6.0 NOISE

6.1 Introduction

6.1.1 Characteristics of Noise

Noise is defined as unwanted or excessive sound. Sound becomes unwanted when it interferes with normal activities such as sleep, work, or recreation. The individual human response to noise is subject to considerable variability since there are many emotional and physical factors that contribute to the differences in reaction to noise.

Sound (noise) is described in terms of loudness, frequency, and duration. Loudness is the sound pressure level measured on a logarithmic scale in units of decibels (dB). For community noise impact assessment, sound level frequency characteristics are based upon human hearing, using an A-weighted (dBA) frequency filter. The A-weighted filter is used because it approximates the way humans hear sound. Table 6-1 presents a list of common indoor and outdoor sound levels. The duration characteristics of sound account for the time-varying nature of sound sources.

The most common way to account for the time-varying nature of sound (duration) is through the equivalent sound level measurement, referred to as L_{eq}. The L_{eq} averages the background sound levels with short-term transient sound levels and provides a uniform method for comparing sound levels that vary over time. The time period used for highway noise analysis is typically one hour. The peak hour L_{eq} represents the noisiest hour of the day/night and usually occurs during the peak periods of automobile and truck traffic. FHWA and NHDOT guidelines (discussed in Section 6.1.2) require the use of the one-hour L_{eq} for assessing highway noise impacts on different land uses.

The following general relationships exist between hourly traffic noise levels and human perception:

- A 1 or 2 dBA increase/decrease is not perceptible to the average person.
- A 3 dBA increase/decrease is a doubling/halving of acoustic energy, but is just barely perceptible to the human ear.
- A 10 dBA increase/decrease is a tenfold increase/decrease in acoustic energy, but is perceived as a doubling/halving in loudness to the average person.

Table 6-1
Examples of Common Sounds (A-weighted (dBA) Sound Level in Decibels)

A-weighted	Overall Level	Noise Environment
120	Uncomfortably loud (32 times as loud as 70 dBA)	Military jet airplane takeoff at 50 feet
100	Very loud (8 times as loud as 70 dBA)	Jet flyover at 1,000 feet Locomotive pass-by at 100 feet
80	Loud (2 times as loud as 70 dBA)	Propeller plane flyover at 1,000 feet. Diesel truck 40 mph at 50 feet
70	Moderately loud	Freeway at 50 feet from pavement edge Vacuum cleaner (indoor)
60	Relatively quiet (1/2 as loud as 70 dBA)	Air condition unit at 100 feet. Dish washer at 10 feet (indoor)
50	Quiet (1/4 as loud as 70 dBA)	Large transformers Small private office (indoor)
40	Very quiet (1/8 as loud as 70 dBA)	Birds calls. Lowest limit of urban ambient sound
10	Extremely quiet	Just audible (1/64 as loud as 70 dBA)
0		Threshold of hearing

6.1.2 Federal and State Highway Noise Policy

The Federal Aid Highway Act of 1970 required FHWA to develop noise standards for mitigating highway traffic noise. The law required the promulgation of traffic noise level criteria for various land use activities. FHWA developed traffic noise procedures and guidelines applicable to federally-aided highway projects. These procedures and guidelines are described in 23 C.F.R. § 772.7 and FHWA's *Highway Traffic Noise Analysis And Abatement Policy and Guidance* (FHWA, June 1995). These documents specify the requirements that state highway agencies must meet, in order to protect public health and welfare, when using federal funds for highway projects. These requirements include:

- Identification of land uses or activities that may be affected by traffic noise.
- Determination of existing noise levels through measurement of current conditions.
- Prediction of traffic noise for the No Build and Build Alternatives.
- Identification of noise impacts.
- Evaluation of noise abatement measures to reduce noise impacts.

For motor vehicle noise FHWA has developed Noise Abatement Criteria (NAC) based on the noise sensitivity of various land uses. These criteria are presented in Table 6-2.

