MDOT Highway Noise Analysis and Abatement Handbook

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2.0 STEP 2 – Noise Analysis Procedures

2.1 Consideration of Areas Sensitive to Noise

The entire project limits of a transportation improvement project will be surveyed for noise sensitive land use areas during its Planning and Scoping Phases. Local officials must be contacted to determine if vacant land is currently permitted for development, or is likely to be permitted prior to the date of public knowledge. Aerial photography and field reconnaissance are necessary for identifying and/or verifying the location of noise-sensitive land uses and highway traffic noise sources. Land uses that are sensitive to transportation noise impacts are identified in FHWA's Noise Abatement Criteria (NAC) table, see Section 2.3 with Table 1 (page 10).

2.2 Common Noise Environment (CNE) Determination

CNEs should be delineated as areas of common highway traffic noise influence throughout the entire project limits of the proposed transportation improvement project. CNE boundaries typically do not traverse over any major and/or substantial highway traffic noise influence source (i.e., existing or proposed roadways). Grouping similar areas into CNEs also assists in evaluating mitigation, organizing reports, and facilitating discussions.

NOTE - *Developed and Developing Lands: Permitted Developments*

Highway traffic noise analyses will be performed for developed lands as well as undeveloped lands when they are considered permitted developments. Undeveloped lands will be deemed to be permitted if a noise-sensitive receptor listed in Table 1 (page 10) under Categories B, C and E has received a building permit from the local agency with jurisdiction at the time of the date of public knowledge. Undeveloped lands without building permits will be analyzed to identify a buffer zone to inform local officials where noise compatible land use zoning or development should be considered to avoid future traffic noise impacts for sensitive receptors.

In the case of a subdivision, if at least one building permit within the approved development plan has been received from the local agency with jurisdiction at the commencement of the EPE Phase highway traffic noise analysis, then the entire subdivision will be deemed to be permitted. When the proposed subdivision is a phased development, MDOT should only consider noise abatement when a building permit is issued within the phase within the traffic noise impact zone or buffer. If the phase with a permitted lot is outside of the traffic impact zone, then the subdivision will not be considered for abatement.

2.3 FHWA Noise Abatement Criteria (NAC) Land Use Activity Categories

The land uses must be identified based on the FHWA Noise Abatement Criteria (NAC) which separates land uses into activity categories based upon similar activities and assigns each an A-weighed decibel level. The levels aid MDOT in identifying noise impacts. Section 3.3.1 details how MDOT defines an impact.

Table 1 **FHWA Noise Abatement Criteria (NAC)[1]**
Hourly A-Weighted Sound Level in Decibels (dB(A))

Activity Category	Activity Criteria[2]		Evaluation Location	Activity Description
	Leq(h)[3]	L10(h)[4]		
A	57	60	Exterior	Lands on 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.
B[5]	67	70	Exterior	Residential
C[5]	67	70	Exterior	Active sport areas, amphitheaters, auditoriums, campgrounds, cemeteries, day care centers, hospitals, libraries, medical facilities, parks, picnic areas, places of worship, playgrounds, public meeting rooms, public or nonprofit institutional structures, radio studios, recording studios, recreation areas, Section 4(f) sites, schools , television studios, trails, and trail crossings
D	52	55	Interior	Auditoriums, day care centers, hospitals, libraries, medical facilities, places of worship, public meeting rooms, public or nonprofit institutional structures, radio studios, recording studios, schools, and television studios
E[5]	72	75	Exterior	Hotels, motels, offices, restaurants/bars, and other developed lands, properties or activities not included in A-D or F.
F	----	----	----	Agriculture, airports, bus yards, emergency services, industrial, logging, maintenance facilities, manufacturing, mining, rail yards, retail facilities, shipyards, utilities (water resources, water treatment, electrical), and warehousing
G	----	----	----	Undeveloped lands that are not permitted

[1] MDOT defines a noise impact as a 10 dB(A) increase between the existing noise level to the design year predicted noise level, OR a predicted design year noise level that is 1 dB(A) less than the levels shown in Table 1.
[2] Either Leq(h) or L10(h) (but not both) may be used on a project. MDOT uses Leq(h). The Leq(h) and L10(h) Activity Criteria values are for impact determination only, and are not design standards for noise abatement measures.
[3] Leq is the equivalent steady-state sound level which in a stated period of time contains the same acoustic energy as the time-varying sound level during the same time period, with Leq(h) being the hourly value of Leq.
[4] L10 is the sound level that is exceeded 10 percent of the time (90th percentile) for the period under consideration, with L10 being the hourly value of L10.
[5] Includes undeveloped lands permitted for this activity category

2.4 Determination of Existing Conditions

2.4.1 Selecting Monitored and Modeled Receptor Sites

Areas to be considered for the placement of monitored and/or modeled receptor sites should include individual sites that are in close proximity and could be impacted by the project. The location of monitored and modeled receptor sites should be consistent throughout the entire project limits.

NOTE – *Calibration of Noise Meters*:

All highway traffic noise meters and acoustical field calibrators should be calibrated once a year or in accordance with manufacturers' specifications. A copy of the certificate of calibration for each piece of equipment used in the study for the period that highway traffic noise monitoring occurred for the proposed transportation improvement project should be included in the project technical files.

