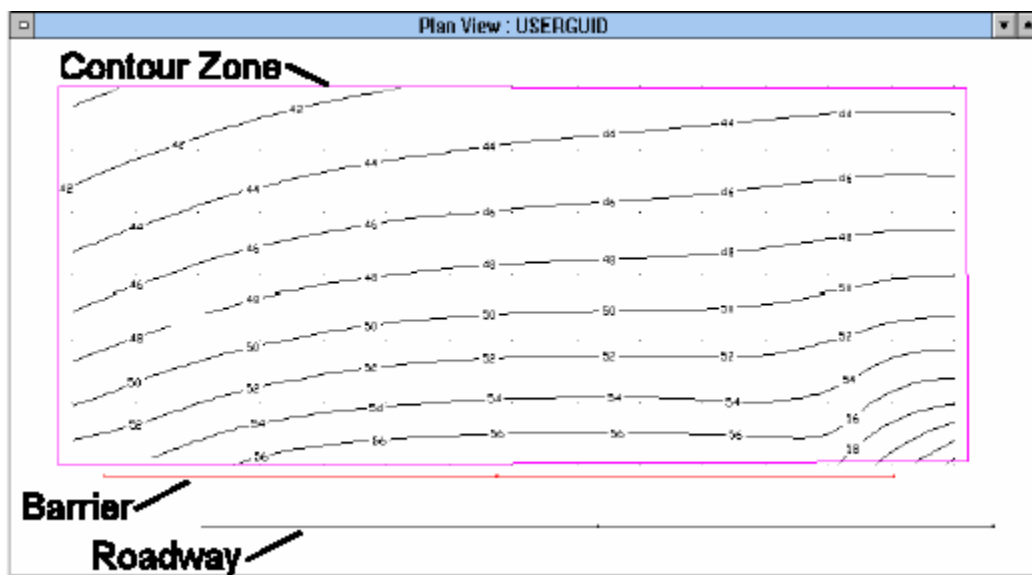


Figure 61. Calculated Sound Level Contour

12.3 Calculate Noise Reduction Contour

A Noise Reduction Contour displays the difference between the computed A-weighted sound levels for a “with barrier” case and the “no barrier” case, i.e., barrier insertion loss contours, for the defined contour zone. To calculate a noise reduction contour: (1) select a contour zone within the Contour

Zone input dialog or by using the mouse to double-click on it in the Plan View (To create a contour zone, see Section 8.10); and (2) select **C**ontours, **C**alculate **N**oise Reduction Contour from the main menu.

Note: The Plan View must be active for Calculate to be available. TNM will display a pop-up box that shows the selected contour zone's name, and allows you to select a barrier design for contour computations. A Remembered barrier design is required because TNM needs to know what sound level results to compute contours for since contour computations will not be computed for all barrier designs, i.e., perturbation-height combinations.

12.4 Calculate Level Diff. Contour

A Level Difference Contour displays the difference between the computed A-weighted sound levels for two different barrier designs for the defined contour zone. To calculate a level diff. (difference) contour: (1) select a contour zone within the Contour Zone input dialog or by using the mouse to double-click on it in the Plan View (To create a contour zone, see Section 8.10); and (2) select **C**ontours, **C**alculate Level **D**iff. Contour from the main menu. Note: The Plan View must be active for Calculate to be available. TNM will display a pop-up box that shows the selected contour zone's name, and allows you to select two barrier designs for which level difference contours will be computed.

12.5 Recalculate Contours from Grid File

This selection allows you to recalculate contours from a previously saved grid file. This is useful when you only want to change the minimum, maximum, and contour step levels, which TNM uses to setup and display the contours.

12.6 Load Grid File, Save Grid File, and Delete Grid File

When TNM finishes contour calculations at all grid and subgrid points, a "grid" file is produced (*.GRD). This grid file is sent to the computer program, NMPLOT Version 3.05, which computes the corresponding contours and returns them to TNM. The exchange between TNM and NMPLOT is transparent to the user.

The grid file that is produced by TNM can be named, saved, and thereby loaded for later use. Note: This grid file can also be run later independently in the NMPLOT computer program. To delete a saved grid file, select **C**ontours, **D**efine in the main menu. TNM will display a list from which to choose.

12.7 Load Contour Set, Save Contour Set, and Delete Contour Set

The contour that is produced by TNM can be named, saved, and thereby loaded for later use, without using NMPLOT for recomputation. To delete a saved contour, select **C**ontours, **D**efine in the main menu. TNM will display a list from which to choose.

13. TABLES MENU

TNM tables provide input and results summaries for printout and documentation. Note: You print data with tables, not with input dialogs. Conversely, you enter data with input dialogs (see Section 8), not with tables. As with most components of TNM, all of its tables are dynamically linked to related aspects of the program. For example, the results tables are linked to the barrier analysis module. This allows you to perturb your barriers up and down while viewing sound level results and costs (see Section 10.1).

13.1 Sound-level Input

Input tables contain all the information from the respective input dialogs. In addition, all input tables contain basic header information, such as your organization, your name, the serial number on your copy of TNM, the type of table, a project name, run name, a date, the program version, and, in some cases, miscellaneous notes and warnings. Figure 62 shows an example of an input table for roadways.

- Sound-level Input: Roadways;
- Sound-level Input: Traffic for TNM Vehicles;
- Sound-level Input: Traffic for User-defined Vehicles;
- Sound-level Input: Receivers;
- Sound-level Input: Barriers;
- Sound-level Input: Building Rows;
- Sound-level Input: Terrain Lines;
- Sound-level Input: Ground Zone;
- Sound-level Input: Tree Zones;
- Sound-level Input: Contour Zones;
- Sound-level Input: Receiver Addjustment Factors; and
- Sound-level Input: Structure Barriers.

Roadway Input Table : USERGUID:2												
Company Name						Date						
User, TNM Serial Number						Version						
INPUT: ROADWAYS						Average pavement type shall be used unless a State highway agency substantiates the use of a different type with the approval of FHWA						
PROJECT/CONTRACT:			Client / Contract									
RUN:			C:\TNM\EXAMPLES\USERGUID									
Roadway		Points		Coordinates (pavement)			Flow Control			Segment		
Name	Width	Name	No.	X	Y	Z	Control Device	Speed Constraint	Percent Vehicles Affected	Pvmt Type	On Struct?	
	m			m	m	m		km/h	%			
I95EB	3.7	EB1	3	-32.4	60.9	52.00				Average		
		EB2	4	14.6	51.3	61.00				Average		
		EB3	28	32.3	51.1	61.75				Average		
		EB4	17	49.9	50.9	62.50				Average	Y	
Turtle Road NB	3.7	TN1	11	10.9	-67.4	54.86	Signal	0.00	40	Average		
		TN2	12	45.3	9.5	54.86				Average		
		TN3	56	53.2	26.8	54.86				Average		
		TN4	72	69.2	61.6	54.86				Average		
I95WB	3.7	WB1	31	320.3	10.1	20.00				Average		
		WB2	32	259.3	32.0	22.00				Average		
		WB3	33	209.2	45.5	32.00				Average		
Roadway12	3.7	R1	68	28.6	39.2	54.00				Average		
Turtle to I95WB	3.7	R2	69	38.2	11.7	54.86				Average		
		R1	82	69.5	81.5	54.86	Onramp	16.00	100	Average		
		R2	83	34.4	69.8	62.00				Average		
		R3	84	13.7	67.8	61.00				Average		
I95WB to Turtle Not modeled precisely.												
Turtle to I95WB Not modeled precisely.												
I95EB::EB4 Structure roadway segment.												
I95WB::WB7 Structure roadway segment.												

Figure 62. Sound-level Input: Roadways table.

13.2 Sound-level Results

Results tables contain information based on calculated results. In addition, all results tables contain basic header information, such as your organization, your name, the serial number on your copy of TNM, the type of table, a project name, run name, a date, the program version, and, in some cases, miscellaneous notes and warnings. There are five different types of results tables described below: (1) Sound Levels; (2) Diagnosis By Barrier Segment; (3) Diagnosis by Vehicle Type; (4) Barrier Descriptions; and (5) Barrier Segment Descriptions.

- (1) **Sound Levels:** This table shows the sound level results at each receiver computed using all barriers at their input heights. It also shows the sound levels for each receiver with no barriers present. Figure 63 is an example of a Sound Levels table.

Sound Levels : USERGUID:2												
Company Name User, TNM Serial Number										Date Version		
RESULTS: SOUND LEVELS												
PROJECT/CONTRACT:				Client / Contract								
RUN:				C:\TNM.31\TNM_RUNS\USERGUID								
BARRIER DESIGN:				INPUT HEIGHTS								
ATMOSPHERICS:				20 deg C, 50% RH								
Average pavement type shall be used unless a State highway agency substantiates the use of a different type with approval of FHWA.												
Receiver												
Name	No.	#DUs	Existing LAeq1h dBA	No Barrier			Increase over existing		Type Impact	With Barrier		
				LAeq1h dBA	Crit'n dBA	Calculated dB	Crit'n dB	Calculated LAeq1h dBA		Noise Reduction Calculated dB	Goal dB	
R2-3	1	2	45.0	43.0	66	-2.0	10	----	17.2	25.8		
R2-5	5	2	45.0	55.1	66	10.1	10	Sub1 Inc	46.6	8.5		
R2-7	7	2	45.0	16.4	66	-28.6	10	----	13.9	2.5		
R2-1	8	2	45.0	49.1	66	4.1	10	----	36.2	12.9		
R3	19	2	45.0	43.0	66	-2.0	10	----	30.1	12.9		
R2	20	2	45.0	56.9	66	11.9	10	Sub1 Inc	42.8	14.1		
R1	21	2	45.0	36.3	66	-8.7	10	----	28.1	8.2		
Dwelling Units		# DUs	Noise Reduction									
			Min dB	Avg dB	Max dB							
All Selected		14	2.5	12.1	25.8							
All Impacted		4	8.5	11.3	14.1							
All that meet NR Goal		12	8.2	13.7	25.8							

Figure 63. Sound-level Results: Sound Levels table.

- (2) **Diagnosis by Barrier Segment:** This table shows the sound level results for each receiver broken down into the partial contributions of up to ten noise barrier segments. These ten barrier/ barrier segments are labeled as “Important” because they are the ten greatest contributors of sound energy in order of magnitude for that receiver. Figure 64 is an example of a Diagnosis by Barrier Segments table.

RESULTS: SOUND-LEVEL DIAGNOSIS BY BARRIER SEGMENT						
PROJECT/CONTRACT:		<Project Name?>				
RUN:		<Run Title?>				
BARRIER DESIGN:		INPUT HEIGHTS				
ATMOSPHERICS:		20 deg C, 50% RH				
Selected Receivers						
Name	No.	Total LAeq1h	Important Barriers Name	Important Segments		
				Name	No.	Partial LAeq1h dBA
A-1	33	57.50	NB Mainline Edge of Road - future bu	eor380.6	8	52.90
			NB Mainline Edge of Road - future bu	eor381.7	9	51.10
			NB Mainline Edge of Road - future bu	eor379.3	7	50.40
			NB Mainline Edge of Road - continue	eor382.7	11	48.30
			NB Mainline Edge of Road - continue	eor383.7	12	45.60
			NB Mainline Edge of Road - future bu	eor378.1	6	38.60
			NB Mainline Edge of Road - future bu	eor375.4	4	38.20
			NB Mainline Edge of Road - future bu	eor377.0	5	37.10
			NB Mainline Edge of Road - future bu	eor372.2	2	36.20
A-2	34	57.40	NB Mainline Edge of Road - future bu	eor375.0	3	32.20
			NB Mainline Edge of Road - future bu	eor380.6	8	52.80
			NB Mainline Edge of Road - future bu	eor381.7	9	50.80

Figure 64. Sound-level Results: Diagnosis by Barrier Segments table.

- (3) **Diagnosis by Vehicle Type:** This table shows the sound level contributions by vehicle type. It includes user-defined vehicles. Figure 65 is an example of a Sound Level Diagnosis by Vehicle Type table.

