

CHAPTER 2 – METHODOLOGY AND COORDINATION

2.1 Characteristics of Noise

Sound is a disturbance created by a moving or vibrating source in a gaseous or liquid medium or the elastic stage of a solid and is capable of being detected by the hearing organs. Noise is defined as unwanted sound. It is emitted from many sources including airplanes, factories, railroads, power generation plants, and highway vehicles. Highway noise, or traffic noise, is usually a composite of noises from engine, exhaust and tire-roadway interaction. The magnitude of noise is usually described by its sound pressure. Because the range of sound pressure varies greatly, the logarithmic scale decibel (dB) is used to relate sound pressure. Sound pressures described in decibels are often defined in terms of frequency-weighted scales (A, B, C, or D).

The A-weighted decibel scale is used almost exclusively in vehicle noise measurements because it reflects the frequency range to which the human ear is most sensitive (1,000-6,000 Hertz). Sound levels measured using an A-weighted decibel scale are generally expressed as dBA. Throughout this technical report, all noise levels are expressed in dBAs. Several examples of sound pressure levels in dBA scale are listed in Table 2-1.

Table 2-1 indicates that most individuals in urbanized areas are exposed to fairly high noise levels from many sources as they go about their daily activities. The degree of disturbance or annoyance of unwanted sound depends essentially on three factors:

- The amount and nature of the intruding noise;
- The relationship between background noise and the intruding noise; and
- The type of activity occurring where the noise is heard.

Because sound is described on a logarithmic scale (i.e. dBA), sound levels cannot be added by ordinary arithmetic means. In fact, a doubling of the sound energy produces only a three dBA increase in the decibel level. Studies have shown that this increase is barely perceptible to the human ear, whereas a change of five dBA is readily perceptible. As a general rule, an increase or decrease of ten dBA in sound level is perceived by an observer to be a doubling or halving of the sound, respectively.

Because the sound pressure level unit of dBA describes a sound level at just one moment and very few sounds are constant, other ways of describing sound over more extended periods have been developed. One way of describing fluctuating sound is to describe the fluctuating sound heard over specific periods as if it had been a steady, unchanging sound. For this condition, a descriptor called the “equivalent sound level,” L_{eq} , can be computed. L_{eq} is the constant sound level that, in a given situation and period (e.g., 1 hour, denoted by $L_{eq(1)}$, or 24 hours, denoted as $L_{eq(24)}$), conveys the same sound energy as the actual time-varying sound. All sound pressure levels reported in this technical report will be $L_{eq(1)}$.

Table 2-1
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 at 10 AM 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

2.2 Regulatory Framework

The Federal Aid Highway Act of 1970 required FHWA to develop noise standards for mitigating highway traffic noise. The law requires the promulgation of traffic noise level criteria for various land use activities.

The FHWA has 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 under project operation.
- 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.
- Examination and evaluation of noise abatement measures to reduce or eliminate noise impacts.
- A general analysis of construction noise.
- Information for local officials

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 2-2.

**Table 2-2
Threshold for Noise Interference and 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 or exceed the NAC shown in Table 2-2 (noise levels that approach the criteria as defined by the State DOT); or
- Projected future traffic sound levels substantially exceed existing sound levels.

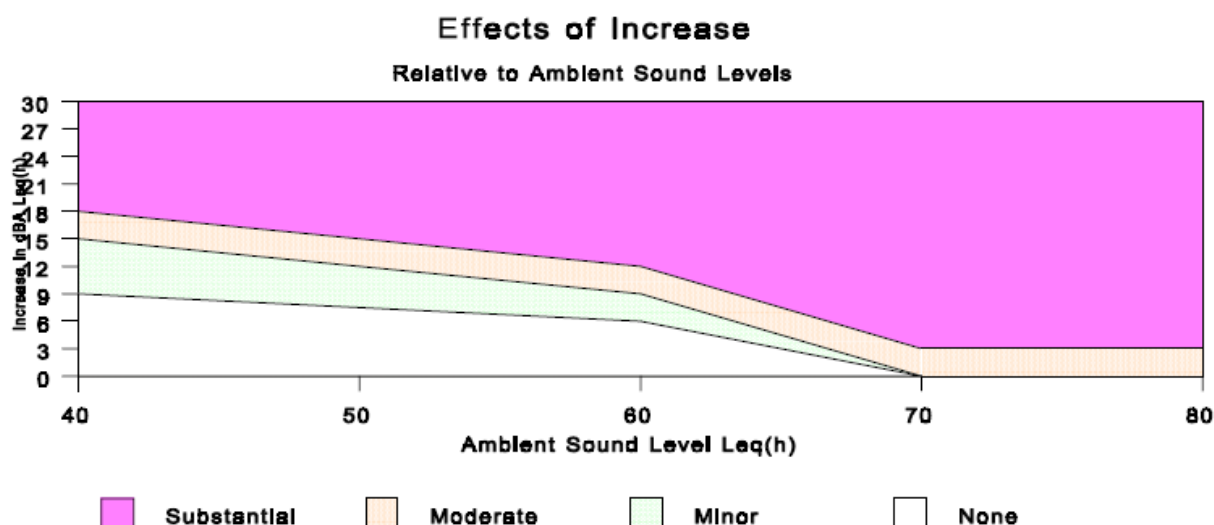
For example, the FHWA NAC for Category B land uses, including residences, is sixty-seven dBA. Noise levels that approach the NAC are defined as one dBA less than the criterion level, or sixty-six dBA for Category B land uses.

