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Minnesota Department of Transportation

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September 30, 2004

U.S. Department of Transportation
Dockets Management Facility
Room PL-401
400 Seventh Street S.W.
Washington, D.C. 20590-0001

Subject: FHWA Docket No. FHWA-2004-18309 -6 RIN 2125-AF03
Comments on NPRM 23 CFR Part 772

To Whom It May Concern:

Thank you for the opportunity to comment on Docket No. FHWA-2004-18309. The Minnesota Department of Transportation (Mn/DOT) offers the following comments:

1. **Transportation Noise Model (TNM) Methodology/Accuracy:** Mn/DOT currently uses the Stamina 2.0 based MINNOISE Version 0.2 noise prediction model. We have conducted a comparison of the MINNOISE Model and TNM 2.5. The assessment compared measured noise levels with modeled noise level predictions. Our findings were submitted to Cheryl Martin, FHWA, David Graeber, FHWA, Brian Timerson, Minnesota Pollution Control Agency (MPCA), and Gregg Fleming, Volpe Center, on August 26, 2004 in a report entitled, "Mn/DOT Noise Model Comparison Summary", (see attached document). In summary, MINNOISE generally proved more accurate than TNM 2.5. Mn/DOT feels that the TNM 2.5 error results are too large, compared to the MINNOISE errors, to justify using the TNM 2.5 model in assessing, designing, and if necessary, denying noise mitigation to residents, who assume Mn/DOT is using the most accurate information available. Clarification is also needed as to what source emission levels are used in TNM 2.5.

2. **Relationship to State Standards/Federalism:** Minnesota has its own State Noise Standards as per Minnesota Rules Chapter 7030. Minnesota noise standards use L_{10} and L_{50} descriptors which are not addressed withTNM's L_{eq} descriptor results. Therefore, the mandatory use of TNM 2.5 will create a financial and legal hardship for the State in our effort to protect the public health and welfare, by upholding and enforcing Minnesota Rule Chapter 7030 as directed by the State's regulatory agency, the MPCA. Using the TNM 2.5 model to address Federal requirements and the MINNOISE model to address State requirements will lead to misunderstandings and questions regarding the interpretation of the model results. Also, there is the concern that the use of two

noise descriptors will be in violation of 23 C.F.R. 772. Mn/DOT feels that the MINNOISE model is "consistent with the methodology of the FHWA TNM,"[1] and that the MINNOISE model should be approved for use by the State of Minnesota.

We want to reiterate our position that Mn/DOT is confident in the accuracy of the MINNOISE model for assessing transportation related noise impacts and the effectiveness of noise mitigation. Mn/DOT believes that the MINNOISE model should be approved by FHWA for use by the State of Minnesota as the traffic noise prediction method to be used in highway traffic noise analyses.

Sincerely,

Richard Elasky, Director
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Phone: 651-284-3751

Enclosure

CC: Representative James Oberstar, w/enclosure
Carol Molnau, Minnesota Lt. Governor/Commissioner of Transportation
Douglas H. Differt, Deputy Commissioner/Chief Engineer, Mn/DOT
Richard A. Stehr, Division Director, Mn/DOT
Patrick Hughes, Metro District Engineer, Mn/DOT
Sheryl Corrigan, Minnesota Pollution Control Agency, Commissioner

[1]Department of Transportation, Federal Highway Administration 23 CFR Part 772, [FHWA Docket No. FHWA-2004-18309], Rin 2125-AF03, Procedures for Abatement of Highway Traffic Noise and Construction Noise, Summary.

STATE OF MINNESOTA
ENVIRONMENTAL MODELING AND TESTING UNIT

Date: August 26, 2004

To: Summary Reader

From: Mel Roseen
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Phone: (612)725-2373

Subject: Noise Model Comparison

Attached is a noise model comparison entitled "Mn/DOT Noise Model Comparison Summary". The comparison is of Mn/DOT's present noise model MINNOISE and the FHWA's proposed model TNM 2.5. The results summarize differences between modeled and measured noise levels. The descriptor used throughout the comparison summary is the L_{eqh} (hourly equivalent noise level).

The comparison was prompted by Mn/DOT's desire to be assured that the most accurate results are being used in evaluating a roadside resident's noise environment and in the proposing or denying of noise mitigation.

Those readers interested in obtaining measured level data, counted traffic data and the vehicle classification data in electronic format can do so by sending an E-mail with the request to melvin.roseen@dot.state.mn.us.

Complying with requests for analysis and attendant results will be done at the discretion of Mn/DOT.

Mn/DOT

Noise Model Comparison

Summary

Conclusions:

Looking at the results of the comparison of the two noise models (MINNOISE and TNM 2.5) it appears that in order to supplant the present model (MINNOISE) with the Federal Highway Administration (FHWA) model TNM 2.5 Mn/DOT would need to abrogate a tacit understanding with the roadside resident that assessing, designing, and if necessary, denying noise mitigation is based on using the most accurate information available. While the comparison is based on a straight forward approach; measure and count, model and compare, it shows that the errors in the TNM 2.5 results are too large, when compared to the MINNOISE errors, to allow facilitating a convenient agreement with the FHWA to supplant the model now in use.

Clarification is needed as to what source emission levels are in use in TNM 2.5. Are they the source emission levels given in "FHWA-PD-96-008, DOT-VNTSC-FHWA-96-2, Final Report, November 1995" and used in MINNOISE for the comparison?

The enhancement of the accuracy of MINNOISE when using the reflective barrier option at the two parallel barrier sites requires Mn/DOT staff to address possible changes in modeling guidance for future use of MINNOISE by consultants, etc.

Summary:

Mn/DOT compared hourly Leq noise level estimates made using Mn/DOT's Stamina 2.0 based model MINNOISE Ver. 02 with hourly Leq estimates using the FHWA's TNM 2.5 (most recent) noise model. The comparison is based on average errors with respect to measured results. Generally MINNOISE proved more accurate then TNM 2.5 (for details see the Tabulated Results section).

At the two sites that had parallel noise walls, additional MINNOISE runs were done with reflections taken into account. There is accuracy enhancement of the MINNOISE estimates at both sites. This wasn't unexpected. In a California DOT (CALTRANS) report: "Field Evaluation of Acoustical Performance of Parallel Highway Noise Barriers in California, Rudolf W. Hendriks, TRANSPORTATION REASEARCH RECORD 1366", criteria based on the ratio of noise wall separation to noise wall height (D/H) were set out. It was noted that when the D/H ratio is less than or equal to 10 that reflections can become a real concern, whereas when the ratio is greater than 10 the reflection will add minimally to the overall level. At the site referred to as site 2 in the report the D/H ratio was equal to 19.75 and, unexpectedly, there was advantage in considering the reflected component. The average overall accuracy of MINNOISE was increased by approximately 1.5 dBA. At the site referred to as site 3, in the report, the D/H ratio equaled 6 and the accuracy of the MINNOISE modeled levels were also enhanced by inclusion of the reflected component. The average overall accuracy was increased by approximately 2 dBA. TNM 2.5 doesn't appear to allow the

inclusion of a reflected component at this time. TNM 2.5 does allow for entry of NRC values for the noise walls being evaluated. TNM 2.5 defaults to an NRC value of zero (reflective) and to consider NRC values greater than zero only increased errors, so there was no further consideration of TNM 2.5 options in regard to wall reflections.

It hasn't been common practice at Mn/DOT to include potentially reflected components by using MINNOISE's reflective option when predicting noise levels in parallel noise wall scenarios. This practice may change after finding sites where the accuracy of the model was enhanced by the inclusion of the reflected component.

Tabulated Results:

Note: Positive (+) results indicate the model erred high on average. Negative (-) results indicate the model erred low on average.

SITE 1

Site 1	* Significant Diff. @ 95%	
LOCATION	MINNOISE (STAMINA)	TNM 2.5
	Ave. Error	Ave. Error
	Std. Dev.	Std. Dev.
	dBA	dBA
130 ft.	-0.5*	-3.3
	1.8	1.8
260 ft.	5.7	3
	3.5	3.5
400 ft.	0.8	-3.2
	4.1	4.2

At 130 ft. from the near lane centerline the difference between the average errors of MINNOISE and TNM 2.5 is significant at a 95% confidence level. The accuracy of MINNOISE at this distance appears considerably better than that of TNM 2.5. The standard deviations of the average error of both models tested equal at a 95% confidence level.

At 260 ft. from the near lane centerline both models erred badly. While TNM 2.5 was more accurate the difference between the two models average error is not significant at a 95% confidence level. As measurements are done at greater distances from the highway of interest, variations due to influences from noise sources other then the highway can affect results. An average error as large as +5.7 dBA is unexpected at this distance. Because measurements were taken on different days, it is suspected that atmospherics (wind direction, temperature gradients, etc) played a role and had an effect on errors when measurements were combined to evaluate average errors. Mn/DOT noise personnel will try to check on this result if and when possible. The standard deviations of the average error of both models tested equal at a 95% confidence level.

At 400 ft. from the near lane centerline the difference between the average errors of the two models is not significant at a 95% confidence level. The accuracy of MINNOISE appears good, on the basis of average errors, and is better than that of TNM 2.5. The large standard deviations are a concern. The standard deviations of the average errors of the models tested equal at a 95% confidence level. It should be noted that a small average error, which would appear to imply good accuracy, can be misleading where the variability of the predictions is very large.