Diagnosis by Vehicle Type : USERGUID:3					
Company Name		Date			
User, TNM Serial Number		Version			
RESULTS: SOUND-LEVEL DIAGNOSIS BY VEHICLE TYPE					
PROJECT/CONTRACT:		Client / Contract			
RUN:		C:\TNM.31\TNM_RUNS\USERGUID			
BARRIER DESIGN:		unsaved INPUT HEIGHTS			
ATMOSPHERICS:		20 deg C, 50% RH			
Receivers					
Name	No.	Total Lden	Vehicle Type		Partial Lden
			Name	dBA	
R2-3	1	17.2	Autos	13.7	
			MTrucks	7.1	
			HTrucks	13.6	
			Buses	-1.8	
			Motorcycles		
			User 1		
R2-5	5	46.6	Autos	43.9	
			MTrucks	37.9	
			HTrucks	41.5	
			Buses	28.8	
			Motorcycles		
			User 1		
R3	19	30.1	Autos	26.7	
			MTrucks	21.9	
			HTrucks	25.9	
			Buses		
			Motorcycles		
R2	20	42.8	Autos	39.5	

Figure 65. Sound-level Results: Diagnosis by Vehicle Type table.

- (4) **Barrier Descriptions:** This table provides a summary of pertinent barrier statistics, including type, min/max/avg height, length, and cost, as well as other parameters. Figure 66 is an example of a Barrier Descriptions table.

Barrier Descriptions Table : USERGUID:3											
Company Name						Date					
User, TNM Serial Number						Version					
RESULTS: BARRIER DESCRIPTIONS											
PROJECT/CONTRACT:			Client / Contract								
RUN:			C:\TNM.31\TNM_RUNS\USERGUID								
BARRIER DESIGN:			INPUT HEIGHTS								
Barriers											
Name	Type	Heights along Barrier			Length	If Wall		If Berm		Run:Rise	Cost
		Min	Avg	Max		Area	Volume	Top Width			
		m	m	m	m	sq m	cu m	m	m:m	\$	
Main barrier	W	4.00	6.92	7.00	268	1858					282400
Across structure	W	6.00	6.00	6.00	85	511					88000
Total Cost											370400

Figure 66. Barrier Descriptions table.

- (5) **Barrier Segment Descriptions:** This table provides the same information as the Barrier Descriptions table, but on a barrier segment level. Figure 67 is an example of a Barrier Segments Descriptions table.

Barrier-Segment Descriptions : USERGUID:3												
Company Name						Date						
User, TNM Serial Number						Version						
RESULTS: BARRIER-SEGMENT DESCRIPTIONS												
PROJECT/CONTRACT:			Client / Contract									
RUN:			C:\TNM.31\TNM_RUNS\USERGUID									
BARRIER DESIGN:			INPUT HEIGHTS									
Barriers												
Name	Type	Segments		Heights			Length	If Wall			If Berm	Cost
		Name	No.	First Point	Average	Second Point		Area	On Struc?	Important Reflections?		
				m	m	m	m	sq m			cu m	\$
Main barrier	W	point34	34	7.00	7.00	7.00	7.00	13	93			14100
		point35	35	7.00	7.00	7.00	7.00	10	69			10400
		point36	36	7.00	7.00	7.00	7.00	11	74			11300
		point37	37	7.00	7.00	7.00	7.00	9	63			9600
		point38	38	7.00	7.00	7.00	7.00	12	81			12400
		point39	39	7.00	7.00	7.00	7.00	11	76			11500
		point40	40	7.00	7.00	7.00	7.00	20	138			20900
		point41	41	7.00	7.00	7.00	7.00	15	105			16000
		point42	42	7.00	7.00	7.00	7.00	19	132			20100
		point43	43	7.00	7.00	7.00	7.00	17	116			17600
		point66	66	7.00	7.00	7.00	7.00	17	116			17600
		point44	44	7.00	7.00	7.00	7.00	17	117			17800
		point67	67	7.00	7.00	7.00	7.00	17	117			17800
		point45	45	7.00	7.00	7.00	7.00	22	153			23200
point46	46	7.00	7.00	7.00	7.00	39	230			34900		
point47	47	7.00	7.00	7.00	7.00	14	100			15200		
point48	48	7.00	5.50	4.00	7.00	14	78			11800		
Across structure	W	point56	56	6.00	6.00	6.00	7	45			7800	
		point57	57	6.00	6.00	6.00	7	43			7500	

Figure 67. Barrier Segment Descriptions table.

13.3 Parallel Barriers

Parallel barrier tables contain all input and results information related to a parallel barrier analysis. There are three different types of parallel barrier tables described below: (1) Roadway tables; (2) Cross Section tables; and (3) Analysis Location tables.

- (1) **Roadways for TNM Vehicles and Roadways for User-defined Vehicles:** This table lists all the roadways, segment coordinates, and traffic (both TNM vehicles and user-defined vehicles), in the current Parallel Barrier analysis. Figure 68 is an example of a Roadway table for Parallel Barrier analyses.

Parallel Roadway Input Table, TNM Vehicles : USERGUID:3														
Company Name										Date				
User, TNM Serial Number										Version				
PARALLEL BARRIER: ROADWAYS														
PROJECT/CONTRACT:										Client / Contract				
RUN:										C:\TNM\EXAMPLES\USERGUID				
PARALLEL BARRIER DESIGN:										PB Design1				
Parallel-Barrier Roadway														
Name	No.	Pvmt Type	Coords (pvmt)		Traffic									
			Horiz	Z	Autos		MTrucks		HTrucks		Buses		Motorcycles	
			m	m	V	S	V	S	V	S	V	S	V	S
					veh/hr	km/h	veh/hr	km/h	veh/hr	km/h	veh/hr	km/h	veh/hr	km/h
I95WB to Turtle-1	1	Average	3.0	58.62	800	25	35	25	20	25	0	0	0	0
Turtle to I95EB-2	2	Average	34.9	52.64	800	65	35	65	20	65	0	0	0	0
I95WB-3	3	Average	9.3	60.71	4200	65	126	65	105	65	15	65	0	0
I95EB-4	4	Average	21.3	61.27	4200	65	126	65	105	65	15	65	0	0

Figure 68. Parallel Barrier: Roadways for TNM Vehicles table.

- (2) **Cross Section:** This table lists all the barriers, segment coordinates, and barrier surface NRC values, in the current Parallel Barrier Analysis. Figure 69 is an example of a Cross Section table for Parallel Barrier Analyses.

Parallel Cross Section Input Table : USERGUID:3				
Company Name				Date
User, TNM Serial Number				Version
PARALLEL BARRIER: CROSS SECTION				
PROJECT/CONTRACT:				Client / Contract
RUN:				C:\TNM\EXAMPLES\USERGUID
PARALLEL BARRIER DESIGN:				PB Design1
Parallel-Barrier Cross Section				Points
Name	No.	Coordinates		Segment NRC
		Horiz	Z	
		m	m	
Surface1	1	21.3	61.24	0.00
	2	25.5	60.99	0.00
	3	25.5	66.99	0.00
	4	25.5	60.99	0.00
	5	34.9	52.61	0.00
	6	38.5	47.00	0.00
	7	42.0	53.00	0.00
	8	42.0	60.00	0.00
	9	42.0	53.00	0.00
	10	51.7	50.82	0.00
	11	51.7	58.32	0.00

Figure 69. Parallel Barrier: Cross Section table.

- (3) **Analysis Locations:** This table lists all the Analysis Location names and their coordinates for the current Parallel Barrier Analysis. It also lists each location's computed increase in sound level. These increases may be used as receiver adjustment factors (see Section 8.4.4). Figure 70 is an example of an Analysis Locations table for Parallel Barrier analyses.

Parallel-Barrier Analysis Location			
Name	Coordinates (ear)		Computed Increase in LAeq1h
	Horiz	Z	
	m	m	dB
R1-5	52.7	58.58	---
PReceiver2	52.6	55.75	---
PReceiver3	52.8	52.18	---
PReceiver4	52.7	61.67	---
PReceiver6	61.6	52.20	---
PReceiver7	61.1	56.14	---
PReceiver8	66.4	52.20	---

Figure 70. Parallel Barrier: Analysis Locations table.

13.4 Hide Rows and Show All Rows

TNM allows you to hide superfluous rows of text, e.g., header rows. To hide rows of text within a given active table:

1. Click on the grey box opposite the first line of text you wish to hide (a column of grey boxes runs down the left-hand side of all tables);
2. Drag the pointer down to include subsequent grey boxes (the text opposite the selected boxes will show up as highlighted);
3. Select Tables, Hide Rows from the main menu. The table will be updated on the screen with the user-selected rows hidden. This feature does not affect printed output.

To show all rows associated with a given table, including all hidden rows, select Tables, Show All Rows. This option will undo any row-hiding performed above.

13.5 Export

All tables can be saved to a comma-delimited ASCII file for manipulation outside of TNM. To export TNM tables to a comma-delimited ASCII file, select Tables, Export.

14. WINDOW MENU

The Window menu is used to rearrange, close, and select windows.

14.1 Cascade

This selection is used to rearrange all open windows. "Cascade" means that the windows will be stacked on top of each other, starting in the upper left-hand corner of the computer display. Each succeeding window is placed on top of the preceding one and offset to the right and down (see Figure 71).

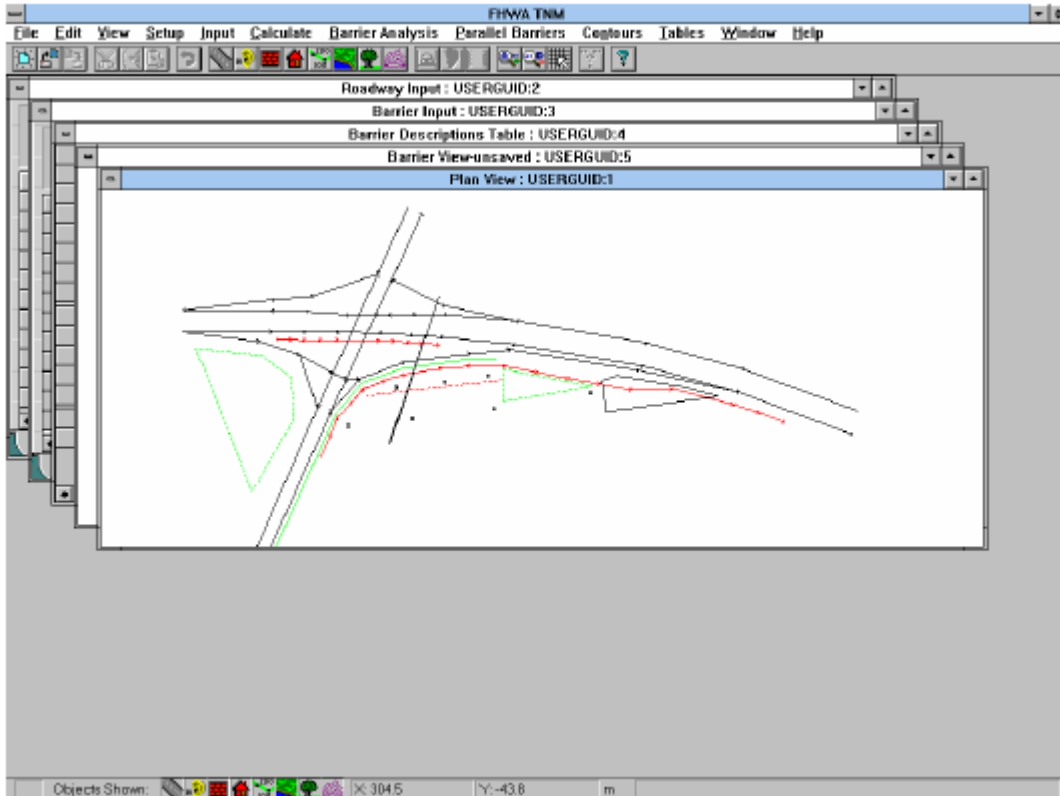


Figure 71. Window: Cascade.

14.2 Tile Vertical

This selection is used to rearrange the set of open windows, such that the windows will be arranged vertically, i.e., side-by-side, without overlapping (see Figure 72).