Table 6-2
Noise Abatement Criteria (NAC)

Activity Category	Noise Abatement Criteria L_{eq} (dBA)	Description of Activity Category
A (Exterior)	57	Tracts of land for which serenity and quiet are of extraordinary significance and serve an important public need, and where the preservation of those qualities is essential if the area is to continue to serve its intended purpose. Such areas could include amphitheaters, particular parks or portions of parks, open spaces, or historic districts dedicated or recognized by appropriate local officials for activities requiring special qualities of serenity and quiet.
B (Exterior)	67	Picnic areas, recreation areas, playgrounds, active sports areas, and parks that is not included in Category A; and residences, motels, hotels, public meeting rooms, schools, churches, libraries and hospitals.
C (Exterior)	72	Developed lands, properties or activities not included in Categories A or B above.
D	--	Undeveloped lands.
E (Interior)	52	Residences, motels, hotels, public meeting rooms, schools, churches, libraries, hospitals and auditoriums.

Source: 23 C.F.R. Part 772 Table 1

A project is defined as having a noise impact when:

- Projected future traffic sound levels approach by one decibel, are at, or exceed the NAC shown in Table 6-2; or
- Projected future traffic sound levels substantially (equal to or greater than 15 dBA) exceed existing sound levels.

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FHWA's regulations do not define approach or substantially increase; however, these terms are defined in NHDOT's *Policy and Procedural Guidelines for the Assessment and Abatement of Highway Traffic Noise for Type I Highway Projects*. NHDOT defines "approach" as being within 1 dBA of the FHWA NAC for the corresponding land use category. NHDOT defines "substantially exceed" as 15 dBA or greater than the existing noise levels.

Where noise impacts are identified, mitigation measures, as specified in 23 C.F.R. § 772.13, may be considered either at the roadway, along the path of the noise or, in limited situations, at the noise receptor. NHDOT's noise policy provides guidance on the process and considerations in evaluating potential noise mitigation measures. Noise mitigation measures must be feasible and

reasonable. Feasibility deals with engineering and safety considerations (e.g. can a barrier be built given the existing geometry and topography). In order for a noise barrier to be considered feasible, the NHDOT noise policy requires the barrier to result in at least a 5 dBA noise reduction. Reasonableness is determined by multiple factors described in the NHDOT noise policy, including:

- Cost effectiveness index (cost per dwelling unit receiving protection),
- Timing of development in relation to the construction of the highway,
- Land use,
- Future noise levels greater than or equal to 66 dBA,
- Build vs. No Build noise levels,
- Views of the impacted receptors, and
- Unusual circumstances.

6.2 Summary of 2004 FEIS Analysis and Record of Decision Commitments

The study area for the 2004 FEIS noise analysis was 1,000 feet on either side of I-93 between Salem and Manchester, New Hampshire. The study area was surveyed to identify receptor sites with outdoor activities sensitive to highway noise. Existing noise levels were determined at selected locations that contained noise-sensitive uses. Most of the receptor locations fall into the FHWA's "Activity Category B" while others fall under "Activity Category C."

The noise study area was subdivided into 35 locations, within which approximately 1,000 receptor sites were identified along the I-93 corridor. Future noise levels were calculated using the FHWA Traffic Noise Model (TNM) - Version 1.1. Measured existing noise levels were used to calibrate the noise model. The predicted future Build condition noise levels were then compared to FHWA's and NHDOT's NAC. Where noise impacts were identified, recommended mitigation measures were evaluated to determine if they were "reasonable" and "feasible" as defined by NHDOT noise policy.

The 2004 FEIS found that 2020 sound levels under the 2005 Selected Alternative would vary from 49 to 75 dBA, which represents up to a 5 dBA increase over existing sound levels. Noise impacts were predicted at 319 out of the approximately 1,000 receptors identified within the 35 noise study locations. The 2004 FEIS noise mitigation analysis recommended the installation of 11[1] noise barriers ranging between 12 and 14 feet in height and having a combined length of approximately 5.6 miles. The proposed barriers would abate noise for 238 impacted receptors as well as 102 non-impacted receptors, resulting in a total of 340 benefited receptors, while meeting the reasonable and feasible mitigation criteria in NHDOT's noise policy. The proposed noise barrier locations are shown in Figures 3.8.1 through 3.8.23 of the 2004 FEIS and are described in greater detail in Appendix F of the 2004 FEIS.