SITE 2

Site 2	* Significant Diff. @ 95%		
LOCATION	MINNOISE (STAMINA) Abs.	MINNOISE (STAMINA) Reflc.	TNM 2.5
	Ave. Error	Ave. Error	Ave. Error
	Std. Dev.	Std. Dev.	Std. Dev.
	dBA	dBA	dBA
50 ft.	-2.2*	-1*	-6.2
	1	1	1
100 ft.	0.9*	2.5*	-4.1
	0.8	0.8	0.9
200 ft.	-1.9*	0.1*	-7.2
	0.6	0.6	0.5
400 ft.	-2.5*	-0.1*	-9
	1.2	1.2	1.1

At 50 ft. from the noise wall the difference between the average errors of MINNOISE (absorptive) and TNM 2.5 is significant at a 95% confidence level. The average error of MINNOISE (absorptive) is less than the average error of TNM 2.5. The standard deviations of the average errors of the models tested equal at a 95% confidence level. When MINNOISE (reflective) was run using the reflective noise wall option the average error of MINNOISE was reduced. The TNM 2.5 model defaults to a noise wall NRC value of zero. Entering NRC values greater than zero only makes matters worse as TNM 2.5 already predicts low in it's default mode. It appears that TNM 2.5 doesn't address a reflected noise component at this time. The standard deviations of the average errors of the models tested equal at a 95% confidence level.

AT 100 ft. from the noise wall the difference between the average errors of MINNOISE (absorptive) and TNM 2.5 is significant at a 95% confidence level. The average error of MINNOISE (absorptive) is less than the average error of TNM 2.5. The standard deviations of the average errors of the models tested equal at a 95% confidence level. When MINNOISE (reflective) was run using the reflective noise wall option the average error of MINNOISE was increased. The standard deviations of the average errors of the models tested equal at a 95% confidence level.

At 200 ft. from the noise wall the difference between the average errors of MINNOISE (absorptive) and TNM 2.5 is significant at a 95% confidence level. The average error of MINNOISE (absorptive) is less than the average error of TNM 2.5. The standard deviations of the average errors for the models tested equal at a 95% confidence level. When MINNOISE (reflective) was run using the reflective noise wall option the average error of MINNOISE was reduced. The standard deviations of the average errors of the models tested equal at a 95% confidence level.

AT 400 ft. from the noise wall the difference between the average errors of MINNOISE (absorptive) and TNM 2.5 is significant at a 95% confidence level. The average error of MINNOISE (absorptive) is less than the average error of TNM 2.5. The standard deviations of the average errors for the models tested equal at a 95% confidence level. When MINNOISE (reflective) was run using the reflective noise wall option the average error of MINNOISE was reduced. The standard deviations of the average errors of the models tested equal at a 95% confidence level.

With a D/H ratio of 19.75 (>10) it was unexpected when, on an overall basis, 3 of the 4 measurement locations showed statistically significant enhancements in accuracy with the use of the reflective option in MINNOISE. The 200 ft. site showed a statistically significant reduction in accuracy with the use of the reflective option.

SITE 3

Site 3	* Significant Diff. @ 95%		
LOCATION	MINNOISE (STAMINA) Abs.	MINNOISE (STAMINA) Reflc.	TNM 2.5
	Ave. Error	Ave. Error	Ave. Error
	Std. Dev.	Std. Dev.	Std. Dev.
	dBA	dBA	dBA
50 ft.	-1.7*	0*	-4.1
	0.8	0.8	0.7
100 ft.	-3.2*	-0.7*	-5.8
	1.3	1.4	1.3
200 ft.	-3.7*	-0.4*	-6.5
	1.8	1.8	1.8

At 50 ft. from the noise wall the difference between the average errors of MINNOISE (absorptive) and TNM 2.5 is significant at a 95% confidence level. The average error of MINNOISE (absorptive) is less than the average error of TNM 2.5. When MINNOISE (reflective) was ran using the reflective noise wall option the average error of MINNOISE was reduced. The standard deviations of the average errors for the models tested equal at a 95% confidence level.

AT 100 ft. from the noise wall the difference between the average errors of MINNOISE (absorptive) and TNM 2.5 is significant at a 95% confidence level. The average error of MINNOISE (absorptive) is less than the average error of TNM 2.5. The standard deviations of the average errors for the models tested equal at a 95% confidence level. When MINNOISE (reflective) was ran using the reflective noise wall option the average error of MINNOISE was reduced. The standard deviations of the average errors for the models tested equal at a 95% confidence level.

AT 200 ft. from the noise wall the difference between the average errors of MINNOISE (absorptive) and TNM 2.5 is significant at a 95% confidence level. The average error of MINNOISE (absorptive) is less than the average error of TNM 2.5. The standard deviations of the average errors for the models tested equal at a 95% confidence level. When MINNOISE was ran using the reflective noise wall option the average error of MINNOISE was reduced. The standard deviations of the average error for the models tested equal at a 95% confidence level.

With an H/D of 6 (<10) the inclusion of the reflected component enhanced the accuracy of MINNOISE at all measurement locations.

SITE 4

Site 4	* Significant Diff. @ 95%	
LOCATION	MINNOISE (STAMINA)	TNM 2.5
	Ave. Error	Ave. Error
	Std. Dev.	Std. Dev.
	dBA	dBA
50 ft.	-2.1*	-3.5
	0.5	0.6
100 ft.	-2.1*	-5.4
	0.5	0.5

At 50 ft. from the near roadway the difference between the average errors of MINNOISE and TNM 2.5 is significant at a 95% confidence level. The average error of MINNOISE is less than the average error of TNM 2.5. The standard deviations of the average errors for the models tested equal at a 95% confidence level.

At 100 ft. from the near roadway the difference between the average errors of MINNOISE and TNM 2.5 is significant at a 95% confidence level. The average error of MINNOISE is less than the average error of TNM 2.5. The standard deviations of the average errors for the models tested equal at a 95% confidence level.

Descriptions of the test sites with pertinent details

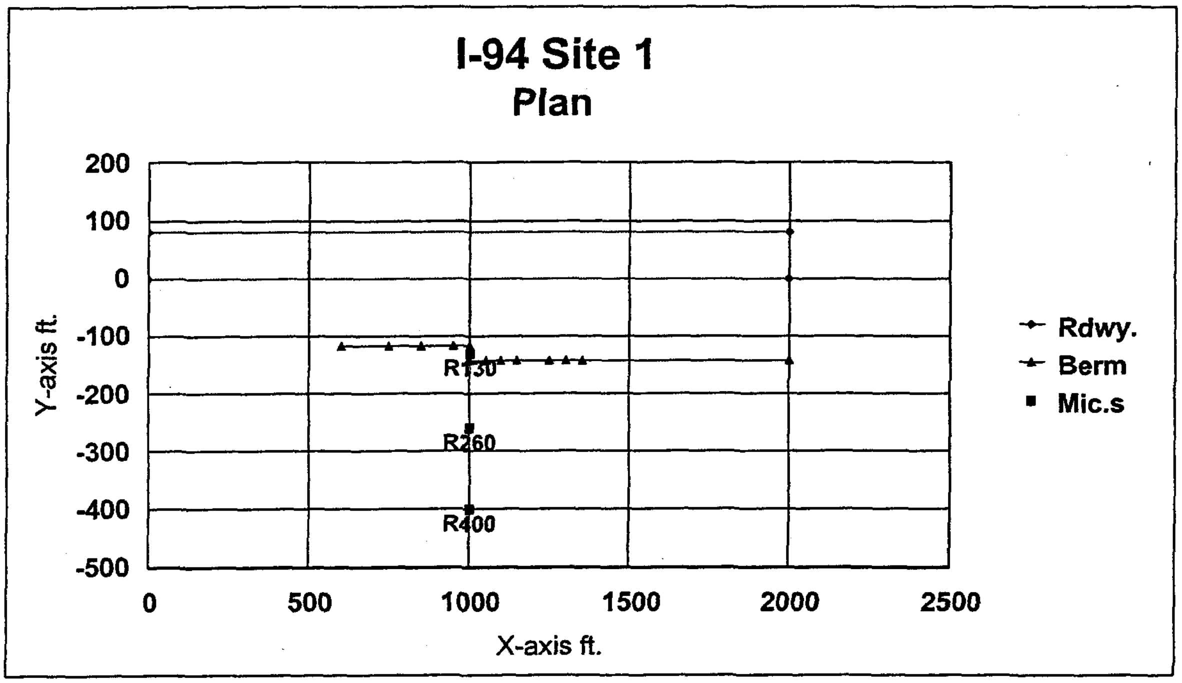
Site 1: Site 1 is a four lane, divided freeway with ditches. Site 1 is a relatively flat, open site. Measurement distances were at 130 ft., 260 ft., and 400 ft. from the near lane centerline. The three measurement positions had grass covered ground (soft ground) intervening the measurement positions and the freeway. There was a field road that acted as a low berm that just broke or grazed the line-of-site to auto tires at the 400 ft. measurement position.

Site 2: Site 2 is an eight lane (four and four), divided freeway. Site 2 has a berm and noise wall combination. Measurement distances were 150 ft., 200 ft., 300 ft., and 500 ft. from the near lane centerline. All four measurement positions had grass covered ground (soft ground) intervening the measurement positions and the freeway. The noise wall was on an undulating berm. The top of the noise wall remained at a relatively constant 18 ft. above the freeway grade and the wall height varied from 9 ft. to 17 ft. There is a parallel noise wall on the other side of the freeway. The ratio of noise wall separation to noise wall height (D/H) is 19.75. Based on the report "Field Evaluation of Acoustical Performance of Parallel Highway Noise Barriers in California, Rudolf W. Hendriks, TRANSPORTATION REASEARCH RECORD 1366", a value this large would indicate that reflections from the opposite wall could be ignored. Our results, however, show that statistically significant enhancements and reductions in the accuracy of MINNOISE occurred. What effects this will have on Mn/DOT's modeling methodology will have to be ascertained.