Where the noise impact assessment shows an impact, 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. More specifically, these measures may include:

- Physical barriers, typically in the form of noise walls between the roadway (noise source) and the receptor locations.
- Traffic management measures that alter vehicle type, speed, volume, and/or time of operations may be effective noise abatement measures.
- Highway alignment alterations, such as shifting the roadway away from noise receptors or depressing the roadway into the ground, can potentially reduce noise impacts.

- Establishment of buffer zones for mitigation purposes requires the acquisition of property.
- Noise insulation is an additional type of mitigation that applies to public buildings, such as schools, and includes the installation of improved acoustical windows and doors to reduce interior noise levels only.

The noise impact evaluation criteria for this project are in agreement with the NAC established by the FHWA in 23 C.F.R. § 772.3 and criteria developed by VTrans in its Transportation Noise Analysis and Abatement Policy, (VTrans, 1997). In accordance with FHWA requirements, VTrans established its Noise Analysis and Abatement Policy in July 1997 for the purpose of providing a basis for statewide uniformity in the analysis of transportation-generated sound, the identification of potential transportation project impacts, and the implementation of noise abatement measures determined to be reasonable and feasible. Under the VTrans policy, future traffic noise levels will be considered as an impact, if they approach or exceed the NAC established in 23 C.F.R. § 772.3 or substantially exceed the existing ambient sound levels. Under this policy, approach has been defined as commencing at one dBA below an NAC; “substantially exceed existing noise levels” has been defined as an increase relative to existing ambient sound levels which has substantial effect (see illustration below).



Source: VTrans. August 2001.

This allows for a progressive scale for dBA increase over existing sound levels for determining substantial noise increases at noise receptors. For example if the existing sound level for a noise receptor is forty dBA , the future sound level according to VTrans’ chart in Figure 2-1 must increase by eighteen dBA to fifty-eight dBA to be considered a substantial increase over the existing sound level. However, if the existing sound level for a noise receptor is fifty dBA, the future sound level need only increase by fifteen dBA to sixty-five dBA to be considered a substantial increase over the existing sound level.

When potential impacts are identified, VTrans will consider noise abatement measures and make a determination regarding the feasibility and reasonableness of such measures. VTrans policy states that only abatement measures which have been determined to be feasible and reasonable will be incorporated in projects. Feasibility depends primarily on engineering

considerations, such as the local topography, safety, road maintenance requirements, or the ability to achieve at least a five dBA reduction in noise at an impacted receptor. Findings based upon common sense and good judgment should be cited in the determination of reasonableness. Factors such as the ability to achieve at least a ten dBA reduction in noise for at least one first row receptor, the number of receptors that will benefit from the noise barrier, the cost of the noise barrier per benefited receptor, neighborhood opinions, and environmental effects are considered when determining reasonableness.

VTrans coordinates with local governments to support compatible land use development. VTrans will identify noise receptors within project corridors which are on or along developed land. VTrans will also identify noise receptors on undeveloped land for which development is planned, provided such development includes activity sites of the types described in the NAC and provided that state and local permits for the development have been acquired or applied for on or before commencement of the noise analysis. VTrans policy addresses the responsibility of local governments and district environmental commissions under Act 250, to regulate development in such a way that developments involving noise sensitive land uses adjacent to highways are planned, designed and constructed so as to eliminate or minimize noise effects.