[1] Noise barriers were recommended at 12 locations in the 2004 FEIS. However, the noise barriers recommended at Location 7 and Location 9 were proposed to be combined. Thus, 11 individual barriers were proposed.

6.3 Methodology

6.3.1 I-93 Mainline

Noise Barrier Design Refinements and Reevaluations

As part of the final design process, NHDOT has continued to refine the design of the noise barriers proposed in the 2004 FEIS, as well as conduct evaluations of additional potential barrier locations. The updated noise barrier evaluations utilized the current version of the FHWA traffic noise model (TNM 2.5), final design roadway geometrics and updated survey data collected along the I-93 corridor. The process has included the reevaluation of noise barriers in locations where additional residential receptors have been constructed since the noise evaluation for the 2004 FEIS (e.g. Squire Armour Road in Windham). The detailed methodology and results of these noise barrier evaluations are reported in the following memorandums:

- Memorandum to Charles Hood, NHDOT from Thomas Wholley, VHB. RE: *I-93 Final Design Salem- Noise Barriers*. September 27, 2006. (Locations 1, 4 and 6).

- Memorandum to Charles Hood, NHDOT from Thomas Wholley, VHB. RE: *I-93 Final Design Salem and Windham- Noise Barriers*. October 6, 2006. (Locations 7, 8 and 9).

- Memorandum to Charles Hood, NHDOT from Thomas Wholley, VHB. RE: *I-93 Final Design: Noise Barriers Northern Segment: Derry -Manchester*. August 15, 2008. (Locations 19, 23, 24, 27, and 28).

- Memorandum to Charles Hood, NHDOT from Thomas Wholley, VHB. RE: *I-93- Noise Barriers Squire Armour*. February 12, 2009. (Location 10).

With the exception of the Squire Armour Road evaluation memo, the remainder of the noise evaluations conducted since the 2004 FEIS have been conducted using the 2004 FEIS 2020 traffic volume projections. The Squire Armour Road evaluation memo included consideration of SEIS Scenario 1 and Scenario 2 peak hour traffic volume projections.

Evaluation of SEIS Scenario 1 and Scenario 2 Traffic Volumes

The need to reanalyze noise impacts and mitigation along the I-93 mainline based on Scenario 1 and Scenario 2 traffic volumes was assessed based on the change in estimated future traffic volumes since the 2004 FEIS. Typically, a 100 percent increase in traffic volumes is needed to cause a barely perceptible (3 dBA) increase in noise levels.[2] Tables 6-3 and 6-4 summarize the percent change in peak hour traffic volumes between the 2004 FEIS results and the DSEIS Scenario 1 and Scenario 2 results. Since the increase in AM and PM peak hour volumes under Scenario 1 and Scenario 2 are less than 100 percent greater than the 2004 FEIS volumes, no perceivable increase in noise levels from those estimated in the 2004 FEIS is expected.

[2] See for example: California Department of Transportation Technical Noise Supplement, 1998. Page 15.

Therefore, other than the evaluations of design refinements and additional receptors noted above, the noise barrier analyses conducted for the 2004 FEIS do not need to be updated.

Table 6-3
AM Peak Hour
Comparison of I-93 Mainline Traffic Volumes Between the 2004 FEIS and SEIS Scenario 1 and Scenario 2

	2004 FEIS 2020 Build	Scenario 1 2020 Build		Scenario 2 2020 Build		Scenario 2 2030 Build	
		Traffic Volume	Percent Change from 2004 FEIS	Traffic Volume	Percent Change from 2004 FEIS	Traffic Volume	Percent Change from 2004 FEIS
NH State Line to Exit 1	9,800	11,460	17%	9,000	-8%	9,665	-1%
Exit 1 to Exit 2	7,750	9,580	24%	7,605	-2%	8,400	8%
Exit 2 to Exit 3	7,775	8,985	16%	7,440	-4%	8,240	6%
Exit 3 to Exit 4	5,550	8,520	54%	6,450	16%	7,105	28%
Exit 4 to Exit 4A**	5,300	7,770	47%	6,345	20%	6,925	31%
Exit 4A to Exit 5	5,300	9,275	75%	6,885	30%	7,820	48%
Exit 5 to I-293	6,175	9,410	52%	7,255	17%	7,960	29%