Site 3. Site 3 is a six lane (three and three), divided freeway. At Site 3 the freeway is in a cut and there is a noise wall at the top of the cut slope. Measurement distances were 117 ft., 167 ft., and 267 ft. from the near lane centerline. All three measurement sites were coded as soft ground, although the presence of the barrier could negate soft ground effects in the MINNOISE model. The noise wall was at the top of a shallow cut and the top of the wall was 28 ft. above freeway grade. The wall height is at a relatively constant 17.5 ft. There is a parallel noise wall on the other side of this portion of the freeway. The ratio of noise wall separation to noise wall height is 6. This value of D/H is less than 10 which, according to the Cal Trans study, would indicate that a reflection from the opposite wall should be taken into account.

Site 4. Site 4 is a four lane (two and two), divided expressway. Site 4 is a flat, open site. Measurement distances were 50 ft., and 100 ft. from the near lane centerline. Both measurement positions had grass cover ground (soft ground) intervening the measurement positions and the freeway.

Graphics of Sites based on MINNOISE input coordinates
Not to scale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2000
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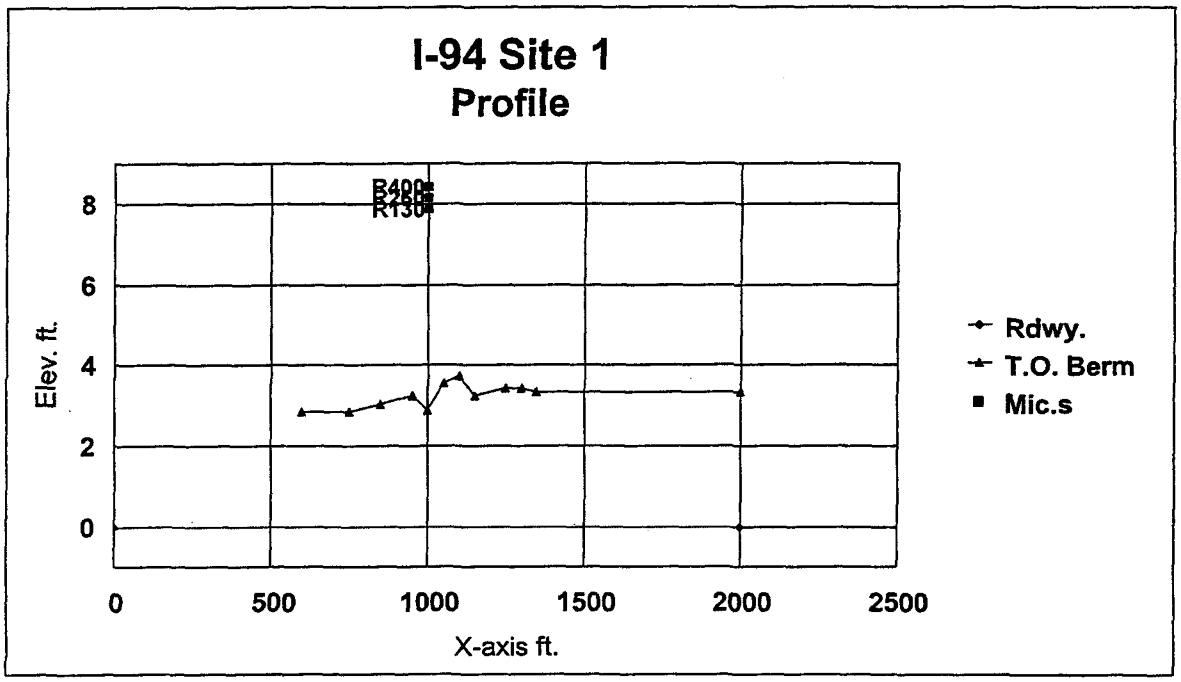
R130
R260
R400
Rdwy.
Berm
Mic.s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X-axis ft.
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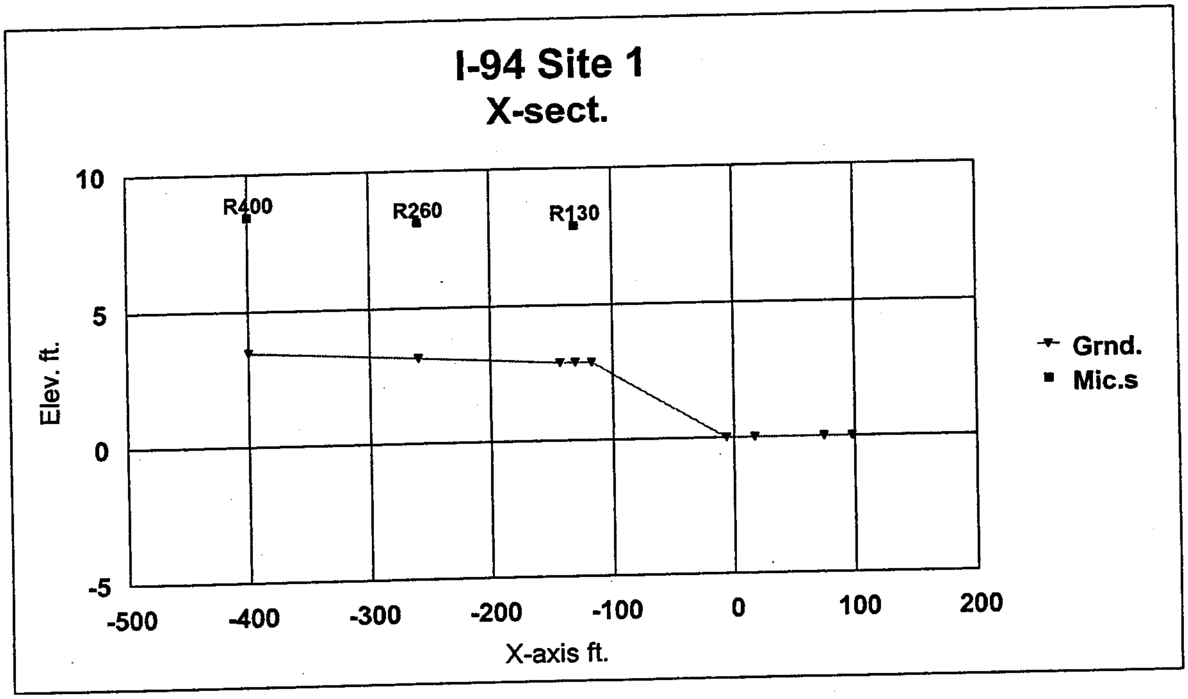
T.O. Berm
Mic.s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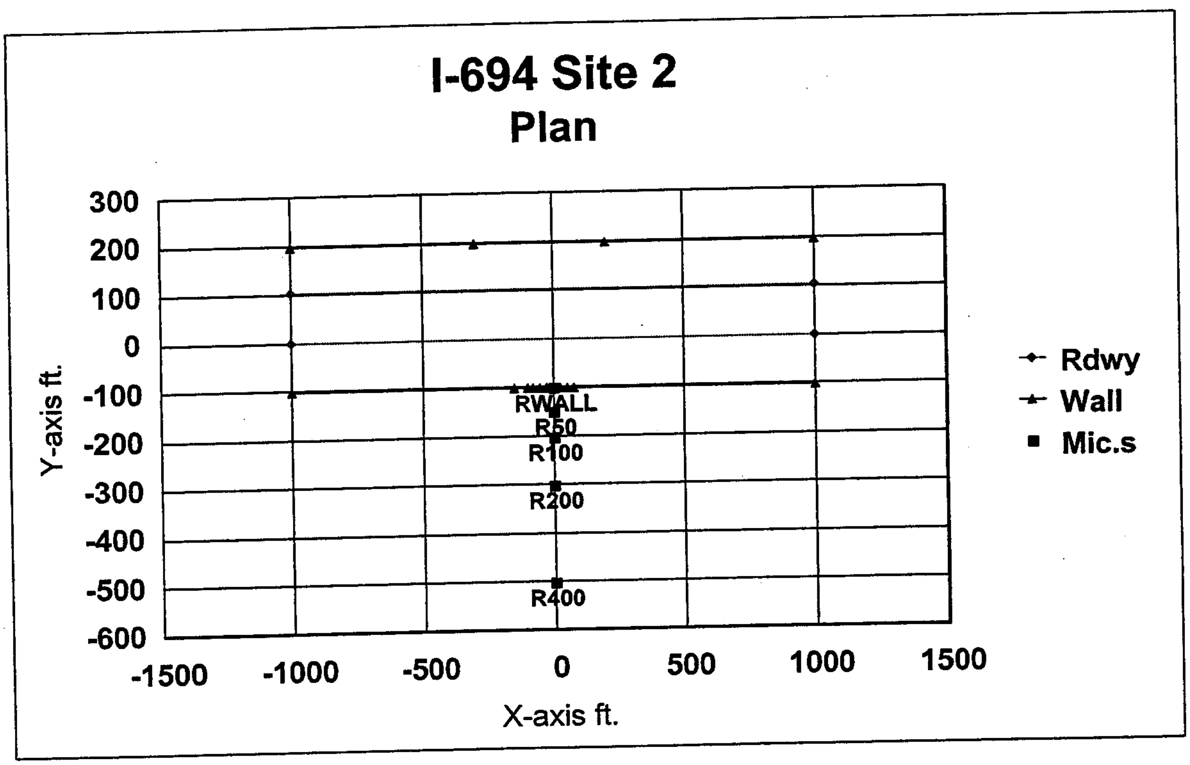
X-axis ft.
Grnd.
Mic.s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200
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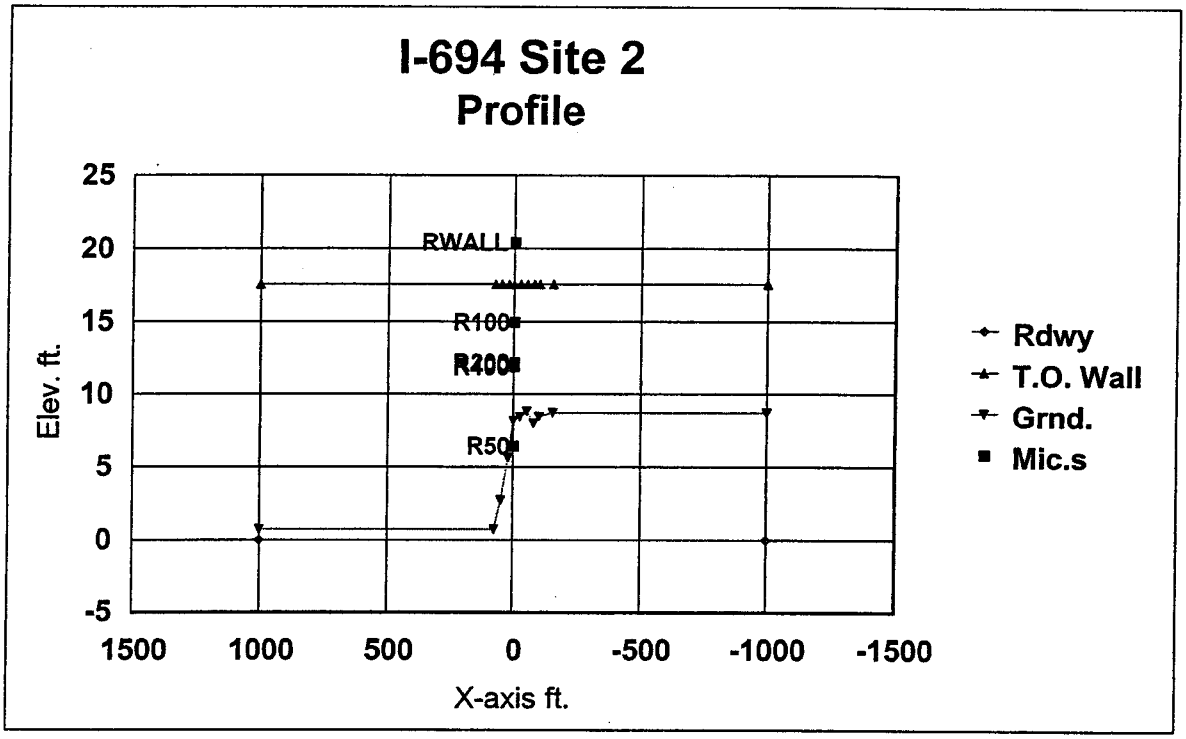
X-axis ft.
Rdwy
Wall
Mic.s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20
15
10
5
0
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1000
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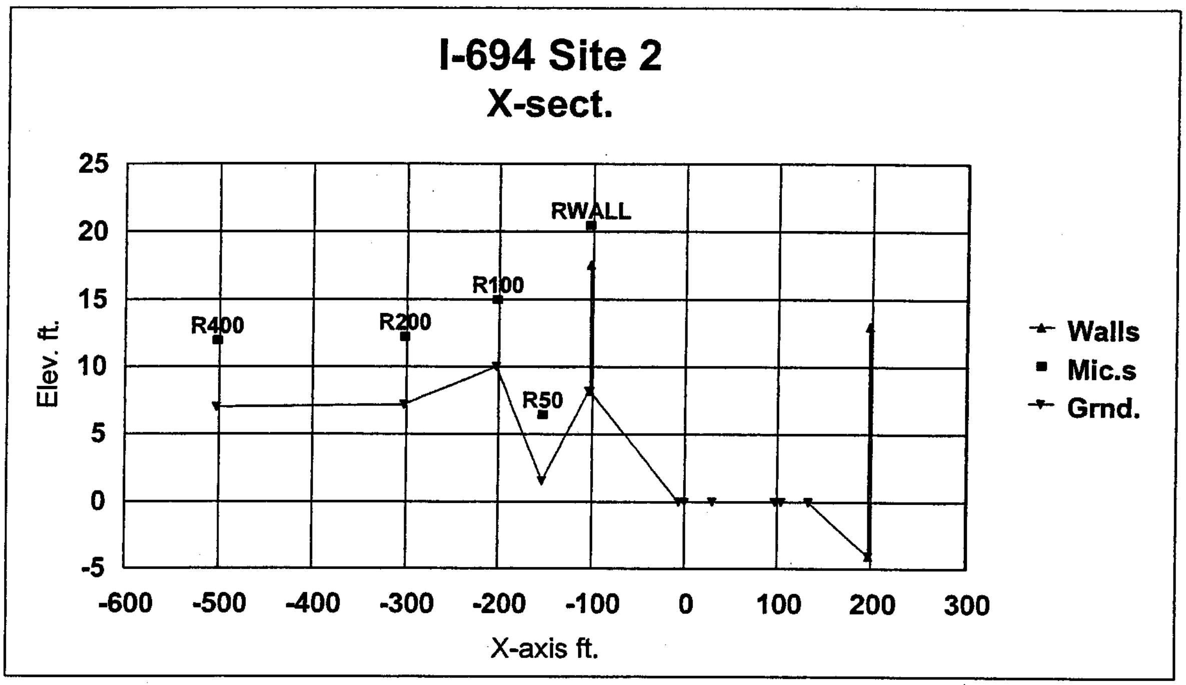
Elev. ft.
RWALL
R100
R200
R400
R50
Rdwy
T.O. Wall
Grnd.
Mic.s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R400