The date of public knowledge for a Federal-aid highway project is the date of approval of the NEPA document for that project. Developments which occurred in the vicinity of an existing highway improvement project or a new highway project after the date of public knowledge will not be provided noise abatement by VTrans.

2.3 Noise Measurements

Noise measurements were taken to determine existing noise levels. Noise receptors were identified within the project area in accordance with 23 C.F.R. § 772.9. Noise receptors are those receptors for which exposure to excessive sound levels might be detrimental. Typically, the type of land use defines what range of sound levels is considered acceptable. Noise receptors typically include residences, schools, churches, hospitals, nursing homes, hotels, motels, libraries, picnic areas, outdoor recreational areas, playgrounds, and parks. Specific concern is given to the receptor's outdoor use area, as is the case with residential dwellings with yards or motels and hotels with swimming pools.

The selection of representative receptors for measurement was designed to maximize the understanding of the variety of roadway-receptor configurations that currently exist (e.g., topography, distance, traffic volumes, etc.). An objective of the receptor selection was to select at least one receptor point in each of the major residential areas along the project corridors and to include the worst-case receptor sites (worst noise exposure) wherever possible.

Short-term sound levels during the AM period peak (7:15-8:15), Midday hours (8:15AM-4:30PM), and PM period peak (4:30-5:30) were measured at twelve noise receptor locations, and long-term (twenty-four hour) noise measurements were conducted at three locations. Noise measurements were collected during the week of November 14, 2005 but due to winter precipitation, some of the sites did not have complete measurements for all peak hours. Measurements were later collected on March 28th and 29th of 2006 for those sites located on VT 2A which had incomplete PM data. All noise measurement locations are depicted in Figure 3-1 in Chapter 3.

To verify existing noise conditions in the project corridors, existing A-weighted noise levels were measured in accordance with VTrans *Traffic Noise and Abatement Policy*, and FHWA's *Measurement of Highway-Related Noise: Final Report* (FHWA-PD-96-046). Measurements at

each identified site were conducted in order to verify the baseline noise environment of the project area. Bruel & Kjaer 2236, 2260, and Rion NL-21 Precision Sound Level Meters (SLM) were utilized for field measurement. The SLMs meet or exceed the requirements set forth in the ANSI S1.4-1983 Standards for Type 1 and 2 quality and accuracy. Acoustical calibrators (Bruel & Kjaer 4230 and 4231) were used to calibrate the SLMs for each measurement interval.

The SLMs were operated on the A-weighting network and slow-meter response, as recommended by FHWA. Measurements were not collected if roadway pavement was wet, or if wind speed exceeded twelve miles per hour. A porous windscreen was used on each SLM during all measurement periods. All of the measurements were taken by mounting the SLMs approximately five feet above the sidewalk or ground surface at each receptor. This height is generally considered representative of ear level of an average person. Wherever possible, measurement sites were located in open areas away from buildings or other potentially reflective surfaces, but which were representative of the outdoor use area of a given receptor.

2.4 Noise Model

The FHWA traffic noise model, TNM 2.5, was used for the noise computations as required for all federally funded highway projects that begin after October 14, 2004 (FHWA, 2004). TNM 2.5 input is based on a three-dimensional model created for the terrain of the study area being modeled. All roadway, barrier and receiver points are defined by their x, y, and z coordinates. Roadways and barriers are coded into TNM 2.5 as line segments defined by their end points. Receivers, defined as single points, are typically located at noise receptors such as residences, schools, and recreational areas. Receivers were modeled at a height of five feet above ground elevation.

PM peak hour traffic volumes were used in the noise model because the future traffic volumes for the PM were in most cases larger than the future traffic volumes for the AM. The highest traffic noise levels occur when traffic is heavy, but remains free-flowing. Where future traffic PM peak hour traffic volumes were not available, level of service (LOS) C was used to represent the worst-case future noise condition.

2.4.1 Data Inputs for Noise Modeling

The following information was used to develop inputs for the noise models:

- The 1"=100' scale topographic maps of the project area corridors were utilized to establish existing roadway horizontal and vertical geometries and terrain features;
- Aerial maps of 1"=100' scale were utilized for the identification of noise sensitive land uses and receptors in the project area; and
- Existing traffic data obtained from the traffic analysis prepared for the project, including peak hour volumes and vehicle composition, were reviewed to identify seasonal, weekly, and diurnal traffic changes and peak traffic conditions.