** Exit 4A was not included in the 2004 FEIS analysis.

Table 6-4
PM Peak Hour
Comparison of I-93 Mainline Traffic Volumes Between the 2004 FEIS and SEIS Scenario 1 and Scenario 2

	2004 FEIS 2020 Build	Scenario 1 2020 Build		Scenario 2 2020 Build		Scenario 2 2030 Build	
		Traffic Volume	Percent Change from 2004 FEIS	Traffic Volume	Percent Change from 2004 FEIS	Traffic Volume	Percent Change from 2004 FEIS
NH State Line to Exit 1	12,175	13,100	8%	10,410	-14%	11,535	-5%
Exit 1 to Exit 2	10,075	10,105	0%	8,250	-18%	9,375	-7%
Exit 2 to Exit 3	10,125	10,650	5%	8,615	-15%	9,975	-1%
Exit 3 to Exit 4	7,175	9,075	26%	7,415	3%	8,570	19%
Exit 4 to Exit 4A**	6,875	8,160	19%	7,440	8%	8,570	25%
Exit 4A to Exit 5	6,875	9,935	45%	8,475	23%	10,295	50%
Exit 5 to I-293	7,600	10,640	40%	8,850	16%	10,445	37%

** Exit 4A was not included in the 2004 FEIS analysis.

6.3.2 Secondary Roads

The Court Order requiring the preparation of this DSEIS did not require analysis of potential secondary road network noise impacts. However, a screening analysis for potential secondary roadway impacts was conducted to provide more information on the potential effects of the 2005 Selected Alternative. The secondary roadway noise screening analysis was conducted using FHWA's TNM 2.5 Look-up Tables. The objective of the look-up tables is to provide a quick screening tool in the form of pre-calculated TNM results for simple highway geometries.

Secondary roadways were selected for the screening analysis based on an evaluation of existing and future No Build and Build traffic data for Scenario 1 and Scenario 2. Three roadways with sensitive noise receptors were selected with the highest percentage increase in traffic volumes between existing and Build conditions and between No Build and Build conditions. Of the roadway segments with sensitive noise receptors, these roadways were expected to have the highest existing noise levels and would therefore be expected to have the highest increase in future build noise levels. The three roadway segments selected for analysis were:

- Main Street from Policy Street to NH 28/ Broadway;
- Folsom Road west of NH 28/Crystal Avenue; and
- Tsienneto Road east of NH 28/Crystal Avenue.

A review of the land use surrounding these roadways showed that most of the noise sensitive receptors fall under FHWA Activity Category B and are located a minimum of 55 feet from these roadways. Therefore, a receptor distance of 55 feet was used in the TNM Look-Up Tables. Noise levels were determined using Scenario 1 and Scenario 2, AM and PM peak hour traffic volumes and speeds.

6.3.3 Tolling Sensitivity Analysis

The tolling sensitivity analysis framework is explained in Chapter 1: Introduction. For noise, the tolling sensitivity analysis involved a secondary road analysis using the same methodology described in Section 6.3.2, except that roadway links were selected for analysis based on the percentage increase in traffic volumes between the Build with Toll and Build without Toll conditions. The three roadway links selected for the tolling sensitivity analysis were:

- NH 111A/Windham Road north of Nashua Road/Main Street;
- Lowell Road south of NH 111; and
- NH 28/Crystal Avenue south of Folsom Road/Tsiennetto Road.

A review of the land use surrounding these roadways showed that most of the noise sensitive receptors fall under FHWA Activity Category B and are located at a minimum of 100 feet from these roadways. Therefore, a receptor distance of 100 feet was used in the TNM Look-Up Tables.

6.4 Impacts and Mitigation

6.4.1 I-93 Mainline

Table 6-5 summarizes the changes in the noise impacts and mitigation measures as a result of design refinements and noise barrier reevaluations conducted since the 2004 FEIS.