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Walls
Mic.s
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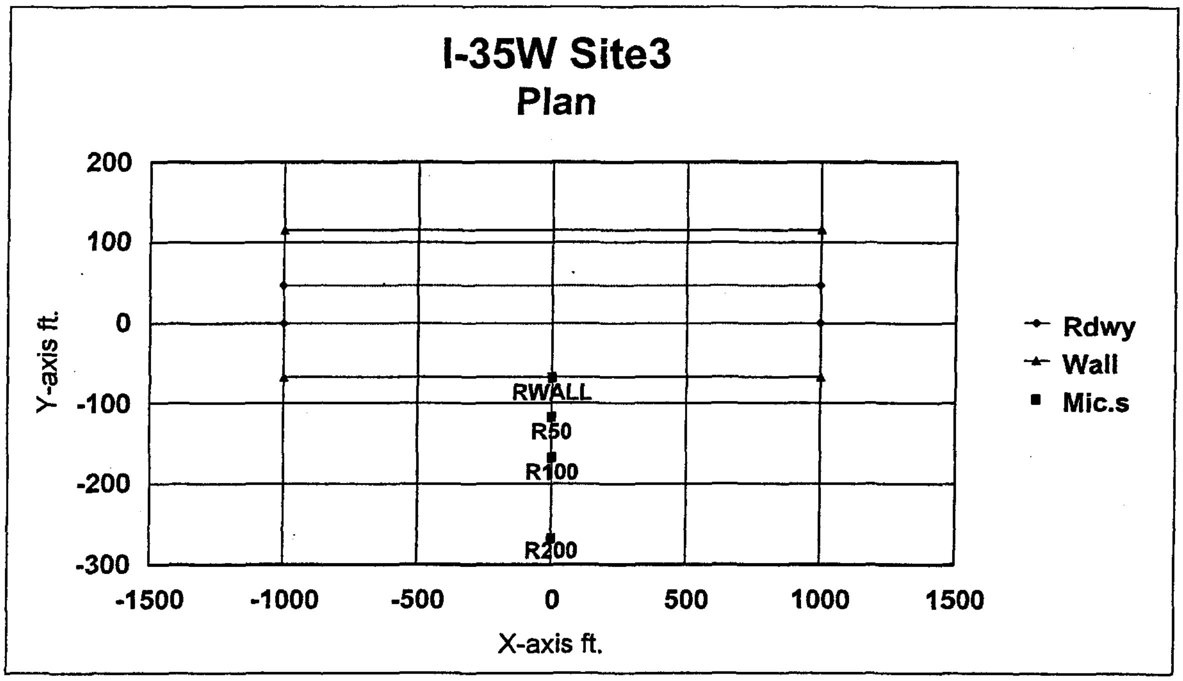
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X-axis ft.
RWALL
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Wall
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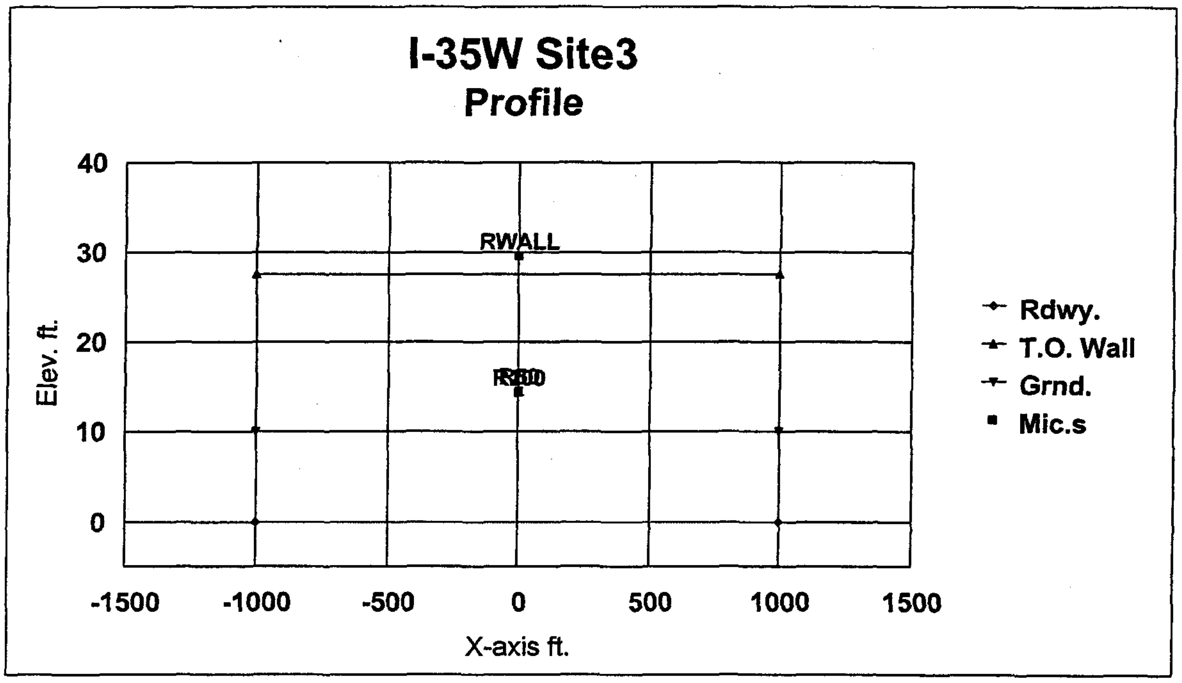
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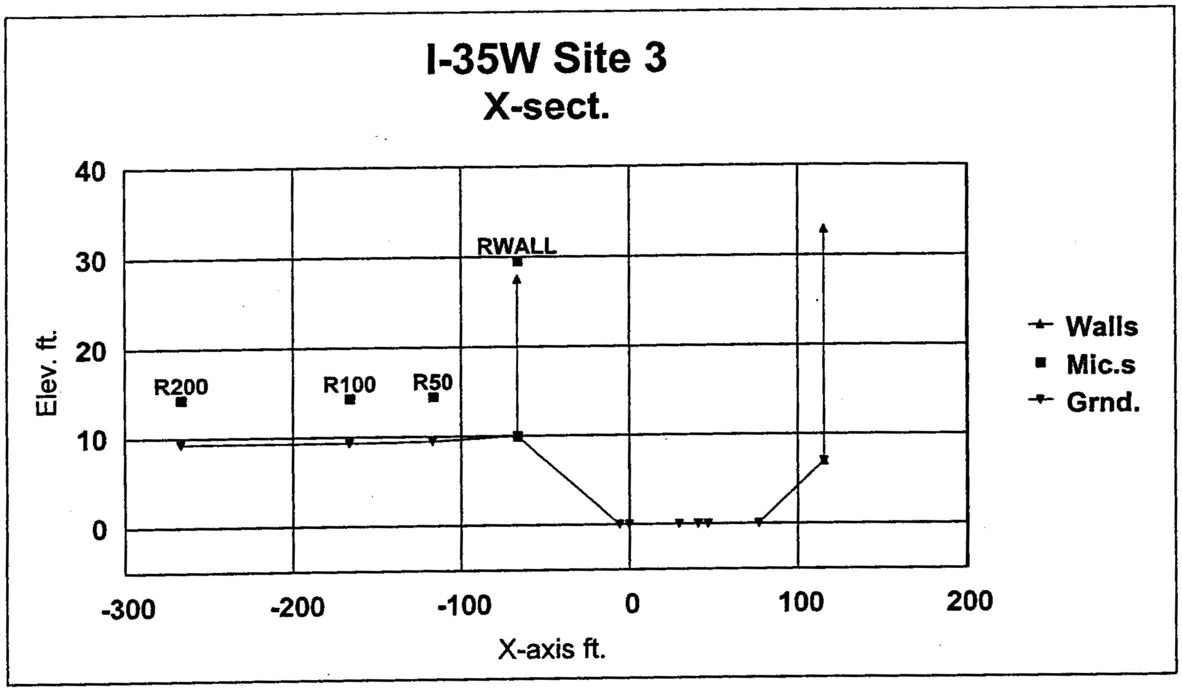
RWALL
Rdwy.
T.O. Wall
Grnd.
Mic.s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200
X-axis ft.
Walls
Mic.s
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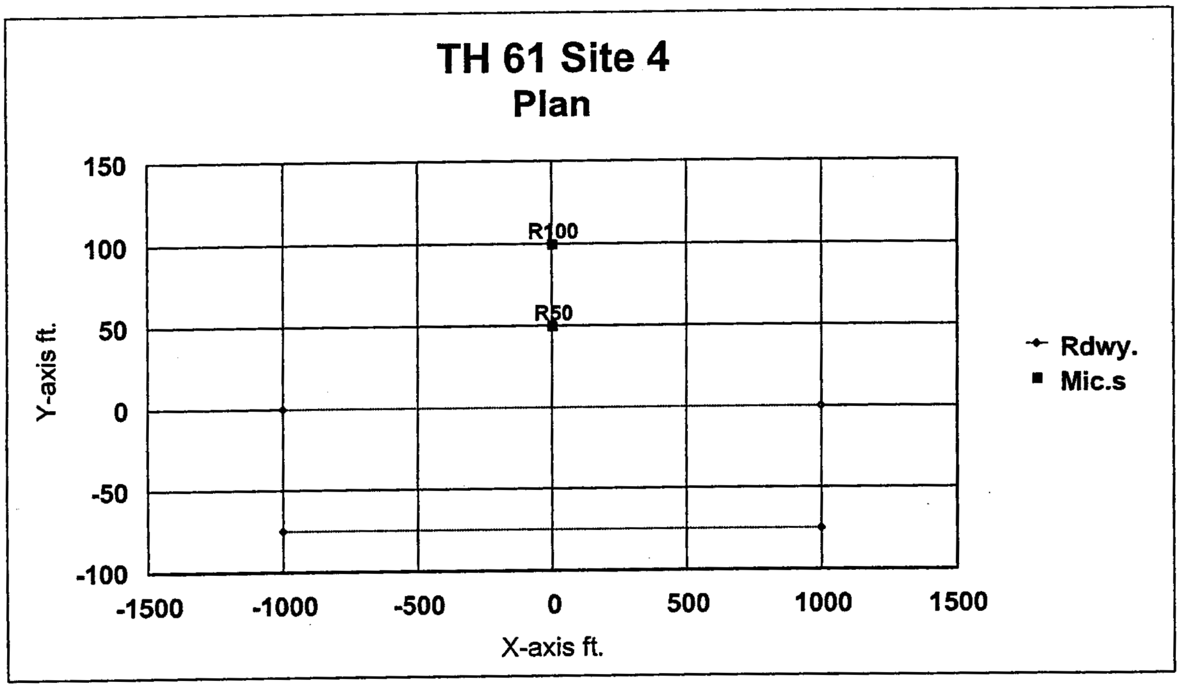
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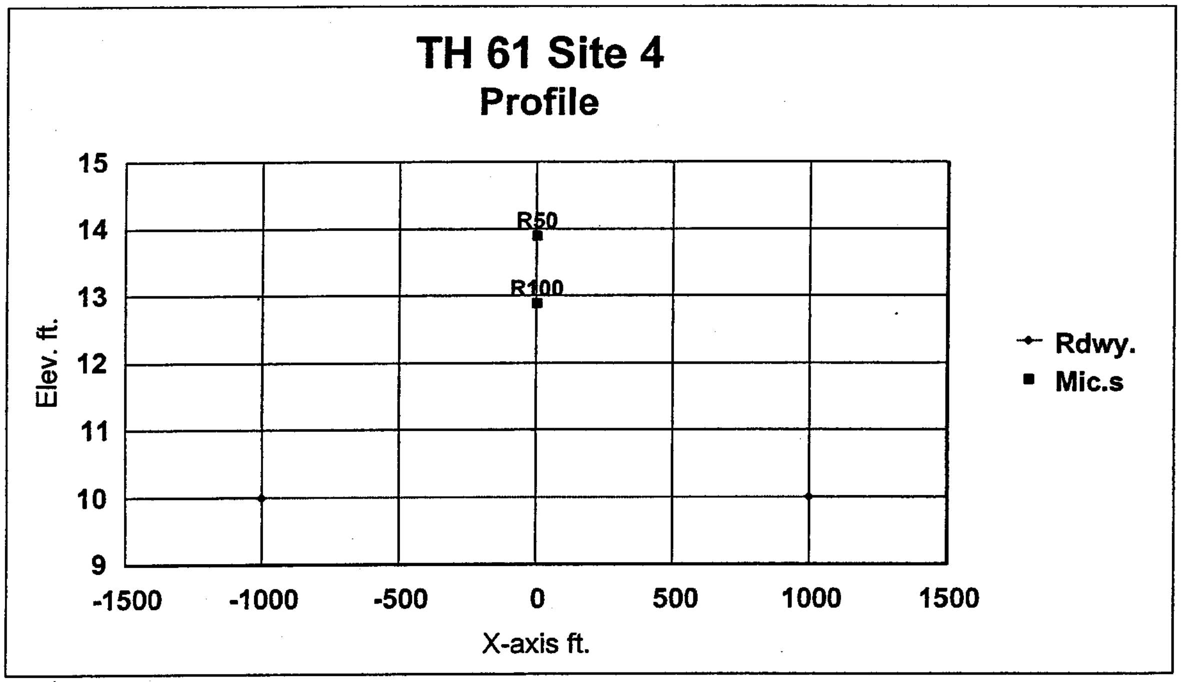
Rdwy.
Mic.s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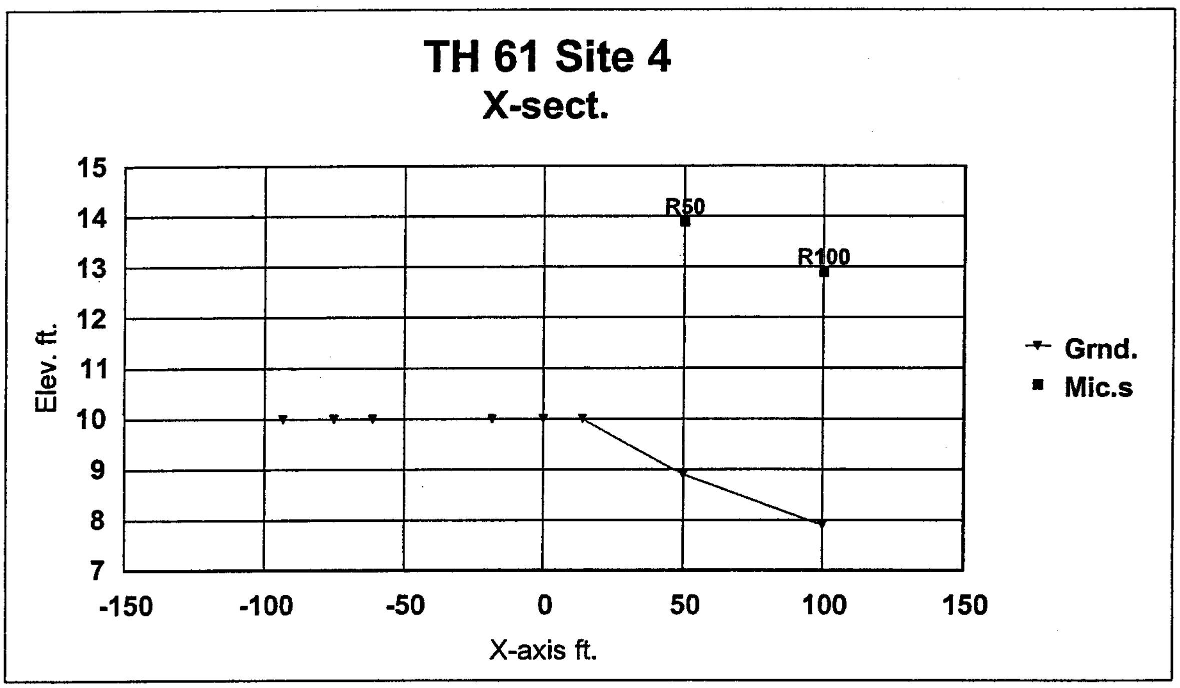
R50
R100
Elev. ft.
X-axis ft.
Rdwy.
Mic.s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X-sect.
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Elev. ft.
X-axis ft.
Grnd.
Mic.s