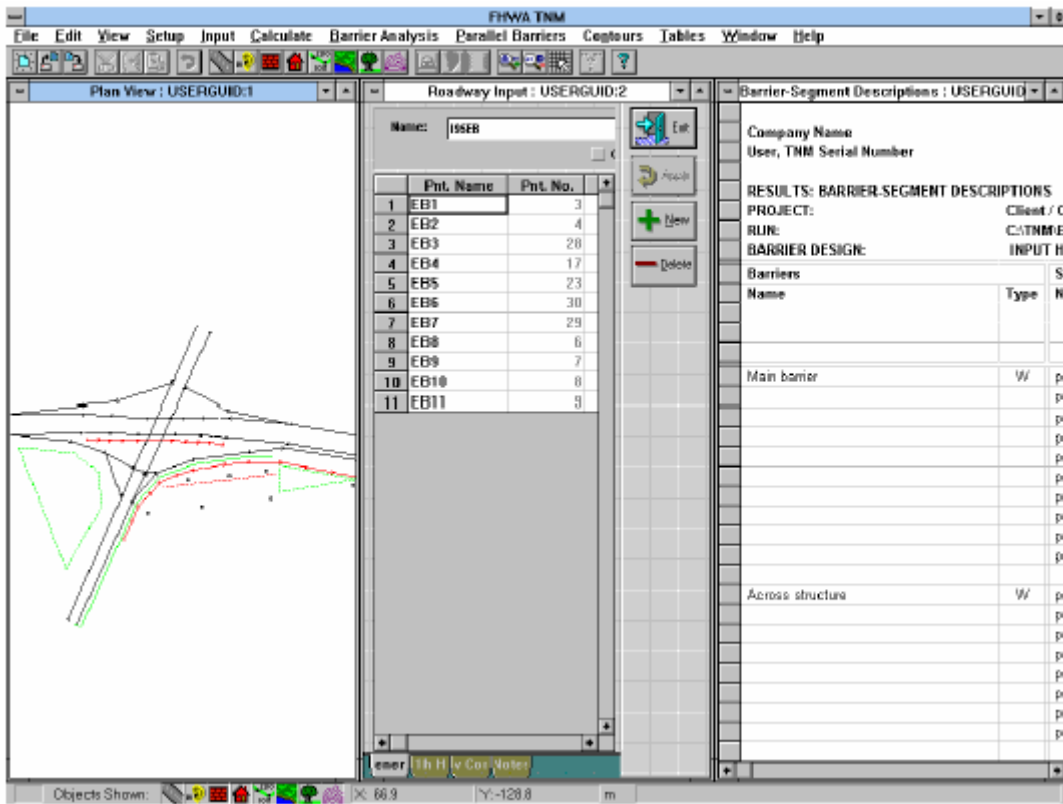


Figure 72. Window: Tile Vertical.

14.3 Tile Horizontal

This selection is used to rearrange the set of open windows, such that the windows will be arranged horizontally without overlapping (see Figure 73).

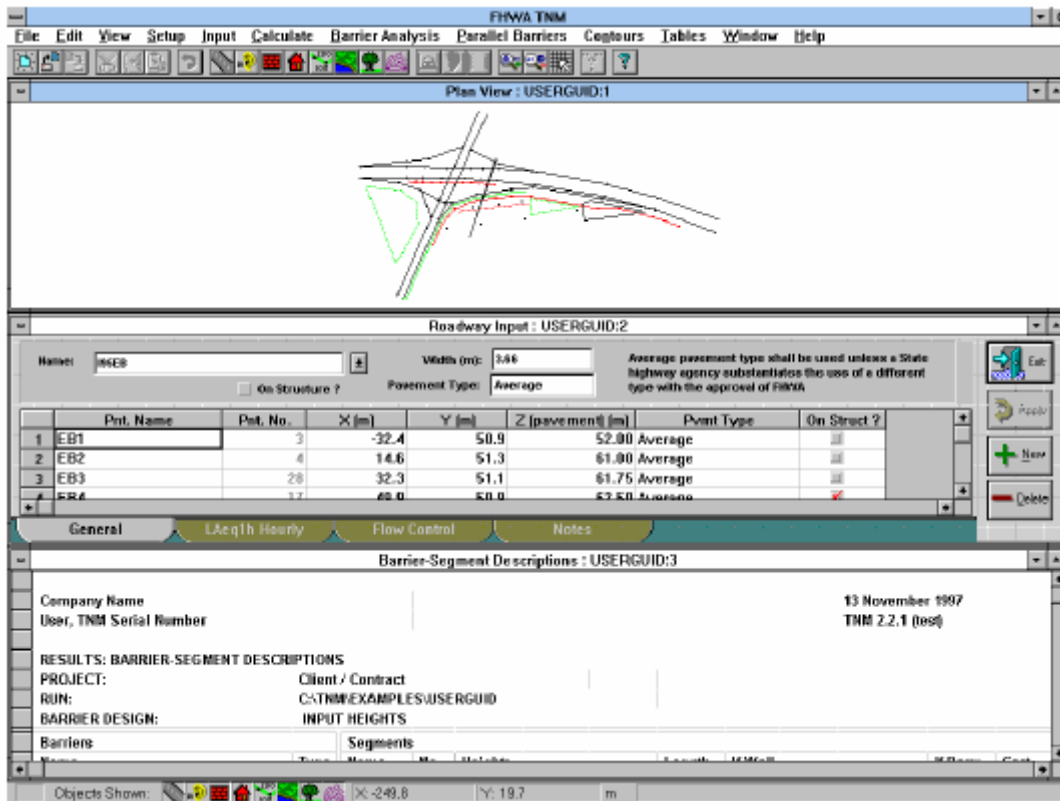


Figure 73. Window: Tile Horizontal.

14.4 Arrange Icons

When you minimize a window, that window is reduced to a Windows icon. This helps to keep the screen uncluttered when several windows are open. The Arrange Icons selection is used to orderly rearrange the icons horizontally at the bottom of the TNM screen. Note: To restore an icon to its original size, use a mouse to double-click on the icon.

14.5 Close All

This selection is used to close all open windows, including any minimized windows (represented by icons). Closing all windows does not exit TNM. To exit, see Section 4.12.

15. HELP MENU

Use TNM's on-line Help system to get immediate information about TNM features, options, and terminology.

15.1 Contents

Tool Bar: 

This selection can be used to access all main components of Help. Available help topics to choose from are listed.

15.2 Menu Items

This selection is used to provide help for a specific menu item.

15.3 Keyboard Shortcuts

This selection allows you to search for help on the available TNM keyboard shortcuts. Keyboard shortcuts are discussed in Section 3.1.7.

15.4 FHWA Policy

This selection displays FHWA policies for highway traffic noise prediction using TNM. Users should apply them to all traffic noise analyses conducted for Federal-aid highway projects. These policies are also included in Appendix A of this User's Guide.

15.5 Using Help

This selection provides basic information about the Help system itself.

15.6 Introducing TNM

This selection will display TNM's sponsoring agencies' names and program developers' credits.

15.7 About TNM

This selection will display the TNM start-up logo that is seen when the program is first invoked.

APPENDIX A

FHWA POLICIES FOR HIGHWAY TRAFFIC NOISE PREDICTION USING TNM

Note: This appendix contains FHWA policy concerning the use of TNM. This policy is current as of publication of this User's Guide.

TNM may be used to calculate highway traffic noise levels in a number of different instances, e.g., land-use planning activities, research studies, and highway project analyses. Choices made during the use of TNM are appropriately left to the discretion of the noise analyst. However, all users should be fully aware of the policies which follow and should apply them to all traffic noise analyses conducted for Federal-aid highway projects. Questions on the policies may be directed to FHWA at (202) 366-2073.

A.1 Phase-out of STAMINA 2.0/OPTIMA

The TNM software will eventually replace STAMINA 2.0/OPTIMA. However, STAMINA 2.0/OPTIMA will be acceptable for use until users have sufficient time to become trained and proficient in the operation of TNM. FHWA will issue appropriate notice for discontinuance of the use of STAMINA 2.0/OPTIMA.

A.2 TNM Copyright and Trademark

The FHWA TNM is a registered copyright. The copyright encompasses the User's Guide, Technical Manual, and software source and executable codes.

The FHWA TNM is a registered trademark. The trademark encompasses the copyrighted User's Guide, Technical Manual, and software source and executable codes. It provides the FHWA with the exclusive right to use the names "Federal Highway Administration Traffic Noise Model" and "FHWA TNM."

Purchase of TNM includes the User's Guide, Technical Manual, and the executable code. A TNM package must be purchased for each distinct company address (site), although copies may be made to permit several individuals at one site to use it. The User's Guide may be photocopied.

For developers interested in obtaining the software source code, acceptance of the TNM Source Code Licensing Agreement is a prerequisite. Under the terms of the Licensing Agreement, any modifications, enhancements, or derivatives of TNM, as well as distribution of the modified source code, which makes reference to the FHWA's trademarks, are strictly prohibited without the express written permission of the FHWA.

Use of TNM signifies the user's acknowledgment of the FHWA TNM as a registered copyright and trademark.

A.3 Test Case

Input for the official test case for TNM is automatically installed with TNM. After installation, this test case must be run, and the results must duplicate the certified output for the test case found in Appendix E. This will ensure proper operation of TNM.

A.4 Run Identification

It is recommended that, in Run Identification, the user enter his/her name and the serial # that is printed on the TNM floppy diskettes in the cell ANALYSIS BY, so that the software user ID # will be included in all tables that are printed by TNM.

A.5 TNM Digitizer Registration

When using TNM to register plan sheets on a digitizer tablet, the user must utilize the "Typed Coordinates" registration method the very first time a plan sheet is registered. This requirement ensures acceptable accuracy. When a sheet is re-registered or contains a match line to the next sheet, the digitizer may be used for registration, and typed coordinates are not required.

A.6 Adjustment Factors

TNM allows the user to enter adjustment factors for each receiver. Adjustment factors should only be used to account for propagation effects not calculated by TNM and, then, only after sufficient field measurements have been made at a given location to verify the adjustment. No adjustments should be made for differences of less than 3 dBA.

A.7 Metric Units

TNM defaults to the use of metric units. The use of metric units in traffic noise analysis documentation is optional.

A.8 Noise Descriptors

TNM allows calculations utilizing an L_{Aeq1h} , L_{dn} , or L_{den} noise descriptor. All project analyses must be performed using the L_{Aeq1h} noise descriptor, not L_{dn} or L_{den} . The use of the hourly L_{10} in project analyses is also acceptable, but approval must be requested and granted by FHWA to modify the TNM source code to permit the calculation of the hourly L_{10} .

A.9 Relative Humidity, Temperature, and Wind

TNM contains default values for relative humidity and temperature. All calculations using TNM must use the default values for relative humidity and temperature unless other values have been substantiated and approved by the FHWA. TNM assumes neutral conditions for the effects of wind - that is, no adjustments are made for wind speed and direction.

A.10 Vehicle Emission Levels

TNM allows the user to input data and calculate noise levels utilizing user-defined vehicle types. This feature should only be used for unique vehicle types which differ substantially from the five standard vehicle types contained in TNM, e.g., recreational vehicles or electric vehicles. It should not be used to input State-specific emission levels for the five standard vehicle types.

A.11 Pavement Types

TNM defaults to "AVERAGE" for pavement type. **The use of any other pavement type must be substantiated and approved by the FHWA.** Traffic noise levels do vary with changes in pavements and tires. However, it is not clear that these variations are substantial when compared with the noise from exhausts and engines, especially when there are a large number of trucks on the highway. Additional studies are needed to determine to what extent different types of pavements and tires contribute to traffic noise. It is very difficult to forecast pavement surface condition into the future. Therefore, unless definite knowledge is available on the pavement type and condition and its noise generating characteristics, no adjustments should be made for pavement type in the prediction of highway traffic noise levels.

A.12 Existing Level, Impact Criterion Level, Substantial Increase, and Noise Reduction Goal

TNM allows the user to input "EXISTING LEVEL," "IMPACT CRITERION LEVEL," "SUBSTANTIAL INCREASE," and "NOISE REDUCTION GOAL" to assist in the identification of traffic noise impacts and the design of noise barriers. The latter three inputs should be values defined in each State highway agency's (SHA) written policies.

The value used for "EXISTING LEVEL" should be the measured or calculated existing noise level at a given location.

Values used for "IMPACT CRITERION LEVEL" and "SUBSTANTIAL INCREASE" should be values defined by a respective SHA. The SHA's definition for "IMPACT CRITERION LEVEL" should be at least 1 dBA less than FHWA's appropriate Noise Abatement Criterion.

The value used for "NOISE REDUCTION GOAL" should be the amount of noise reduction that is desired. This value should be defined by a respective SHA and should be typically in the range of 5-10 dBA. Noise barriers must provide at least a 5 dBA reduction in highway traffic noise levels in order to provide noticeable and effective attenuation. A noise barrier should be designed to achieve the greatest reduction possible, but in no instance less than 5 dBA.