At Location 10, a noise barrier was reevaluated based on the construction of additional residences on Squire Armour Road. Three alternative barrier configurations were considered in this area, but none would meet the NHDOT noise policy cost effectiveness index criterion ($30,000 per benefited residence). The possibility of extending the barrier proposed at Location 8 (May Lane Drive and Jewell Drive) to the Squire Armour Road area was evaluated, but the combined barrier would not meet the cost effectiveness index criterion.

At Location 28, the extension of the barrier proposed for the Bodwell Road area to cover new residences on Marathon Way met the cost effectiveness index criterion and was recommended.

In the Brickett Hill Road area in Manchester, a barrier was evaluated as part of the final design process, but was not recommended because it would not meet the cost effectiveness index criterion.

In addition to the evaluations summarized in Table 6-5, the update analysis also identified three locations from the 2004 FEIS that came the closest to meeting the NAC, but fell short. The three locations were:

- Location 14 East in Windham,
- Location 25 in Londonderry, and
- Location 26 in Londonderry

The cost per benefited receptor for noise barriers at these locations ranged from $56,000 at Location 26 to $140,000 at Location 25. Noise barriers are not recommended at these locations because they would not meet the cost effectiveness index criterion. It is possible that the increase in traffic volumes under the SEIS population and employment scenarios could result in one or more of these locations meeting the NAC. However, these locations would still not qualify for a noise barrier because they would not meet the cost effectiveness index criterion.

Table 6-5
Summary of Final Design Noise Barrier Evaluations

Location Number	Town	Location Description	2004 FEIS Analysis		Final Design Update Analysis	
			Number of Benefited Residences[1]	Noise Barrier Recommended	Number of Benefited Residences[1]	Noise Barrier Recommended
1	Salem	I-93 Northbound, including residences along Haigh Avenue, Streeter Avenue, Hanson Avenue, Spencer Avenue and Azarian Drive	90	Yes	90	Yes
4	Salem	I-93 Northbound, including residences along McLarnon Road, MacGregor Street, Mcfarland Road and South Policy Street.	22	Yes	24	Yes
6	Salem	I-93 Southbound, including residences along Lowell Road and Fern Road.	26	Yes	31	Yes
7 and 9	Salem and Windham	I-93 Northbound, including residences along Brookdale Road and South Shore Road.	29	Yes	25	Yes
8	Salem	I-93 Southbound, including residences along May Lane Drive and Jewell Drive.	19	Yes	18	Yes
10	Windham	I-93 Southbound, including residences along Squire Armour Road.	3	No	3-11	No
19	Derry	I-93 Northbound, including residences along Matthew Drive, Derryfield Road and Friar Tuck Lane.	26	Yes	50	Yes
23	Londonderry	I-93 Southbound, including residences along Trolley Car Lane.	28	Yes	28	Yes
24	Londonderry	I-93 Northbound, including residences along Seasons Lane.	19	Yes	21	Yes

Location Number	Town	Location Description	2004 FEIS Analysis		Final Design Update Analysis	
			Number of Benefited Residences[1]	Noise Barrier Recommended	Number of Benefited Residences[1]	Noise Barrier Recommended
27	Manchester	I-93 Northbound, including residences along Newton's Meadow Way.	36	Yes	45	Yes
28	Manchester	I-93 Northbound, including residences along Bodwell Road.	27	Yes	60[2]	Yes
N/A	Manchester	I-93 Northbound, including residences along Brickett Road and Cohas Avenue	N/A	N/A	12	No

1. A benefited residence receives a 5 dBA or greater reduction in sound levels as a result of the noise barrier.
2. Includes barrier extension to cover new residences on Marathon Way (north of Bodwell Road).

6.4.2 Secondary Roads

Scenario 1

Table 6-6 shows that noise levels along the secondary roadways would not be at, approach or exceed the Category B NAC (67 dBA) under the Scenario 1 Build condition. The difference in sound levels between existing conditions and the Build condition is less than 3.5 dBA in the AM and PM peak hours. No noise impacts are expected along secondary roadways based on the results of the screening analysis for Scenario 1; therefore no consideration of mitigation is warranted.