Background, Methodology and Analysis

Mn/DOT has tested and compared the FHWA's TNM 2.5 (TNM 2.5) noise model and Mn/DOT's STAMINA 2.0 based noise model MINNOISE Ver. 02 using measured Leq noise levels. Mn/DOT located 4 sites where noise level measurements and traffic counts were made . Site geometrics were measured, delineated and setup for input into both models. The comparison is based on assessing the comparative accuracy of both TNM 2.5 and MINNOISE. The 4 sites represent 2 open, soft sites and 2 sites with in-place noise walls. Mn/DOT counted and classified all traffic during the measurement periods. When running the TNM 2.5 model we entered all traffic as classified. When running MINNOISE, we entered Cars, M. Trucks, and H. Trucks as classified. Buses (highway buses and school buses) and Motorcycles were entered as M. Trucks.

We felt that in order to eliminate a confounding factor (the differences in emission levels between the two models) the Mn/DOT MINNOISE emission levels were modified to match the emission levels given in "FHWA-PD-96-008, DOT-VNTSC-FHWA-96-2, Final Report, November 1995"; the basis for emission levels used in earlier TNM versions prior to the TNM 2.5 model. At this time, however, it isn't clear that the emission levels used in TNM 2.5 weren't modified from those in earlier versions. Hopefully this question can be cleared up at some point. As noted above, only three vehicle categories were entered in MINNOISE and average roadway surface emission levels were used. In the TNM 2.5 model a finer breakdown of traffic was used. Unlike TNM 2.5, MINNOISE assumes that all the energy emission from Heavy Trucks occurs at a point 8 ft. above the pavement and that the point of Medium Truck emission is at 2 ft. 3in. above the pavement.

Each site's roadway most germane geometry and topography features were digitized. Roadway and measurement microphone elevations and locations were digitized for input. Obstructions (noise walls, berms, ground-lines, etc.) to line-of-sight from measurement microphones to the roadway were digitized and entered as input. The input data was entered into TNM 2.5 by importing MINNOISE data files into TNM 2.5. Once the data were in the TNM 2.5 format the TNM 2.5 models vehicle classification scheme was utilized by making a finer breakdown of vehicle classifications (Buses and Motorcycles) in the TNM 2.5 input data. Once the input data were in the TNM 2.5 format the measurement microphone and barrier elevations had to be broken out into the ground elevation at the microphone and barrier locations and the height above the ground of the microphones and barriers. After these adjustments no further tweaking of the input data was done.

The results used for comparison are the modeled hourly Leq's minus corresponding measured hourly Leq's. The difference between a modeled Leq and a measured Leq is a sampled error of a specific modeled – measurement level pair. The results of the comparison are given as the average error (difference) between modeled and measured levels and the standard deviation of the errors with respect to the average error. With this approach a positive average error indicates that the average modeled level is higher than the average measured level and a negative error indicates that the average modeled level is lower than the average measured level.

Each measurement site has a tabulation (see Tabulated Results section) of the average error and the error standard deviation at the specified distances from the near traffic lane or noise as dictated by the site being analyzed.

The Student's T-test was used at a 95% confidence level in order to determine if the difference between the average errors, from the two models, are statistically significant. A Fischer's F-test at a 95% confidence level was used to check on the equality of the values of error standard deviations between the two models.

Tabulated Results of Measurements and Modeling

Table 1 Site 1 Measurements and Results

LOCATION REL. TO NEAR LANE Ft.	Leq(h) MEASURED dBA		Leq(h) MINNOISE dBA		Leq(h) TNM 2.5 dBA
130	72.7		73		70.2
130	73.2		73.6		70.7
130	71.8		73.2		70.3
130	70.6		73.1		70.3
130	70.8		74.4		71.5
130	70.7		74.4		71.5
130	75.8		74.1		71.3
130	76.3		74.3		71.4
130	75.8		74.2		71.3
130	75.5		73.7		70.8
130	76		73.7		70.9
130	75.9		73.9		71.1
130	76.6		74.1		71.2
130	76.3		73.9		70.9
130	73.7		73.8		71.1
130	74		73.8		71.1
130	75.5		74.1		71.4
130	74.6		73.6		70.8
130	74.5		73.3		70.4
130	74.2		73.6		70.9
130	74.8		73.7		70.9
130	75.3		73.9		71.1
260	61.8		67.9		65.2
260	61.5		68.4		65.7
260	58.8		68		65.2
260	58.3		67.7		65
260	59.4		69		66.2
260	58.6		68.9		66.2
260	68		68.7		66
260	68.4		68.9		66.1
260	68.2		68.8		66.2
260	63.6		68.7		66.1
260	62		68.8		66.2
260	65.3		69		66.4
260	63.6		68.6		65.9
400	64.9		65.6		61.5
400	68.1		65.6		61.7
400	68.1		65.7		61.7
400	68.6		65.8		61.8
400	70.2		65.6		61.5

Table 1 Cnt'd Site 1 Measurements and Results

LOCATION					
REL. TO	Leq(h)		Leq(h)		Leq(h)
NEAR LANE	MEASURED		MINNOISE		TNM 2.5
Ft.	dBA		dBA		dBA
400	60.1		65.2		61.3
400	58.2		65.7		61.9
400	62.3		65.8		62.1
400	63.5		66		62.1