A.13 Custom Ground Zones

TNM allows the user to input a "CUSTOM" ground zone type. If this option is chosen, the value that is entered for flow resistivity of "CUSTOM" ground type must be measured in accordance with the American National Standards Institute's (ANSI) standard for measuring **ground impedance**, scheduled for publication in 1998.¹⁰

A.14 Tree Zones

TNM allows the user to model "tree zones." Such zones should consist of long, wide regions of heavy, non-deciduous woods and undergrowth, not just individual trees or several rows of trees. The vegetation also must be sufficiently dense to completely block the view along the sound propagation path. This requires dense undergrowth as well as dense tree-top foliage. "Tree zones" should not be modeled unless they have this vegetative density.

A.15 Noise Reduction Coefficient (NRC)

TNM allows the user to input a Noise Reduction Coefficient (NRC) in the modeling of absorptive surfaces. The value that is entered for "NRC" must be measured in accordance with either the American Society of Testing and Materials (ASTM) Recommended Practice C 384-95a (Impedance Tube Method),¹⁶ or ASTM Recommended Practice C 423-90a (Reverberation Room Method).¹¹ Users should document which method was used.

A.16 Line-of-Sight Check

The use of the line of sight check is not required. TNM contains this feature, for use when desired, to allow analysis of the perceptual noise problem created when a person can see the top of a truck exhaust stack above the top of a noise barrier.

A.17 Parallel Barriers

TNM allows the user to model parallel barriers. Studies have suggested that to avoid a reduction in the performance of parallel reflective noise barriers, the width-to-height ratio of the roadway section to the barriers should be at least 10:1. The width is the distance between the barriers, and the height is the average height of the barriers above the roadway. This means, that two parallel barriers 3 meters tall should be at least 30 meters apart. Accordingly, it is recommended that parallel plane surfaces not be modeled with TNM unless the width-to-height ratio of the surfaces is less than 10:1 (note that modeling parallel plane surfaces greatly increases TNM run time).

A.18 Contour Zones

TNM allows the user to model contour zones. However, calculating noise contours with TNM greatly increases run time. It is strongly recommended that this feature of TNM only be utilized for land-use planning activities and/or performing screening analyses to determine the number of impacted receivers in an area.

APPENDIX B DETAILS OF ALL INPUT TYPES

This appendix contains details of all TNM input types. It supplements the input process of Section 8. (Note: ---- denotes “Not Applicable” or “No Action Required.”)

B.1 Roadways

Input for a full roadway: Several roadway properties pertain to a full roadway. Table 13 describes these full-roadway properties.

Table 13. Input for a full roadway.

Property	Purpose	Units	Built-in Default	Constraints
Roadway name	Identifies the roadway.	-----	Roadway <No.>	-----
Width	Affects propagation near the roadway. Within this width, the ground is always "pavement."	m, ft	3.66, 12.01	∃ 0

Input for each roadway point. Other properties can vary from point to point along the roadway. Table 14 describes these roadway-point properties.

Table 14. Input for each roadway point.

Property	Purpose and choices	Units	Built-in Default	Constraints
Point name	Identifies the roadway point and the segment that follows it.	-----	Roadway Point <No.>	-----
Point number	Also identifies the roadway point and the segment that follows it.	-----	Assigned by TNM	-----
XYZ coordinates	Locates the roadway point. The Z coordinate must be for the roadway pavement.	m, ft	0	-----
Control device	Affects vehicle speeds along the roadway, until vehicles accelerate back up to your input speed. TNM computes speeds as traffic accelerates away from the device, as a function of distance and grade. The choices are Stop Sign, Traffic Signal, Toll Booth, Onramp Start point, None.	-----	None	-----
Speed constraint	Sets the initial speed at Onramp Start points. The default value (0) is proper for all other traffic-control devices.	km/hr, mph	0.00	∃ 0
Vehicles affected	Sets the percentage of vehicles affected by Traffic Signals. The default value (100) is proper for all other traffic-control devices.	%	100	∃ 0 # 100

Input for each roadway segment. Finally, several properties pertain to each roadway segment. Table 15 describes these roadway-segment properties.

Table 15. Input for each roadway segment.

Property	Purpose and choices	Units	Built-in Default	Constraints
Pavement type	Affects sound emission. Choices: Average, DGAC (dense-graded asphaltic concrete), PCC (Portland cement concrete), OGAC (open-graded asphaltic concrete). See FHWA policy in Appendix A before choosing any pavement type other than Average.	-----	Average	-----
On structure?	If yes, the edges of this roadway segment shield only its own traffic, not traffic on any other roadway.	-----	No	-----

Traffic for L_{Aeq1h} . Table 16 describes traffic properties for L_{Aeq1h} , depending upon whether you enter vehicle volumes or vehicle percentages.

Table 16. Traffic for L_{Aeq1h} .

Property	Definition	Units	Built-in Default	Constraints
Vehicle type	Tells TNM the type of vehicle. Choices: Auto, Medium truck, Heavy truck, Bus, Motorcycle, User-defined vehicles	-----	All of them	-----
Volumes				
Volume (veh/hr)	Number of vehicles per hour, separately for each vehicle type.	veh/hr	0	≥ 0
Speed	Each vehicle type's speed.	km/hr, mph	0.00	≥ 0
Percentages				
Total hourly volume	Total number of vehicles per hour (all vehicle types combined).	veh/hr	0	≥ 0
Percent	Each vehicle type's percentage of the total volume.	%	0	≥ 0 # 100
Speed	Each vehicle type's speed.	km/hr, mph	0.00	≥ 0

Note: In L_{Aeq1h} Percent, for each roadway segment, the sum of each column must equal 100 percent. TNM will check this sum during its Input Check.

Traffic for L_{dn} . If you choose to compute L_{dn} , you must enter traffic for two time periods: daytime (7 am to 10 pm) and nighttime (10 pm to 7 am the next day). Table 17 describes traffic properties for L_{dn} .

Table 17. Traffic for L_{dn} .

Property	Definition	Units	Built-in Default	Constraints
Vehicle type	Tells TNM the type of vehicle. The choices are Auto, Medium truck, Heavy truck, Bus, Motorcycle, User-defined vehicles	-----	All of them	-----
ADT	Average Daily Traffic (all vehicle types combined, all 24 hours combined).	veh/24 hrs	0	$\exists 0$
% Day	Each vehicle type's daytime percentage of the total ADT. Daytime means 7 am to 10 pm.	%	0	$\exists 0$ # 100
% Night	Each vehicle type's nighttime percentage of the total ADT. Nighttime means 10 pm to 7 am.	%	0	$\exists 0$ # 100
Speed	Each vehicle type's speed.	km/hr, mph	0.00	$\exists 0$

Note: For each roadway segment, the sum of each column must equal 100 percent. TNM will check this sum during its Input Check. Times of day are not adjustable.

Traffic for L_{den} . If you choose to compute L_{den} , you must enter traffic for three time periods: daytime (7 am to 7 pm), evening (7 pm to 10 pm) and nighttime (10 pm to 7 am the next day). Table 18 describes traffic properties for L_{den} .

Table 18. Traffic for L_{den} .

Property	Definition	Units	Built-in Default	Constraints
Vehicle type	Tells TNM the type of vehicle. The choices are Auto, Medium truck, Heavy truck, Bus, Motorcycle, User-defined vehicles	-----	All of them	-----
ADT	Average Daily Traffic (all vehicle types combined, all 24 hours combined).	veh/24 hrs	0	$\exists 0$
% Day	Each vehicle type's daytime percentage of the total ADT. Daytime means 7 am to 7 pm.	%	0	$\exists 0$ # 100
% Evening	Each vehicle type's evening percentage of the total ADT. Evening means 7 pm to 10 pm.	%	0	$\exists 0$ # 100
% Night	Each vehicle type's nighttime percentage of the total ADT. Nighttime means 10 pm to 7 am.	%	0	$\exists 0$ # 100
Speed	Each vehicle type's speed.	km/hr, mph	0.00	$\exists 0$

Note: For each roadway segment, the sum of each column must equal 100 percent. TNM will check this sum during its Input Check. Times of day are not adjustable.

B.2 Receivers

Required input for receivers. Table 19 describes all required receiver input.

Table 19. Required input for receivers.

Property	Purpose	Units	Built-in Default	Constraints
Receiver name	Identifies the receiver.	-----	Receiver <No.>	-----
Receiver number	Also identifies the receiver.	-----	Assigned by TNM	-----
Dwelling units	The number of dwelling units represented by this receiver. TNM needs this value to compute the number of impacted and/or protected dwelling units, if you wish cost-effectiveness output.	-----	1	∃ 0
XYZ coordinates	Locates the receiver. The Z coordinate must be for the ground directly under the receiver, not for the receiver's ear height. TNM uses this Z coordinate to position the ground vertically as it computes sound propagation.	m, ft	0	-----
Height above ground	The height of the receiver's ear above the ground. TNM adds this to the receiver's Z coordinate (at the ground) to determine the receiver's ear height for computation.	m, ft	1.52, 5.00	∃ 0

Optional input for receivers. In addition to the required input, you may input several optional receiver properties. Table 20 describes these optional receiver properties.

Table 20. Optional input for receivers.

Property	Purpose	Units	Built-in Default	Constraints
Existing level	The baseline for judging sound-level increases at this receiver.	dBA	0.00	-----
Impact criterion level: L_{Aeq1h} , L_{dn} , or L_{den}	If the calculated sound level equals or exceeds this value, TNM tallies the receiver's dwelling units as "impacted." You must interpret the FHWA policy clause "approaches or exceeds" yourself, by entering the proper value here.	dBA	66	-----
Substantial increase	If the calculated increase over existing sound level equals or exceeds this value, TNM tallies the receiver's dwelling units as "impacted." You must interpret the FHWA policy clause "substantial increase" yourself, by entering the proper value here.	dB	10	∃ 5
Noise reduction goal	If your barrier design reduces the receiver's sound level by this amount or more, then TNM tallies the receiver's dwelling units as "benefited."	dB	8	∃ 5 # 23
Adjustment factors	TNM algebraically adds these decibel adjustments to its calculated sound levels. You can enter different adjustments for each receiver/roadway-segment pair.	dB	0	-----

Notes: TNM uses the same sound metric for its impact criterion as you choose for sound-level calculations: L_{Aeq1h} , L_{dn} , or L_{den}

B.3 Barriers

Input for a full barrier. Several barrier properties pertain to a full barrier. Table 21 describes these full-barrier properties.

Table 21. Input for a full barrier.

Property	Purpose and choices	Units	Built-in Default	Constraints
Barrier name	Identifies the barrier.	-----	Barrier <No.>	-----
Barrier type	Tells TNM this barrier's type, which affects its nearby topography and sound diffraction over its top. Choices: Wall, Berm.	-----	Wall	-----
Minimum height	Allows TNM to check perturbed barrier heights, to see if any are too low. TNM will find such improper barrier perturbations during its Input Check.	m, ft	0.00	∃ 0
Maximum height	Allows TNM to check perturbed barrier heights, to see if any are too high. TNM will find such improper barrier perturbations during its Input Check.	m, ft	30.48, 99.99	∃ 0 ∃ min
Wall: Cost	Allows TNM to compute wall-barrier costs.	\$/m ² , \$/ft ²	0.00	∃ 0
Berm: Cost	Allows TNM to compute berm-barrier costs.	\$/m ³ , \$/yd ³	0.00	∃ 0
Berm: Top width	Allows TNM to determine ground topography near berms.	m, ft	0	∃ 0
Berm: Run : rise	Allows TNM to determine ground topography near berms.	-----	2.00 : 1.00	both > 0
Additional cost	Supplements barrier costs if you determine that part of the cost is proportional to barrier length, rather than barrier area (or volume, for berms). Unit-length cost items might include engineering design, clearing and grubbing, and landscaping.	\$/m, \$/ft	0.00	∃ 0

Input for each barrier point. Barrier properties can vary from point to point along the barrier. Table 22 describes these barrier-point properties.

Table 22. Input for each barrier point.

Property	Purpose	Units	Built-in Default	Constraints
Point name	Identifies the barrier point and the segment that follows it.	-----	Point <No.>	-----
Point number	Also identifies the barrier point and the segment that follows it.	-----	Assigned by TNM	-----
XYZ coordinates	Locates the barrier point. The Z coordinate must be for the bottom of the barrier. This is often the ground Z but is sometimes the barrier-bottom Z, on structure.	m, ft	0	-----
Height (at point)	Sets the barrier point's input height. TNM perturbs barrier segments up and down relative to this input height.	m, ft	0.00	≥ 0

Input for each barrier segment. Finally, several properties pertain to each barrier segment. Table 23 describes these barrier-segment properties.