Table 6-6
Secondary Road Noise Screening Analysis
Scenario 1, 2020

Roadway	Distance from Roadway	Existing Leq (dBA)		AM Peak Leq (dBA)		PM Peak Leq (dBA)	
		AM Peak	PM Peak	No Build	Build	No Build	Build
Main Street: From Policy Street to NH 28/ Broadway	55	59.6	59.4	59.6	60.5	59.4	59.8
Folsom Road: West of NH 28/Crystal Avenue	55	59.9	61.2	63.1	63.2	64.2	64.4
Tsienneto Road: East of NH 28/Crystal Avenue	55	62.8	61.0	61.9	62.1	62.3	62.6

Scenario 2

Table 6-7 shows that noise levels along the secondary roadways would not be at, approach or exceed the Category B NAC (67 dBA) under the Scenario 2 Build condition. The difference in sound levels between existing conditions and the Build condition is 5.5 dBA or less in the AM and PM peak hours. No noise impacts are expected along secondary roadways based on the results of the screening analysis for Scenario 2; therefore no consideration of mitigation is warranted.

Table 6-7
Secondary Road Noise Screening Analysis
Scenario 2, 2020 and 2030

Roadway	Distance from Roadway	Existing Leq (dBA)		2020 AM Peak Leq (dBA)		2020 PM Peak Leq (dBA)		2030 AM Peak Leq (dBA)		2030 PM Peak Leq (dBA)	
		AM Peak	PM Peak	No Build	Build	No Build	Build	No Build	Build	No Build	Build
Main Street: From Policy Street to NH 28/ Broadway	55	59.6	59.4	62.1	64.1	62.0	63.2	60.2	61.7	59.9	61.4
Folsom Road: West of NH 28/Crystal Avenue	55	59.9	61.2	64.1	65.4	64.7	65.4	62.5	63.3	63.7	64.1
Tsienneto Road: East of NH 28/Crystal Avenue	55	62.8	61.0	63.0	64.3	63.5	64.6	61.9	62.8	62.3	63.2

6.4.3 Tolling Sensitivity Analysis

Table 6-8 shows that noise levels along the secondary roadways would not be at, approach or exceed the Category B NAC (67 dBA) under the Scenario 2 Build with Toll condition. While noise levels would increase (primarily on NH 111A) in the Build with Toll condition as compared to the Build without Toll condition, no noise impacts would occur and no consideration of mitigation is warranted.

Table 6-8
Secondary Road Noise Tolling Sensitivity Analysis
Scenario 2, 2020 and 2030

Roadway	Distance from Roadway	Existing Leq (dBA)		2020 AM Peak Leq (dBA)		2020 PM Peak Leq (dBA)		2030 AM Peak Leq (dBA)		2030 PM Peak Leq (dBA)	
		AM Peak	PM Peak	Build with Toll	Build w/o Toll	Build with Toll	Build w/o Toll	Build with Toll	Build w/o Toll	Build with Toll	Build w/o Toll
NH 111A/ Windham Road: North of Nashua Road/Main Street	100	50.5	48.6	55.2	52.6	54.6	52.1	57.6	54.4	57.4	54.0
Lowell Road: South of NH 111	100	56.3	54.6	57.1	58.1	56.4	56.9	58.1	58.3	57.8	57.8
NH 28 /Crystal Avenue: South of Folsom Road/ Tsiennetto Road	100	53.1	54.3	54.9	54.5	56.0	55.9	55.5	55.1	56.6	56.6

6.5 Conclusions

The final design noise barrier evaluations identified one barrier location (Location 28 in Manchester) where the barrier could be extended to cover new residential receptors and still meet the NHDOT noise policy cost effectiveness index criterion. While barriers were evaluated at other locations with new residential receptors, barriers in these locations would not be reasonable under the NHDOT noise policy (e.g. the cost per benefited receptor would be greater than $30,000). With some minor design refinements, noise barriers are still proposed at all the locations where noise barriers were recommended in the 2004 FEIS. The secondary road screening assessment did not identify any receptors which would approach, be at, or exceed the NAC based on Scenario 1 and Scenario 2 traffic volumes.