Table 2 **Site 2 Measurements and Results**

LOCATION REL. TO NOISE WALL Ft.	Leq(h) MEASURED dBA		Leq(h) MINNOISE (ABS.) dBA		Leq(h) MINNOISE (REF.) dBA		Leq(h) TNM 2.5 dBA
50	66.1		64.8		66		60.8
50	66.3		64.9		66		60.9
50	65.8		64.8		65.9		60.8
50	65.7		64.8		65.9		60.7
50	66.7		64.9		66.1		60.9
50	65.7		64.8		66		60.8
50	67.3		63.9		65.1		59.9
50	67.5		64.2		65.5		60.2
50	67.5		64		65.1		60.1
50	67.9		64.3		65.4		60.4
50	67.3		64.6		65.8		60.6
50	68.3		65.6		66.8		61.4
50	67.4		64.6		65.7		60.6
50	68.7		65.4		66.5		61.5
50	67		64.7		65.9		60.6
50	66.1		64.8		65.9		60.7
50	65.4		64.6		65.8		60.6
100	67.7		68.1		69.8		63.1
100	67.8		68.2		69.8		63.1
100	67.5		68.1		69.7		63.1
100	67.3		68.1		69.7		63
100	68.5		68.2		69.9		63.2
100	66.9		68.1		69.8		63.1
100	66.4		68.1		69.7		63.1
100	65.6		68		69.6		63
200	66.8		64.3		66.3		59
200	66.4		64.7		66.8		59.4
200	66.7		64.3		66.4		59.1
200	67		64.6		66.7		59.5
200	66.5		65		67.1		59.7
200	67.3		66.3		68.3		60.7
400	64.6		62		64.5		55.6
400	66.4		62.7		65.2		56.4
400	63.6		62.3		64.7		55.7

Table 3 **Site 3 Measurements and Results**

LOCATION REL. TO NOISE WALL Ft.	Leq(h) MEASURED dBA		Leq(h) MINNOISE (ABS.) dBA		Leq(h) MINNOISE (REF.) dBA		Leq(h) TNM 2.5 dBA
50	66.3		63.6		65.4		61.4
50	65.6		63		64.8		60.7
50	66		63.1		64.9		60.6
50	65.5		62.9		64.8		61.4
50	65.2		63.1		64.9		60.7
50	65.8		62.7		64.5		60.4
50	64.7		63.2		65		60.8
50	64.8		63.1		65		60.9
50	65.7		63.3		65.2		61
50	64.9		63		64.9		60.8
50	65.6		63.8		65.6		61.3
50	64.3		63.1		64.9		60.7
50	63.9		62.8		64.6		60.4
50	63.7		62.5		64.3		60.2
50	63.5		62.3		64.2		60.1
50	64		62.9		64.7		60.5
50	64		63.8		64.8		60.6
50	64.1		62.8		64.7		60.5
50	63.7		63.2		65		60.7
100	67.1		62.6		65		59.9
100	66.3		62		64.5		59.3
100	66.9		62.1		64.5		59.3
100	66.2		61.9		64.4		59.9
100	65.5		62		64.4		59.5
100	66.4		62.7		65.1		59.9
100	63.9		62.1		64.6		59.4
100	63.5		61.7		64.2		59
100	63		61.4		63.9		58.8
100	63		61.3		63.8		58.7
200	65.2		59.8		63.1		57
200	65.8		59.4		62.7		56.7
200	64		60		63.2		57.1
200	64		59.9		63.2		57.2
200	65.5		60.1		63.4		57.3
200	61.7		59.7		63		56.8
200	62		59.7		63		56.9
200	61.6		59.7		63		56.8
200	61.5		60.1		63.3		57.1

Table 4 Site 4 Measurements and Results

LOCATION					
REL. TO	Leq(h)		Leq(h)		Leq(h)
NEAR LANE	MEASURED		MINNOISE		TNM 2.5
Ft.	dBA		dBA		dBA
50	75.6		73.2		71.9
50	75.1		73.2		72
50	75.4		72.7		71.3
50	75.2		73.7		72.3
100	71.4		69.1		65.8
100	70.9		69.1		65.8
100	71.3		68.7		65.2
100	71.2		69.7		66.3

Example Input/Output Files

Example TNM 2.5 Output Sheet

MN/DOT
RS

10-Jun-04
TNM 2.5
Calculated with TNM 2.5

RESULTS: SOUND LEVELS
PROJECT/CONTRACT: MEAS 1
RUN: I35SITE1
BARRIER DESIGN: INPUT HEIGHTS

ATMOSPHERICS: 68 deg F, 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	No Barrier LAeq1h Calculated	Crit'n	Increase over existing Calculated	Crit'n Sub'l Inc	Type Impact	With Barrier Calculated LAeq1h	Noise Reduction Calculated	Goal	Calculated minus Goal
			dBA	dBA	dBA	dB	dB		dBA	dB	dB	dB
RWALL	1	1	0	80.8	66	80.8	10	Snd Lvl	80.8	0	8	-8
R50	2	1	0	71.9	66	71.9	10	Snd Lvl	61.4	10.5	8	2.5
R100	3	1	0	68	66	68	10	Snd Lvl	59.9	8.1	8	0.1
R200	4	1	0	64.5	66	64.5	10	—	57.3	7.2	8	-0.8

Dwelling Units	# DUs	Noise Reduction Min	Avg	Max
		dB	dB	dB
All Selected	4	0	6.4	10.5
All Impacted	3	0	6.2	10.5
All that meet NR Goal	2	8.1	9.3	10.5

Example TNM 2.5 Roadways Input Sheet

MN/DOT 10-Jun-04
RS TNM 2.5

INPUT: ROADWAYS
PROJECT/CONTRACT: MEAS 1
RUN: I35SITE1

Average pavement type shall be used unless a State highway agency substantiates the use of a different type with the approval of FHWA

Roadway Name	Width	Points Name	No.	Coordinates (pavement) X	Y	Z	Flow Control Control Device	Speed Constraint	Percent Vehicles Affected	Segment Pvmt Type	On Struct?
	ft			ft	ft	ft		mph	%		
NB35	12	NB1	1	0	1,000.00	0				Average	
		NB2	2	0	-1,000.00	0					
SB35	12	SB1	3	47	-1,000.00	0				Average	
		SB2	4	47	1,000.00	0					

Example TNM 2.5 Traffic Input Sheet

MN/DOT 10-Jun-04
RS TNM 2.5

INPUT: TRAFFIC FOR LAeq1h'
PROJECT/CONTRACT: MEAS 1
RUN: I35SITE1

Roadway Name	Points Name	No.	Segment Autos V veh/hr	S mph	MTrucks V veh/hr	S mph	HTrucks V veh/hr	S mph	Buses V veh/hr	S mph	Motorcycles V veh/hr	S mph
NB35	NB1	1	3318	67	270	67	330	67				
	NB2	2										
SB35	SB1	3	3300	67	164	67	324	67				
	SB2	4										

Example TNM 2.5 Barrier Input Sheet

MNDOT 10-Jun-04
RS TNM 2.5

INPUT: BARRIERS
PROJECT/CONTRACT: MEAS1
RUN: I35SITE1

Barrier Name	Type	Height Min ft	Max ft	If Wall $ per Unit Area $/sq ft	If Berm $ per Unit Vol. $/cu yd	Top Width ft	Run:Rise ft:ft	Addtnl $ per Unit Length $/ft	Points Name	No.	Coordinates (bottom) X ft	Y ft	Z ft	Height at Point ft	Segment Seg Ht Increment ft	Perturbs #Up	#Dn	On Struct?
BARRIER1(EAST)	W	0	99	0				0	STA1	1	-67	-1,000.00	10	17.6	2	2	2	
									STA2	2	-67	1,000.00	10	17.6				
BARRIER2(WEST)	W	0	99	0				0	STA1	3	116	-1,000.00	7	26	2	2	2	
									STA2	4	116	1,000.00	7	26				

Example TNM 2.5 Receiver Input Sheet

MN/DOT
RS

10-Jun-04
TNM 2.5

INPUT: RECEIVERS
PROJECT/CONTRACT: MEAS 1
RUN: I35SITE1

Receiver Name	No.	#DUs	Coordinates (ground) X	Y	Z	Height above Ground	Input Sound Levels and Criteria Existing LAeq1h	Impact Criteria LAeq1h	Sub'l	NR Goal	Active in Calc.
			ft	ft	ft	ft	dBA	dBA	dB	dB	
RWALL	1	1	-66.9	0	10	19.6	0	66	10	8	Y
R50	2	1	-117	0	9.5	5	0	66	10	8	Y
R100	3	1	-167	0	9.4	5	0	66	10	8	Y
R200	4	1	-267	0	9.4	5	0	66	10	8	Y

Example MINNOISE Output Sheet (Absorptive)

```
1           STAMINA 2.0/BCR
        FHWA VERSION (MARCH 1982)
       TRAFFIC NOISE PREDICTION MODEL
      DEVELOPED UNDER CONTRACT BY BBN

  (INPUT UNITS- ENGLISH , OUTPUT UNITS- ENGLISH )



MINNESOTA DEPT. OF TRANSPORTATION NOISE PREDICTION
  MODEL MINNTNM, VERSION 0.0 REVISED DEC 2003
MODIFIED BY THE MINNESOTA DEPT. OF TRANSPORTATION
FOR OPERATION ON A MS-DOS PERSONAL COMPUTER, 1985
TNM EMISSION LEVELS INCORPORATED, 1998

TH35 BLOOMINGTON,SITE3,MEAS1
0PROGRAM INITIALIZATION PARAMETERS

  HEIGHT  CODE   DESCRIPTION
   0.00     1  RECEIVER HEIGHT ADJUSTMENT
   1.00     2  A-WEIGHTED SOUND LEVEL ONLY
   0.00     3  HEIGHT ADJUSTMENT FOR PASSENGER CARS (CARS)
   8.00     4  HEIGHT ADJUSTMENT FOR HEAVY TRUCKS  (HT)
   2.30     5  HEIGHT ADJUSTMENT FOR MEDIUM TRUCKS  (MT)


0ROADWAY  1    NB35


            VEHICLE TYPE  VEHICLES/HOUR    SPEED
            CARS           3318.      67.
            HT             330.      67.
            MT             270.      67.
0            ------------COORDINATES-------------
                X        Y        Z    GRADE
NB1                0.0   1000.0      0.0    0
NB2                0.0  -1000.0      0.0    0
```