Table 23. Input for each barrier segment.

Property	Definition and purpose	Units	Built-in Default	Constraints
Perturbation increment	The segment's perturbation increment, up and down from the input heights of its two end points.	m, ft	0.00	≥ 0
# perturbations up	The number of perturbations up (no maximum number).	-----	0	≥ 0
# perturbations down	The number of perturbations down (no maximum number).	-----	0	≥ 0
On structure?	Tells TNM that this barrier segment is on structure and therefore that sound can pass under it. You must pair this barrier segment with roadway segments you wish it to shield.	-----	No	-----
Important reflections?	Important Reflections are not implemented in TNM Version 1.0.	-----	No	-----
Noise Reduction Coefficient (left side and right side)	Tells TNM the single-number rating of the sound absorption properties of a material. You can enter a different NRC for the two barrier sides, left and right.	dB	0.00	≥ 0.00 # 0.95

B.4 Building rows

Input for a full building row. Several building-row properties pertain to a full row of buildings. Table 24 describes these building-row properties.

Table 24. Input for a full building row.

Property	Purpose and choices	Units	Built-in Default	Constraints
Building-row name	Identifies the building row.	-----	Building Row <No.>	-----
Average height	Affects shielding due to the building row.	m, ft	0.00	∃ 0
Building percentage	Also affects shielding due to the building row.	%	0	∃ 20 # 80

Input for each building-row point. Other building-row properties can vary from point to point along the row. Table 25 describes these properties of building-row points.

Table 25. Input for each building-row point.

Property	Purpose	Units	Built-in Default	Constraints
Point number	Identifies the building-row point and the segment that follows it.	-----	Assigned by TNM	-----
XYZ coordinates	Locates the building-row point. The Z coordinate must be for the ground.	m, ft	0	-----

B.5 Terrain lines

Input for a full terrain line. Only one terrain-line property pertains to a full terrain line. Table 26 describes this property of a full terrain line.

Table 26. Input for a full terrain line.

Property	Purpose	Units	Built-in Default	Constraints
Terrain-line name	Identifies the terrain line.	-----	Terrain Line <No.>	-----

Input for each terrain-line point. Coordinates vary from point to point along a terrain line. Table 27 describes these coordinates.

Table 27. Input for each terrain-line point.

Property	Purpose	Units	Built-in Default	Constraints
XYZ coordinates	Locates the terrain-line point.	m, ft	0	-----

B.6 Ground zones

Input for a full ground zone. Several ground-zone properties pertain to a full zone. Table 28 describes these full-zone properties.

Table 28. Input for a full ground zone.

Property	Purpose and choices	Units	Built-in Default	Constraints
Ground-zone name	Identifies the ground zone.	-----	Ground Zone <No.>	-----
Type (of ground)	Specifies the type of ground within this zone. Outside of all ground zones, you enter ground type under Setup. Choices: See Table 30.	-----	Pavement	-----
Flow resistivity	Enables TNM to compute the ground's effect on propagation. TNM chooses this value for you, from your choice of ground type. However, if you choose "Custom" as your ground type, you must enter your own value for flow resistivity. See FHWA policy in Appendix A before entering flow resistivity for a custom ground type.	cgs rayls	0	∃ 20 # 30,000

Input for each ground-zone point. Coordinates vary from point to point along a ground zone. Table 29 describes these coordinates.

Table 29. Input for each ground-zone point.

Property	Purpose	Units	Built-in Default	Constraints
XY coordinates	Locates the ground-zone point in your Plan View. Ground-zone points do not have Z coordinates. Therefore, they do not help to locate the terrain vertically.	m, ft	0	-----

Ground-zone types: Table 30 summarizes each TNM built-in ground type.

Table 30. Ground-zone types.

Ground type	Description	Flow resistivity in cgs rayls
Pavement	Pavement of all types (acoustically, pavement and water are treated identically)	20,000
Water	Water or water-soaked ground (acoustically, pavement and water are treated identically)	20,000
Hard soil	Hard-packed soil, or dirt road	5,000
Loose soil	Loose soil, or gravel	500
Lawn	Residential-style lawn	300
Field grass	Field grass	150
Granular snow	Granular snow	40
Powder snow	Powder snow	10
Custom	----- You enter your own flow resistivity for custom ground type. See FHWA policy in Appendix A before using.	



Hard and soft ground. Use TNM’s Pavement ground type, if you would like to model a generic acoustically hard ground surface. Use TNM’s Field grass ground type, if you would like to model a generic acoustically soft ground surface.

B.7 Tree zones

Input for a full tree zone. Several tree-zone properties pertain to a full zone. Table 31 describes these properties of full tree zones.

Table 31. Input for a full tree zone.

Property	Purpose and choices	Units	Built-in Default	Constraints
Tree-zone name	Identifies the tree zone.	-----	Tree Zone <No.>	-----
Average height	Affects attenuation due to the tree zone. TNM attributes attenuation only for that part of the line-of-sight that actually penetrates the tree zone, not that portion that passes above it.	m, ft	0.00	≥ 0

Input for each tree-zone point. Coordinates vary from point to point along the perimeter of a tree zone. Table 32 describes these coordinates.

Table 32. Input for each tree-zone point.

Property	Purpose	Units	Built-in Default	Constraints
XYZ coordinates	Locates the tree-zone point. The Z coordinate must be for the ground.	m, ft	0	-----

B.8 Contour zones

Input for a full contour zone. Several contour-zone properties pertain to a full zone. Table 33 describes these properties of full contour zones.

Table 33. Input for a full contour zone.

Property	Purpose and choices	Units	Built-in Default	Constraints
Contour-zone name	Identifies the contour zone.	-----	Contour Zone <No.>	-----
Contour tolerance	Tells TNM your desired contour tolerance. TNM subdivides the contour grid to obtain this tolerance, but stops when grid size reduces to your Minimum Grid Spacing.	dB	1	∃ 1
Grid height (above the ground)	Tells TNM where to locate its contour grid and subgrid points, relative to the ground. TNM estimates ground elevations at all grid points by interpolating the Z coordinates of nearby input such as roadways, receivers, and so forth.	m, ft	1.52, 5.00	∃ 0
Minimum grid spacing	Tells TNM your desired minimum grid spacing.	m, ft	60.96, 200.00	∃ 0

Input for each contour-zone point. Coordinates vary from point to point along the perimeter of a contour zone. The following table describes these coordinates.

Table 34. Input for each contour-zone point

Property	Purpose	Units	Built-in Default	Constraints
XY coordinates	Locates the contour-zone point. Contour zones do not need a Z coordinate.	m, ft	0	-----

APPENDIX C INPUT-ERROR MESSAGES

C.1 Overview

TNM checks for unallowable input prior to calculating sound levels. During the input process you may also check for unallowable input by selecting Input, Input Check in the main menu. In brief:

- An input segment is not allowed to exactly duplicate another segment, except for combination wall/berm barriers;
- Most types of input segments are not allowed to intersect other segments or a receiver point. Where intersections are allowed, however, the point of intersection must define the Z coordinate of the ground without ambiguity, i.e., the Z coordinates associated with the intersecting points must be identical;
- Barriers are not allowed to perturb below the minimum barrier height;
- Barriers are not allowed to perturb above the maximum barrier height;
- Roadway grades are not allowed to exceed 20 percent; and
- Traffic vehicle percentages must add to 100 percent. Note: Roadways with no traffic is not considered an input error. Those roadways/roadway segments simply emit no sound, i.e., 0 dB.

The remainder of this appendix specifically lists each error message and describes what you must do to correct it. The error messages are ordered alphabetically by name.

C.2 Ambiguous point intersection

Some input points are ambiguous to TNM because they intersect in an unusual way with other objects.

Example: Ambiguous point intersection: Barrier I95 West Side::point15 and Roadway Spreen Street::point 4

In this example, “Barrier” is the type of offending object, “I95 West Side” is the offending object’s name, and “point15” is the *start point* of the offending segment -- and similarly for the intersecting segment.

To repair your input:

1. In the Plan view, either delete or move a point on the offending segment, to eliminate the intersection.
2. In the Plan View:
 - Subdivide the offending segment until two of its points just straddle the other segment. Subdivision produces properly interpolated Z coordinates for all the new points.
 - Delete the offending small portion of the newly subdivided segment.

C.3 Bad traffic percentage

For every vehicle type where a traffic speed has been entered, a traffic volume or percentage must also be entered. Also, traffic percentages for each column must add to 100 percent

Example: Bad traffic percentage: Roadway I95SB::point55

In this example, "Roadway" is the type of offending object, "I95SB" is the offending object's name, and "point55" is the *start point* of the offending segment.

To repair your input:

1. Correct traffic percentages for the offending roadway segment.

C.4 Bad traffic speed

For every vehicle type where a traffic volume or percentage has been entered, a traffic speed must also be entered.

Example: Bad traffic speed: Roadway I95SB::point55

In this example, "Roadway" is the type of offending object, "I95SB" is the offending object's name, and "point55" is the *start point* of the offending segment.

To repair your input:

1. Correct traffic speeds for the offending roadway segment.

C.5 Bad traffic volume

For every vehicle type where a traffic speed has been entered, a traffic volume or percentage must also be entered.

Example: Bad traffic: Roadway I95SB::point55

In this example, "Roadway" is the type of offending object, "I95SB" is the offending object's name, and "point55" is the *start point* of the offending segment.

To repair your input:

1. Correct traffic volumes for the offending roadway segment.

C.6 Barrier on structure and shielding list empty

When barriers are on structure, TNM requires that they shield at least one roadway segment.

Example: Barrier on structure, and shielding list empty:I95SB::point15

In this example, "I95SB" is the offending barrier's name and "point15" is the *start point* of the offending segment.

To repair your input:

1. Designate a roadway segment for that barrier segment to shield.

C.7 Berm segment on structure

Berms are not allowed to be on structure. For this reason, TNM does not contain a Structure Tab for berms. However, if you start with a wall barrier, designate it to be on structure, and then change the barrier type to "berm," the structure aspect of the barrier persists within TNM, even though not allowed. It persists to allow you to change the barrier type back to wall without losing the barrier's shielded-roadway information.

Example: Berm segment on structure:I95SB::point55

In this example, "I95SB" is the offending berm's name and "point55" is the *start point* of the offending segment.

To repair your input:

1. Change the barrier type to "wall."
2. Click the newly reappeared Structure Tab, and then uncheck the offending on-structure marks.
3. Change the barrier type back to "berm."

C.8 Degenerate segment

Segments of zero length are not allowed. Neither are perfectly vertical segments. Both zero-length and perfectly-vertical segments are called "degenerate." Because degenerate segments have zero length in the Plan View, you will have to select them through their input dialogs.

Example: Degenerate segment: Roadway I95NB::point18

In this example, "Roadway" is the type of offending object, "I95NB" is the object's name, and "point18" is the *start point* of the offending segment.

To repair your input:

1. In the relevant input dialog box, use the Name pull-down list to call up the offending full object.
2. Select its offending segment by clicking on its start point's row label (far left) in the spreadsheet. The segment's start point and endpoint (the next row) will have identical XY coordinates. That is the source of the error.
3. In the Plan View, select View, Center View by Item -- to bring the selected segment to the center of the screen.

4. If the offending segment's start point and endpoint have identical Z coordinates, then the segment has zero length. In this case:
 - In the Plan View, select Edit, Delete Start Point. This will eliminate the segment. *Or*, if the offending segment's start point and endpoint have different Z coordinates, then the segment is perfectly vertical. You must then be careful which point you delete, for one of the Z coordinates is correct and the other is not. If the start point's Z coordinate is not correct, then: In the Plan View, select Edit, Delete Start Point. On the other hand, if the endpoint's Z coordinate is not correct, then: In the Plan View, select Edit, Delete End Point.

C.9 Duplicate found (receiver)

Receivers with exactly the same ear positions are not allowed. Such receivers will have identical XY coordinates and the same value for Z + Height. Note that receivers may have the same XYZ coordinates as long as their heights differ. Because duplicate receivers lie exactly on top of each other in the Plan View, you will have to select them through their input dialogs.

Example: Duplicate found: Receiver 17 and Receiver 23

In this example, "Receiver" is the type of offending object and "17" is the offending object's number -- and similarly for the duplicate object.

To repair your input:

1. In the relevant input dialog box, use the Name pull-down list to call up the offending receiver.
 2. Change either the receiver's Z coordinate or its Height;
- or either move the receiver horizontally or delete it.
- In the Plan View, select View, Center View by Item -- to bring the selected receiver to the center of the screen.
 - Either move or delete the offending receiver.

C.10 Duplicate found (segment)

Exactly duplicate segments are not allowed. Duplicate segments will have identical XYZ coordinates at each of their two endpoints. Because duplicate segments lie exactly on top of each other in the Plan View, you will have to select them through their input dialogs.

Example: Duplicate found: Roadway I95NB::point18 and Roadway Harris Street::point 35

In this example, "Roadway" is the type of offending object, "I95NB" is the offending object's name, and "point18" is the *start point* of the offending segment -- and similarly for the duplicate segment.

To repair your input:

1. In the relevant input dialog box, use the Name pull-down list to call up either one of the offending full objects.

2. Select its offending segment by clicking on its start point's row label (far left) in the spreadsheet.
3. In the Plan View, select View, Center View by Item -- to bring the selected segment to the center of the screen.
4. If an entire object is a duplicate, then select the entire object and delete it;
or either delete the segment or move one of its endpoints.

C.11 Grade above limit

If you enter a wildly erroneous Z coordinate for a roadway point, you will produce very high roadway grades. To check for this type error, TNM computes the grades of all roadway segments and reports grades higher than 20 percent.

Example: Grade above limit: Roadway I95SB::point62

In this example, "Roadway" is the type of offending object, "I95SB" is the offending object's name, and "point62" is the *start point* of the offending segment.

To repair your input:

1. Repair the erroneous Z coordinate.

C.12 Illegal intersection (segments)

Most segment intersections are not allowed by TNM, because the resulting acoustics is impossible to calculate.

Example: Illegal intersection: Barrier I95 West Side::point15 and Roadway Spreen Street::point 4

In this example, "Barrier" is the type of offending object, "I95 West Side" is the offending object's name, and "point15" is the *start point* of the offending segment -- and similarly for the intersecting segment.

To repair your input:

1. In the Plan View, either delete or move a point on the offending segment, to eliminate the intersection.
2. In the Plan View:
 - # Subdivide the offending segment until two of its points just straddle the other segment. Subdivision produces properly interpolated Z coordinates for all the new points.
 - # Delete the offending small portion of the newly subdivided segment.



Gaps in barriers. If a roadway intersects a barrier, do not subdivide the barrier and thereby leave a gap in it. Subdivide the roadway, instead.

C.13 Illegal intersection (zones)

Most zones are not allowed to intersect or to touch other zones, even just a single point.

Example: Illegal intersection: Ground Zone Parking Lot and Ground Zone Barnegat Bay

In this example, “Ground Zone” is the type of offending zone and “Parking Lot” is the offending zone’s name.

To repair your input:

1. In the Plan View, either delete the offending zone or move a point on it, to eliminate the intersection.
2. Split the zone into two portions, so that the intersecting zone or segment can go through it without intersection. To split the zone into two parts, Part 1 and Part 2:
 - Digitize Part 1, while snapping the relevant points to the original zone's points.
 - Digitize Part 2 in the same manner.
 - Delete the original zone.

C.14 Inconsistent intersection

Some types of TNM segments are allowed to intersect others. However, they must have the same elevation (Z coordinate) where they intersect. Otherwise, the terrain would be ambiguous at the intersection. TNM does not compute Z coordinates at intersection points. Instead, you must insert another point on each intersecting segment and must snap the points together so that they have the same Z coordinates.

Example: Inconsistent intersection: Tree Zone West Acres with Terrain Line Terrain Line3::point 4

In the example, “Tree Zone” is the type of offending object and “West Acres” is the offending object’s name. For the intersecting segment, “Terrain Line” is the type of intersecting object, “Terrain Line3” is the intersecting object’s name, and “point4” is the *start point* of the intersecting segment.

To repair your input:

1. In the Plan View, subdivide one of the offending segments (Segment 1) into pieces. Subdivide Segment 1 into enough portions so that one of its new points is close to the offending intersection point. You will later snap to this properly positioned new point. Note that subdivision produces properly interpolated Z coordinates for all the new points.
2. Replace the other offending segment (Segment 2), as follows:
 - Set Segment 2 as the default object of its type. This guarantees that its parameters will flow down to the new object you will enter next.
 - Input a new three-point object that duplicates Segment 2, by snapping its three points to (1) Segment 2's start point, (2) the new subdivided point on Segment 1, and then (3) Segment 2's end point.

- Delete Segment 2.
- If desired, combine the new object at its two ends to the original object of which it was once part.

C.15 Invalid Segment Height

Your barrier input height must lie between the barrier's minimum and maximum heights.

Example: Invalid Segment Height: Barrier I95SB::point55

In this example, "Barrier" is the type of offending object, "I95SB" is the offending object's name, and "point55" is the *start point* of the offending segment.

To repair your input:

1. Change one of the following for the offending barrier segment: Height, Minimum Height, or Maximum Height.

C.16 Perturbation too high

Barriers are not allowed to perturb above the barrier's maximum height.

Example: Perturbation too high: Barrier I95SB:point6 Max # up = 6

In this example, "Barrier" is the type of offending object, "I95SB" is the offending object's name, "point6" is the *start point* of the offending segment, and "Max # up = 6" is the maximum permissible number of upward perturbations.

To repair your input:

1. Change the number of upward perturbations. The error message tells you how many are allowed without perturbing above the barrier's maximum height.

C.17 Perturbation too low

Barriers are not allowed to perturb below the barrier's minimum height. Note: For combination barriers, this error occurs when the user tries to perturb the wall barrier portion below the top of the berm portion.

Example: Perturbation too low: Barrier I95SB:point6 Max # down = 3

In this example, "Barrier" is the type of offending object, "I95SB" is the offending object's name, "point6" is the *start point* of the offending segment, and "Max # down = 3" is the maximum permissible number of downward perturbations for the wall barrier portion of the combination barrier.

To repair your input:

1. Change the number of downward perturbations. The error message tells you how many are allowed.

C.18 Receiver inside surface horizontal extents

In a Parallel Barrier analysis, analysis locations (receivers) should not be placed within the horizontal extents defined by the cross section (surface).

Example: PReceiver20 inside surface horizontal extents

In this example, "PReceiver" is the type of offending object and "PReceiver20" is the offending object's name.

To repair your input:

1. In the Plan View, either delete the offending object;
- or
- change it's coordinates such that it lies outside the horizontal extents defined by the cross section surface.

C.19 Receiver Too Close

Receivers are not allowed to intersect a roadway, taking into account the roadway's width. Note: A roadway's coordinates are defined at the center of the roadway, thus, this error will occur whenever a receiver is within $\frac{1}{2}$ the width distance from a roadway, e.g., a receiver cannot be located within 3 m of a 6-m wide roadway.

Example: Receiver R1 and Roadway I95SB must be more than 3.7 m away.

In this example, "Receiver" is the type of offending object, "R1" is the offending object's name, Roadway I95SB is the place of illegal intersection, and 3.7 is $\frac{1}{2}$ the roadway's width.

To repair your input:

1. Change the receiver's coordinates to a distance at least $\frac{1}{2}$ the roadway width;
- or
- decrease the roadway's width.

C.20 Roadway outside surface horizontal extents

In a Parallel Barrier analysis, roadways (sources) should not be placed outside the horizontal extents defined by the cross section (surface).

Example: Source I95SB outside surface horizontal extents

In this example, "Source" (roadway) is the type of offending object and "I95SB" is the offending object's name.

To repair your input:

1. In the Plan View, either delete the offending object;
or change it's coordinates such that it lies inside the horizontal extents defined by the cross section surface.

C.21 Self intersection (zones)

Zones are not allowed to loop back and intersect themselves.

Example: Self intersection: Ground Zone Parking Lot

In this example, "Ground Zone" is the type of offending zone and "Parking Lot" is the offending zone's name.

To repair your input:

1. Split the zone into two parts, to eliminate its self intersection:
 - Digitize Part 1 while snapping the relevant points to the original zone's points.
 - Digitize Part 2 in the same manner.
 - Delete the original zone.

C.22 Too many errors

TNM can only remember a limited number of input errors at the same time.

Example: Too many errors

To learn about any remaining errors:

1. Repair the errors that TNM told you about.
2. Rerun the input check, by clicking **Input**, **Input Check** in the main menu.

C.23 Too many receivers in design

In a Parallel Barrier analysis design, TNM allows a maximum of 25 receivers (analysis locations).

Example: Too many receivers in design: Can only have a maximum of 25

To repair your input:

1. Delete receivers (analysis locations) until no more than 25 remain.

APPENDIX D COMPARISON OF TNM WITH STAMINA 2.0/OPTIMA

This appendix compares TNM with FHWA's prior computer programs for highway traffic noise: STAMINA 2.0/OPTIMA.

D.1 General comparison

Similarities and differences: Like STAMINA 2.0/OPTIMA, TNM computes sound levels for all possible combinations of barrier heights (with more perturbations than STAMINA 2.0/OPTIMA) and then stores its partial results for later use. Like STAMINA 2.0/OPTIMA, TNM uses these partial results to determine sound levels for specific barrier designs: one height per barrier segment.

TNM differs from STAMINA 2.0/OPTIMA in other ways, however. First, TNM runs under Microsoft® Windows instead of simply under the DOS operating system. Under Microsoft® Windows, you control TNM with pull-down menus and the mouse. Under Microsoft® Windows, you may easily display and print out many graphical and tabular views of your input. In addition, you may digitize coordinates and may import DXF files from CAD programs.

Emission levels and calculations: Internally, TNM includes newly measured noise emissions, in 1/3rd-octave bands, separately for two subsource heights. In addition to STAMINA 2.0/OPTIMA's automobiles, medium trucks and heavy trucks, TNM has built-in emissions for two additional vehicle types:

- Buses; and
- Motorcycles.

In addition, TNM's revised calculation algorithms, in 1/3rd-octave bands, are more precise than those of STAMINA 2.0/OPTIMA. TNM also computes L_{dn} and L_{den} (day-night average sound level and Community Noise Exposure Level) if you input traffic for the required times of day. It does not compute L_{10} , however. In addition to STAMINA 2.0/OPTIMA capabilities, TNM also calculates:

- Speed and sound-level changes due to upgrades and traffic-control devices, thereby replacing NCHRP Report 311;¹⁷
- Additional ground types;
- Multiple barriers in sequence between sources and receivers;
- Increased attenuation over acoustically absorptive berms;
- Attenuation over/through rows of buildings;
- Attenuation through heavy woods;
- Shielding by intervening roadways that block the line-of-sight between a source roadway and a receiver;

- Increases in sound level due to reflections between parallel barriers that flank the roadway; and
- Three types of contours: sound levels, noise reduction, i.e., barrier insertion loss, and sound-level differences between any two barrier designs.

D.2 Comparison of specific input types

TNM has eight input types, compared with five types in STAMINA 2.0/OPTIMA. Table 35 lists the five STAMINA 2.0/OPTIMA input types and matches them to their comparable TNM input.

Table 35. Comparison of input types: TNM with STAMINA 2.0/OPTIMA.

STAMINA 2.0/OPTIMA input	Comparable TNM input
Roadways	Same, but TNM traffic can include other times of day, for computation of L_{dn} or L_{den} .
Receivers	Same.
Barriers	Same, but TNM barriers include berms as well as walls.
Alpha Factors	Alpha Factors are completely gone from TNM. Instead, TNM computes ground effects from: <ul style="list-style-type: none"> ▪ Ground Zones, which show the type of intervening ground; and ▪ Terrain Lines, which locate the ground vertically.
Shielding Factors	Shielding Factors are often not needed, because TNM computes explicitly for: <ul style="list-style-type: none"> ▪ Intervening Building Rows; and ▪ Intervening Tree Zones. ▪ In addition, TNM includes: ▪ Adjustment Factors.

In addition, TNM has no limits on the numbers of input objects you may enter, of any type, or on the number of segments that a single input object can have.

Roadways: TNM roadways have the following properties beyond those of STAMINA 2.0/OPTIMA roadways:

- Width;
- Traffic-control devices for accelerating traffic; and
- Pavement type.

In contrast to STAMINA 2.0/OPTIMA, intervening TNM roadways can also shield receivers from other roadways, or can be on structure so that other roadway sound passes under them, unshielded.