Example MINNOISE Output Sheet (Absorptive) Cnt'd

```
0ROADWAY  2    SB35


              VEHICLE TYPE   VEHICLES/HOUR    SPEED
              CARS               3300.        67.
              HT                  324.        67.
              MT                  164.        67.
0               ------------COORDINATES-------------
                   X         Y          Z     GRADE
SB1                  47.0    -1000.0       0.0    0
SB2                  47.0    1000.0        0.0    0
1BARRIER  1  TYPE(A)    BARRIER1(EAST)
0           ---------COORDINATES----------
           X        Y          Z        Z0        DELZ   P
STA1         -67.0   -1000.0      27.6      10.0       2.0    2
STA2         -67.0   1000.0       27.6      10.0
1BARRIER  2  TYPE(A)    BARRIER2(WEST)
0           ---------COORDINATES----------
           X        Y          Z        Z0        DELZ   P
STA1         116.0   -1000.0      33.0      7.0       2.0    2
STA2         116.0   1000.0       33.0      7.0


BARRIER LENGTH BY SECTION
 2000.00  2000.00
1RECEIVERS
0               ------------COORDINATES-------------
                  X         Y          Z
RWALL                  -66.9       0.0       27.6
R50                -117.0       0.0      14.5
R100               -167.0       0.0       14.4
R200               -267.0       0.0       14.4
1  ALPHA FACTORS - ROADWAY ACROSS,RECEIVER DOWN

 1 * 0.0 0.0
 2 * 0.5 0.5
 3 * 0.5 0.5
 4 * 0.5 0.5
1  SHIELDING FACTORS - ROADWAY ACROSS,RECEIVER DOWN

 1 * 0.0 0.0
 2 * 0.0 0.0
 3 * 0.0 0.0
 4 * 0.0 0.0
```

Example MINNOISE Output Sheet (Absorptive) Cnt'd

1TH35 BLOOMINGTON,SITE3,MEAS1

0RECEIVER	LEQ(H)	SIG	L10	L50	L90
RWALL	82.5	2.1	84.7	81.9	79.2
R50	63.6	1.5	65.3	63.4	61.5
R100	62.6	1.4	64.2	62.3	60.5
R200	60.4	1.4	61.9	60.2	58.4

Example MINNOISE Input Sheet (Absorptive)

```
*NNN
TH35 BLOOMINGTON,SITE3,MEAS1
1,3
2,2
NB35
'CARS' 3318,67
'MT' 270,67
'HT' 330,67
'L'/
'NB1' 0,1000,0,0
'NB2' 0,-1000,0,0
'L'/
SB35
'CARS' 3300,67
'MT' 164,67
'HT' 324,67
'L'/
'SB1' 47,-1000,0,0
'SB2' 47,1000,0,0
'L'/
3,2
BARRIER1(EAST)
'STA1' -67,-1000,27.6,10,2,2
'STA2' -67,1000,27.6,10
'A'/
BARRIER2(WEST)
'STA1' 116,-1000,33,7,2,2
'STA2' 116,1000,33,7
'A'/
5,4
RECEIVERS
'RWALL' -66.9,0,29.6
'R50' -117,0,14.5
'R100' -167,0,14.4
'R200' -267,0,14.4
6,1
ALPHA FACTORS
0.0 0.0
0.5 0.5
0.5 0.5
0.5 0.5
6,2
```

Example MINNOISE Input Sheet (Absorptive) Cnt'd

SHIELDING FACTORS
0 0
0 0
0 0
0 0
7/

Example MINNOISE Output Sheet (Reflective)

1 STAMINA 2.0/BCR
FHWA VERSION (MARCH 1982)
TRAFFIC NOISE PREDICTION MODEL
DEVELOPED UNDER CONTRACT BY BBN

(INPUT UNITS- ENGLISH , OUTPUT UNITS- ENGLISH)

MINNESOTA DEPT. OF TRANSPORTATION NOISE PREDICTION
MODEL MINNTNM, VERSION 0.0 REVISED DEC 2003
MODIFIED BY THE MINNESOTA DEPT. OF TRANSPORTATION
FOR OPERATION ON A MS-DOS PERSONAL COMPUTER, 1985
TNM EMISSION LEVELS INCORPORATED, 1998

TH35 BLOOMINGTON,SITE3,MEAS1
0PROGRAM INITIALIZATION PARAMETERS

HEIGHT	CODE	DESCRIPTION
0.00	1	RECEIVER HEIGHT ADJUSTMENT
1.00	2	A-WEIGHTED SOUND LEVEL ONLY
0.00	3	HEIGHT ADJUSTMENT FOR PASSENGER CARS (CARS)
8.00	4	HEIGHT ADJUSTMENT FOR HEAVY TRUCKS (HT)
2.30	5	HEIGHT ADJUSTMENT FOR MEDIUM TRUCKS (MT)

0ROADWAY 1 NB35

VEHICLE TYPE	VEHICLES/HOUR	SPEED
CARS	3318.	67.
HT	330.	67.
MT	270.	67.

0 -------------COORDINATES-------------

	X	Y	Z	GRADE
NB1	0.0	1000.0	0.0	0
NB2	0.0	-1000.0	0.0	0

Example MINNOISE Output Sheet (Reflective) Cnt'd

```
0ROADWAY  2    SB35


                VEHICLE TYPE   VEHICLES/HOUR    SPEED
                CARS            3300.      67.
                HT             324.      67.
                MT              164.      67.
0                ------------COORDINATES-------------
                   X        Y         Z     GRADE
SB1                   47.0    -1000.0       0.0     0
SB2                   47.0    1000.0       0.0     0
1BARRIER  1  TYPE(R)   BARRIER1(EAST)
0          ---------COORDINATES----------
           X        Y         Z         Z0         DELZ   P
STA1        -67.0   -1000.0      27.6       10.0      2.0   2
STA2        -67.0    1000.0      27.6       10.0
1BARRIER  2  TYPE(R)   BARRIER2(WEST)
0          ---------COORDINATES----------
           X        Y         Z         Z0         DELZ   P
STA1        116.0   -1000.0      33.0       7.0      2.0   2
STA2        116.0    1000.0      33.0       7.0


BARRIER LENGTH BY SECTION
 2000.00  2000.00
1RECEIVERS
0                ------------COORDINATES-------------
                   X        Y         Z
RWALL                   -66.9       0.0       29.6
R50                 -117.0       0.0      14.5
R100                 -167.0       0.0      14.4
R200                 -267.0       0.0      14.4
1  ALPHA FACTORS - ROADWAY ACROSS,RECEIVER DOWN

 1 * 0.0 0.0
 2 * 0.5 0.5
 3 * 0.5 0.5
 4 * 0.5 0.5
1  SHIELDING FACTORS - ROADWAY ACROSS,RECEIVER DOWN

 1 * 0.0 0.0
 2 * 0.0 0.0
 3 * 0.0 0.0
 4 * 0.0 0.0
```

Example MINNOISE Output Sheet (Reflective) Cnt'd

1TH35 BLOOMINGTON,SITE3,MEAS1

0RECEIVER	LEQ(H)	SIG	L10	L50	L90
RWALL	83.5	2.1	85.7	83.0	80.4
R50	65.4	1.4	67.0	65.2	63.4
R100	65.0	1.4	66.6	64.8	63.1
R200	63.6	1.3	65.1	63.4	61.8

Example MINNOISE Input Sheet (Reflective)

```
*NNY
TH35 BLOOMINGTON,SITE3,MEAS1
1,3
2,2
NB35
'CARS' 3318,67
'MT' 270,67
'HT' 330,67
'L'/
'NB1' 0,1000,0,0
'NB2' 0,-1000,0,0
'L'/
SB35
'CARS' 3300,67
'MT' 164,67
'HT' 324,67
'L'/
'SB1' 47,-1000,0,0
'SB2' 47,1000,0,0
'L'/
3,2
BARRIER1(EAST)
'STA1' -67,-1000,27.6,10,2,2
'STA2' -67,1000,27.6,10
'R'/
BARRIER2(WEST)
'STA1' 116,-1000,33,7,2,2
'STA2' 116,1000,33,7
'R'/
5,4
RECEIVERS
'RWALL' -66.9,0,29.6
'R50' -117,0,14.5
'R100' -167,0,14.4
'R200' -267,0,14.4
6,1
ALPHA FACTORS
0.0 0.0
0.5 0.5
0.5 0.5
0.5 0.5
6,2
```

Example MINNOISE Input Sheet (Reflective) Cnt'd

SHIELDING FACTORS
0 0
0 0
0 0
0 0
7/

Acknowledgment of Assistance:

Name	Location	Assistance
Marilyn Jordahl-Larson	Office of Environmental Services	Data verification, Editing
Bill Rose	Metro Planning	Data collection
Roger Sadecki	Office of Environmental Services	Site Location, Mapping, Data collection, Modeling, Analysis, Editing
Lyle Tiemann	Office of Environmental Services	Site location, Mapping, Data Collection
Pete Wasko	Metro Planning	Data verification, Editing