Receivers: TNM receivers have the following characteristics beyond those of STAMINA 2.0/OPTIMA receivers:

- Number of dwelling units represented;

- Height above the ground; and
- Input sound levels and criteria: The existing sound level, an impact criterion for L_{Aeq1h} , an impact criterion for increase over existing noise levels, and a noise-reduction goal.

Barriers: TNM barriers have the following properties beyond those of STAMINA 2.0/OPTIMA barriers:

- Type: Berm, in addition to vertical wall;
- Berms: Top width and side slope;
- Minimum and maximum height; and
- Unit costs.

Also in contrast to STAMINA 2.0/OPTIMA, you can tell TNM about the sound absorption properties of a barrier's material by assigning noise reduction coefficients.

Building rows: STAMINA 2.0/OPTIMA does not have building rows. Within STAMINA 2.0/OPTIMA you independently estimate the shielding due to rows of buildings, between every roadway/receiver pair, and then you enter these estimates as shielding factors. TNM computes building-row shielding for you.

Terrain lines: STAMINA 2.0/OPTIMA does not have terrain lines. Instead of terrain lines that protrude through lines-of-sight, within STAMINA 2.0/OPTIMA you use "terrain barriers" to approximate hillsides, edges of cuts, and so forth. Instead of terrain lines that lie below lines-of-sight, within STAMINA 2.0/OPTIMA you use "alpha" factors to compute the effect of the ground. TNM terrain lines substitute for both "terrain barriers" and "alpha" factors. Combined with ground zones, terrain lines determine the propagation effects of intervening ground, protruding or not.

Ground zones: STAMINA 2.0/OPTIMA does not have ground zones. Instead, within STAMINA 2.0/OPTIMA you use "alpha" factors to compute the effect of the ground. Combined with terrain lines, TNM ground zones determine the propagation effects of intervening ground.

Tree zones: STAMINA 2.0/OPTIMA does not have tree zones. Within STAMINA 2.0/OPTIMA you independently estimate the shielding due to trees, between every roadway/receiver pair, and then enter these estimates as shielding factors. TNM computes shielding due to intervening trees for you.

APPENDIX E

CERTIFIED OUTPUT FOR THE OFFICIAL TNM TEST CASE

This appendix contains the certified output for the official TNM test case. Input for this test case is automatically installed with TNM. To open, calculate, and view the results of the official TNM test case, complete the following procedures:

1. Create a new run (see also Section 4.2):
 - In the File menu, select New.
 - Choose a directory to save this run and enter a desired run name.
2. Import the STAMINA 2.0 input file, *STAMINA.DAT*, included in your TNM package (see also Section 4.7.1):
 - In the File menu, select Import, then select Import Stamina-2.0 input file.
 - Go to *C:\[your TNM directory]\EXAMPLES\RESULTS* by clicking on the appropriate directories and subdirectories.
 - Highlight the *STAMINA.DAT* file, then click on the OK button. The resultant plan view with the imported file should look like Figure 74.

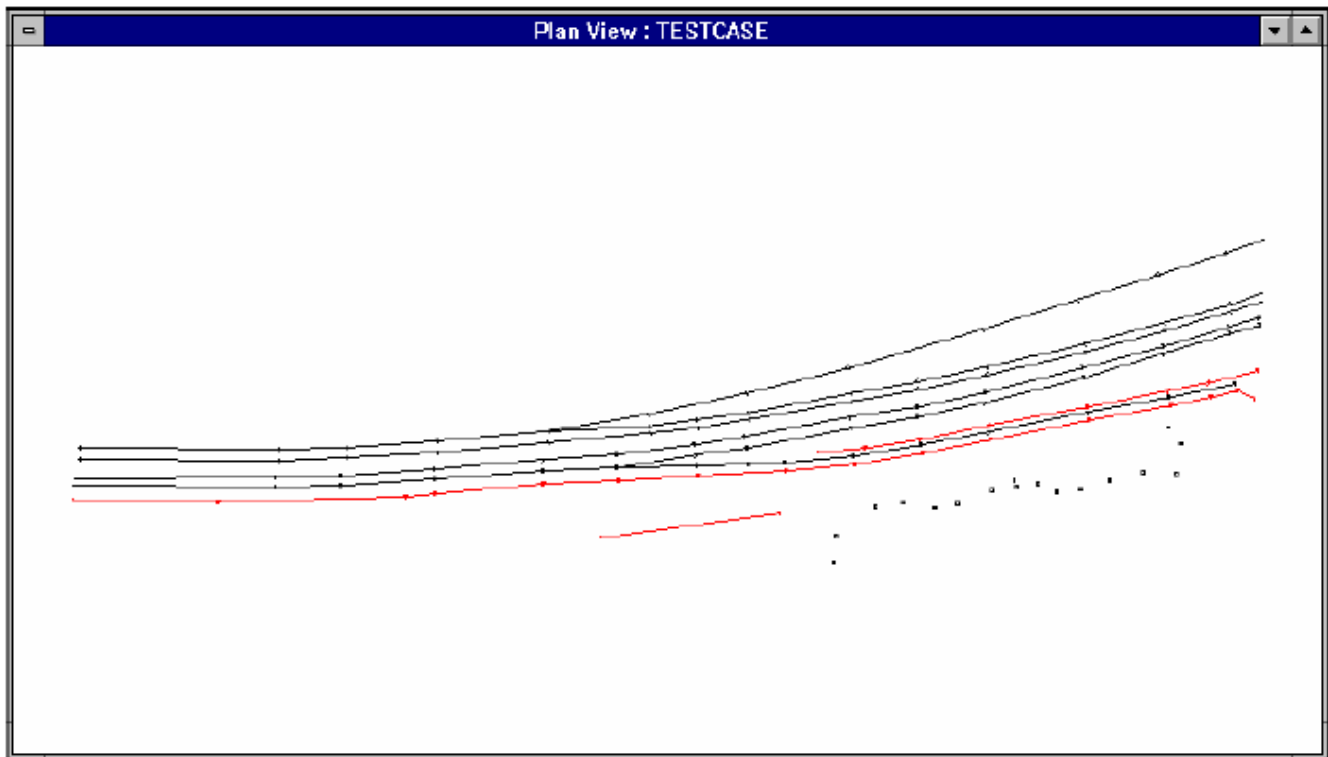


Figure 74. Resultant plan view of official TNM test case.

3. Save your run (see also Section 4.4) by selecting Save in the File menu.
4. Perform calculations (see also Section 9) by selecting Sound Levels in the Calculate menu.

- Open, view, and compare your sound level results table with the results table shown below (see Figure 75). The results in your table must match with those in the figure shown below. If they do not, re-install TNM (see Section 1.4) and repeat the above procedures or contact technical support (see Section 1.8).

<Organization?>										Date			
<Analysis By?>										Version			
RESULTS: SOUND LEVELS													
PROJECT/CONTRACT: <Project Name?>													
RUN: C:\TNM.NT\EXAMPLES\TESTCASE													
BARRIER DESIGN: INPUT HEIGHTS										Average pavement type shall be used unless a State highway agency substantiates the use of a different type with approval of FHWA.			
ATMOSPHERICS: 20 deg C, 50% RH													
Receiver													
Name													
	No.	#DUs	Exleting LAeq1h	No Barrier			Increase over existing		Type Impact	With Barrier			
				LAeq1h	Crit'n		Calculated	Crit'n Sub'l Inc		Calculated LAeq1h	Noise Reduction		Calculated minus Goal
			dBA	dBA	dBA		dB	dB		dBA	dB	dB	dB
A-1	1	1	0.0	68.3	66		66.3	10	Snd Lvl	58.2	10.1	8	2.1
A-2	2	1	0.0	71.0	66		71.0	10	Snd Lvl	60.4	10.6	8	2.6
B-1	3	1	0.0	70.7	66		70.7	10	Snd Lvl	59.8	10.9	8	2.9
B-2	4	1	0.0	72.7	66		72.7	10	Snd Lvl	62.3	10.4	8	2.4
C-1	5	1	0.0	72.3	66		72.3	10	Snd Lvl	61.4	10.9	8	2.9
C-2	6	1	0.0	74.8	66		74.8	10	Snd Lvl	64.2	10.6	8	2.6
D-1	7	1	0.0	71.9	66		71.9	10	Snd Lvl	61.3	10.6	8	2.6
D-2	8	1	0.0	74.6	66		74.6	10	Snd Lvl	64.0	10.6	8	2.6
E-1	9	1	0.0	72.4	66		72.4	10	Snd Lvl	60.9	11.5	8	3.5
E-2	10	1	0.0	73.8	66		73.8	10	Snd Lvl	63.8	10.0	8	2.0
F-1	11	1	0.0	72.4	66		72.4	10	Snd Lvl	60.9	11.5	8	3.5
F-2	12	1	0.0	74.0	66		74.0	10	Snd Lvl	63.8	10.2	8	2.2
G-1	13	1	0.0	73.7	66		73.7	10	Snd Lvl	61.4	12.3	8	4.3
G-2	14	1	0.0	74.7	66		74.7	10	Snd Lvl	64.7	10.0	8	2.0
19aE-1	15	1	0.0	74.4	66		74.4	10	Snd Lvl	61.7	12.7	8	4.7
H-1	16	1	0.0	73.4	66		73.4	10	Snd Lvl	61.3	12.1	8	4.1
H-2	17	1	0.0	74.5	66		74.5	10	Snd Lvl	64.7	9.8	8	1.8
I-1	18	1	0.0	73.4	66		73.4	10	Snd Lvl	61.1	12.3	8	4.3
I-2	19	1	0.0	74.2	66		74.2	10	Snd Lvl	64.5	9.7	8	1.7
J-1	20	1	0.0	71.9	66		71.9	10	Snd Lvl	60.4	11.5	8	3.5
J-2	21	1	0.0	73.1	66		73.1	10	Snd Lvl	63.3	9.8	8	1.8
K-1	22	1	0.0	71.4	66		71.4	10	Snd Lvl	60.1	11.3	8	3.3
K-2	23	1	0.0	72.7	66		72.7	10	Snd Lvl	62.9	9.8	8	1.8
L-1	24	1	0.0	71.1	66		71.1	10	Snd Lvl	59.9	11.2	8	3.2
L-2	25	1	0.0	72.6	66		72.6	10	Snd Lvl	62.8	9.8	8	1.8
M-1	26	1	0.0	70.5	66		70.5	10	Snd Lvl	59.6	10.9	8	2.9
M-2	27	1	0.0	72.3	66		72.3	10	Snd Lvl	62.4	9.9	8	1.9
19aE-2	28	1	0.0	73.8	66		73.8	10	Snd Lvl	61.1	12.7	8	4.7
N-1	29	1	0.0	69.1	66		69.1	10	Snd Lvl	59.1	10.0	8	2.0
N-2	30	1	0.0	71.3	66		71.3	10	Snd Lvl	61.8	9.5	8	1.5
O-1	31	1	0.0	72.2	66		72.2	10	Snd Lvl	60.5	11.7	8	3.7
O-2	32	1	0.0	74.2	66		74.2	10	Snd Lvl	64.1	10.1	8	2.1
Dwelling Units		# DUs	Noise Reduction										
			Min	Avg	Max								
			dB	dB	dB								
All Selected		32	9.5	10.8	12.7								
All Impacted		32	9.5	10.8	12.7								
All that meet NR Goal		32	9.5	10.8	12.7								

Figure 75. Sound level results table for official TNM test case.

APPENDIX F

REMEL DATA BASE

The FHWA Traffic Noise Model (TNM) computes a noise level through a series of adjustments to a reference sound level. The reference sound level is found in the REMEL data base.

The REMEL Data Base was developed by the U.S. Department of Transportation, Research and Special Programs Administration, John A. Volpe National Transportation Systems Center, Acoustics Facility (Volpe Center), in support of the FHWA, Office of Environment and Planning and Office of Engineering and Highway Operations Research and Development, and a 25-State National Pooled-Fund Study, titled: "Highway Noise Model Data Base Development."

The REMEL data base is an entirely new data base of vehicle noise emission levels that resulted from 1994/1995 measurements of over 6000 vehicle pass-bys events. These events include constant-flow REMEL data, interrupted-flow REMEL data, and subsource-height data measured in 9 states across the country.

Specifically, constant-flow measurements were performed by the Volpe Center, with the assistance of the Maryland State Highway Administration (MSHA), at 40 sites in California, Connecticut, Florida, Kentucky, Maryland, Massachusetts, New Jersey, Michigan, and Tennessee. Measurements were made at 7.5-, 15-, and 30-m offset positions from the centerline of the near travel lane. Data for constant vehicle speeds between 10 and 70 mph were obtained, as well as data for idling vehicles. The constant-flow data help correct many of the limitations of STAMINA 2.0/OPTIMA, such as limited speed ranges, vehicle types, and the inability to account for vehicles on grade.

Interrupted-flow measurements were performed by the Volpe Center, with the assistance of MSHA, Vanderbilt University, the University of Central Florida, and Ohio University, at 5 sites in Florida, Kentucky, and Tennessee. Measurements were made at a 15-m offset position from the centerline of the near travel lane. Data were collected as vehicles accelerated to, and decelerated from constant speeds at various points along the roadway, typically 15, 30, 60, 120, 240, 300, and 400 m from the stop line, i.e., toll booth, stop sign, or similar vehicle idling position. The interrupted-flow data facilitate the modeling of traffic at various traffic-control devices, such as toll booths, traffic lights, and highway ramps, by allowing the development of a relationship between interrupted-flow data and the corresponding constant-flow data.

Lastly, one-third octave-band subsource-height measurements were performed by Florida Atlantic University under the direction of FHWA, Florida DOT, and the Volpe Center. Measurements were performed for the same conditions represented by the constant- and interrupted-flow measurements. The subsource-height data allowed for a percent-energy apportioning of the constant-flow noise levels to fractional noise representative of typical vehicle noise subsources, i.e., engine/exhaust noise and tire/pavement noise.

The REMEL data and related subsource-height data were used to develop the regression equations of sound level versus speed versus frequency versus subsource-height required for TNM. The general

form of the regression equations differs from that used by STAMINA 2.0/OPTIMA in that it contains not only a "tire/pavement noise" component that increases with vehicle speed (similar to STAMINA 2.0/OPTIMA), but also an "engine/exhaust noise" component that is independent of vehicle speed. Baseline regression equations were developed for automobiles (A), medium trucks (MT), heavy trucks (HT), buses (B), and motorcycles (MC). The resultant curves are presented in Figure 76. Baseline conditions refer to dense-graded asphaltic concrete (DGAC) and Portland cement concrete (PCC) pavements combined (referred to as "Average" pavement in this User's Guide), level-graded roadways, and constant-flow traffic.

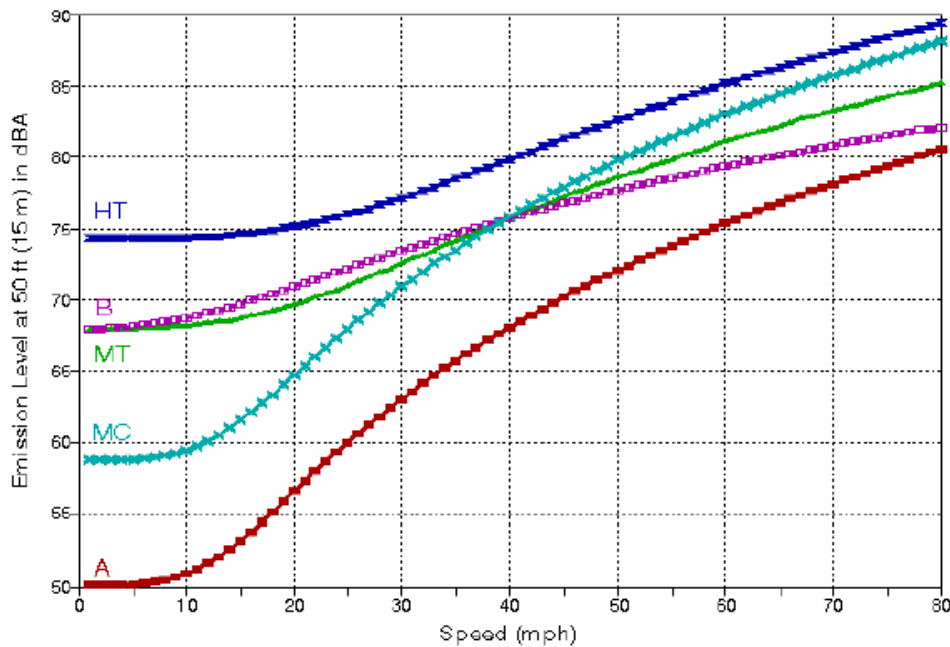


Figure 76. Emission level comparison.

To account for specific pavement types, grade conditions, and interrupted-flow traffic, similar regression equations were developed by applying adjustments to the "tire/pavement noise" component and/or the "engine/exhaust noise" component of the above baseline regression curves.

The general REMEL equation, expressed as a function of vehicle speed (mph) and frequency (Hz), is defined as follows:

$$\begin{aligned}
 L_E(s,f) = & 10 \cdot \log_{10} [10^{(C+E_c)/10} + (s^{A/10})(10^{(B+E_b)/10})] \\
 & - (K_1+K_2 \cdot s) + D_1+D_2 \cdot s + (E_1+E_2 \cdot s) \log_{10} f \\
 & + (F_1+F_2 \cdot s)(\log_{10} f)^2 + (G_1+G_2 \cdot s)(\log_{10} f)^3 \\
 & + (H_1+H_2 \cdot s)(\log_{10} f)^4 + (I_1+I_2 \cdot s)(\log_{10} f)^5 \\
 & + (J_1+J_2 \cdot s)(\log_{10} f)^6
 \end{aligned}$$

where: A is the slope of the tire/pavement-noise portion of the regression curve;

$B + \Delta E_b$ is the height of the tire/pavement-noise portion of the regression curve;
 $C + \Delta E_c$ is the height of the engine/exhaust-noise portion of the regression curve;
 D1 through J2 are for the sixth-order polynomial fit through the one-third octave-band spectral data as a function of speed; and
 K1 and K2 calibrate the A-levels resulting from the sixth-order polynomial fit, such that they are essentially equal to the A-levels from the A-level REMEL equations expressed independent of frequency, i.e., $L_E(s)$ instead of $L_E(s,f)$.

Finally, to apportion REMELs to fractional noise levels representative of the "tire/pavement" and "engine/exhaust" subsources, one-third octave-band subsource-height adjustments were applied to all regression equations.

The general subsource-height-ratio equation, expressed as a function of frequency, is defined as follows:

$$\text{Subsource-height-ratio (f)} = L + [1-L-M][1 + e^{[(N \log f) + P]}]^Q$$

where: L is the subsource-height ratio at low frequencies;

1-M is the subsource-height ratio at high frequencies; and

N, P, and Q control the exponential transition which occurs at the mid-frequencies.

In total, the regression equations developed for TNM are as follows:

- 10 subsource, one-third octave-band, average-pavement (data from both DGAC and PCC pavements combined) regressions for constant-flow vehicles on level grade;
- 24 subsource, one-third octave-band, specific-pavement (representing data from three pavement types: DGAC, PCC, and open-graded asphaltic concrete (OGAC)) regressions for constant-flow vehicles on level grade;
- 2 subsource, one-third octave-band, grade/interrupted-flow adjustment regressions (heavy trucks); and
- 8 subsource, one-third octave-band, adjustment regressions for interrupted-flow vehicles (autos, medium trucks, buses, and motorcycles).

These regressions exist in TNM as a matrix of coefficients expressed as a function of vehicle type, vehicle speed, one-third octave-band frequency, pavement type, roadway grade condition, traffic-flow condition, and vehicle subsource height. The coefficients have been integrated into the Data Base of TNM and are used for computing sound levels in the vicinity of a roadway, and for designing noise barriers. It is important to note that this relatively complex matrix is transparent to the TNM user.

The measurements, analysis and results are documented in more detail in the Volpe Center Final Report, "Development of the Reference Energy Mean Emission Level Data Base for the FHWA Traffic Noise Model (FHWA TNM[®]), Version 1.0."² Supplemental documentation includes References 4 and 5.

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FEDERAL HIGHWAY ADMINISTRATION TRAFFIC NOISE MODEL (FHWA TNM®)

VERSION 1.0
January 1998

The Federal Highway Administration (FHWA) is pleased to announce the release of the Traffic Noise Model, Version 1.0 (FHWA TNM). The FHWA TNM is an entirely new, state-of-the-art computer program used for predicting noise impacts in the vicinity of highways. It uses advances in personal computer hardware and software to improve upon the accuracy and ease of modeling highway noise, including the design of effective, cost-efficient highway noise barriers.

The FHWA TNM contains the following components:

- Modeling of five standard vehicle types, including automobiles, medium trucks, heavy trucks, buses, and motorcycles, as well as user-defined vehicles.
- Modeling of both constant-flow and interrupted-flow traffic using a 1994/1995 field-measured data base.
- Modeling of the effects of different pavement types, as well as the effects of graded roadways.
- Sound level computations based on a one-third octave-band data base and algorithms.
- Graphically-interactive noise barrier design and optimization.
- Attenuation over/through rows of buildings and dense vegetation.
- Multiple diffraction analysis.
- Parallel barrier analysis.
- Contour analysis, including sound level contours, barrier insertion loss contours, and sound-level difference contours.

These components are supported by a scientifically-founded and experimentally-calibrated acoustic computation methodology, as well as an entirely new, and more flexible data base, as compared with that of its predecessor, STAMINA 2.0/OPTIMA. The Data Base is made up of over 6000 individual pass-by events measured at forty sites across the country. It is the primary building block around which the acoustic algorithms are structured.

The most visible difference between the FHWA TNM and STAMINA 2.0/OPTIMA, is TNM's Microsoft® Windows interface. Data input is menu-driven using a digitizer, mouse, and/or keyboard. Users also have the ability to import STAMINA 2.0/OPTIMA files, as well as roadway design files

saved in CAD, DXF format. Color graphics will play a central role in both case construction and visual analysis of results.

Computer Requirements

The recommended computer system requirements for TNM Version 1.0 are:

- Computer: IBM-compatible PC;
- Processor: 120 MHz Pentium (or faster);
- Memory: 32 MB (or more);
- Disk Drive: 3.5 inch, 1.44 MB;
- Mouse input device;
- Monitor: Accelerated Super VGA (1024 x 768), 16 colors, configured with “small” fonts;
- Software: Microsoft® Windows 3.1 (or later): Note: TNM will run under Microsoft® Windows 95 or Windows NT, however, TNM is a 16-bit program and will not take full advantage of the 32-bit architecture associated with Windows 95 or NT.
- 10 MB of hard-disk space for the TNM system (including sample runs); and
- Up to 1 MB of hard-disk space for each TNM run.

- To digitize coordinates from plan sheets and roadway profiles, the following is required:
- Digitizer: Any manufacturer/model that meets the LCS/Telegraphics Wintab Interface Specification, preferably with a 16-button puck. The digitizer manufacturer should provide the file WINTAB.DLL, which must be resident on the hard disk for digitizer use.

The FHWA TNM Package: The FHWA TNM package includes the following:

- Two TNM manuals: This User's Guide and the TNM Technical Manual (Note: The User's Guide and Technical Manual may be photocopied. See below for information on how to order additional copies of either document.);
- The FHWA TNM software on three 3½" diskettes;
- One CD-ROM with the “TNM Trainer” tutorial; and
- The TNM registration card located on the last page of this User's Guide. Please fill out and return this card. Registered owners are entitled to receive technical support (see Section 1.8) and information on upgrades and supplementary guides.

Copyright: FHWA TNM is a registered copyright.

Trademark: FHWA TNM is a registered trademark.

Availability: The FHWA will distribute TNM Version 1.0 free of cost to every State Department of Transportation (DOT). All State DOTs may make sufficient copies of the TNM package for internal use only. For all other users, TNM will be distributed by the McTrans Center at the University of Florida. Non-State DOT users have three McTrans licensing options for the FHWA TNM: (1) they

may purchase a single license, which is valid for a distinct address (or site); (2) they may purchase an unlimited agency license, which is valid for multiple addresses (or sites) within the same organization; or (3) they may purchase a license for training or educational purposes. A McTrans order form is attached. Purchase the FHWA TNM by selecting from the following McTrans product ordering numbers:

<u>Product No.</u>	<u>Description</u>	<u>Cost</u>
TNM.WIN	FHWA TNM (for single site license):	\$695.00
TNM.AL	FHWA TNM (for unlimited agency license):	\$2750.00
TNM.TC	FHWA TNM (for training/educational license):	\$2750.00
TNM.D	FHWA TNM User's Guide:	\$20.00
TNM.DS	FHWA TNM Technical Manual:	\$20.00

Further information on TNM can be found on the McTrans website (<http://www-mctrans.ce.ufl.edu>).

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