2.4.1.1 Field Measurement/Monitor Sites

A monitored receptor site should be placed in every CNE area with attempts to represent an entire community as a whole. Field measurement, or monitoring, is primarily used to confirm that the TNM model inputs reflect site conditions, so only a few representative sites are necessary. The monitoring should occur at the ROW line. Avoid placing monitors on private property. However, additional monitoring sites or sites located on private property may be required if the roadway noise is not the dominant source of noise, where there is unusual topography, or under special circumstances, such as U.S. Department of Housing and Urban Development (HUD) properties. MDOT Lansing Office should be consulted in these cases. Modeled receptor sites for the purpose of TNM confirmation should the same site as the monitored site.

2.4.1.2 Modeled Receptor Sites

Modeled receptor sites for the purpose of determining existing conditions should be in all areas necessary in order to establish highway traffic noise impacts; to evaluate the noise barrier location, length, and height; to provide individual residential noise level information; as well as at specific locations due to the nature of the transportation improvement project (i.e., topography, locations of special concern). Professional judgment should be used when placing modeled receptor sites. FHWA requires giving primary consideration to exterior areas of human activity when locating modeled receptor sites (see NOTE – *Exterior Areas of Frequent Human Use* on the next page). Historic and Section 4(f) properties should also be included during the monitoring/modeling phase of the noise analysis. Please see Section 7.1.5 and Section 7.1.6 for additional information when considering historic and Section 4(f) properties.

NOTE – *Multi-family Dwelling Units*

When analyzing areas with multi-family dwelling units, such as apartments or condominiums, the analyst must identify all dwelling units' exterior areas of frequent human use which may experience highway traffic noise impacts. This may include units above the ground level, such as balcony/deck locations. Consider abatement for all identified highway traffic noise impacts and implement abatement that is feasible and reasonable.

NOTE – *Exterior Areas of Frequent Human Use*:

In accordance with Title 23 CFR 772.11(b):
"In determining traffic noise impacts, a highway agency shall give primary consideration to exterior areas where frequent human use occurs."

and Title 23 CFR 772.11 (c)(2)(iv):
"Activity Category D… A highway agency shall conduct an indoor analysis after a determination is made that exterior abatement measures will not be feasible and reasonable. An indoor analysis shall only be done after exhausting all outdoor analysis options. In situations where no exterior activities are to be affected by the traffic noise, or where the exterior activities are far from or physically shielded from the roadway in a manner that prevents an impact on exterior activities, the highway agency shall use Activity Category D as the basis of determining noise impacts…"

Contact MDOT Lansing Office Environmental Staff prior to performing interior monitoring activities.

2.4.2 Worst-Case Highway Traffic Noise Hour

Highway traffic noise analysis should begin by determining the worst-case existing noise hour(s) within the project area. The Region and, when needed, Lansing Office should discuss the traffic characteristics during the EPE Phase in order to adequately determine the worst-case highway traffic noise hour(s). As such, it is necessary to evaluate hourly traffic volume, speed, and composition to the extent such data are available. There are several techniques to help determine the existing worst-case highway traffic noise hour(s), including the following:

1. Evaluation of Peak and Off-Peak Traffic Data

   In most cases, experience has shown that the peak traffic hour is the noisiest hour of the day. However, on occasion, conditions such as capacity, effects on vehicle speed, higher-than-normal off-peak truck percentages, or unusual hourly traffic distribution may cause the noisiest hour of the day to be different from the peak traffic hour of the day. Evaluation may be based on the review

and/or analysis of historical traffic data, predicted traffic data, supplementary traffic counts, or a combination thereof.

2. 24-Hour Monitoring Sites with Evaluation of Diurnal Traffic Patterns

   If there is some question as to the worst-case highway traffic noise hour, it may be necessary to conduct 24-hour monitoring to determine the worst-case highway traffic noise hour(s). In this case, 24-hour monitoring should be done in conjunction with evaluating the existing diurnal traffic patterns to determine the existing worst-case highway traffic noise hour. The worst-case highway traffic noise hour may not necessarily correspond with the design year hour since traffic scenarios may vary as a result of the proposed transportation improvement project. Therefore, design year peak highway traffic noise hours will have to be confirmed using the existing 24-hour data, diurnal traffic patterns, and compositions. Major projects and projects with public controversy related to highway traffic noise may necessitate 24-hour monitoring. In these cases, the report will include projected 24-hour data, diurnal traffic patterns, and compositions.

3. Public Comment

   Public comment may also produce some helpful information on the noisiest day of the week or the noisiest hour of the day.

4. Combination of two or all of the above techniques

2.4.3 Monitoring Existing Noise Level Determination

Existing noise is the current noise level, comprised of all natural and man-made noises, considered to be usually present within a particular area's acoustic environment, including existing roadways. Existing noise levels are monitored for one or more of the following reasons:

- comparing noise measurements with the output from the FHWA TNM at locations currently influenced by existing highway traffic noise sources;
- determining existing noise levels for proposed roadways on a new alignment;
- assisting in determining the existing worst-case traffic noise hour (as referenced in Section 2.4.2); and/or
- supplementing other noise-related data in defining the existing noise environment.

2.4.4 Monitoring Unique Conditions

When a unique condition is proposed whereby highway traffic noise level predictions (derived by the techniques discussed above) cannot accurately assess the future acoustical environment, it may be necessary to monitor a similar location elsewhere if such a location has similar characteristics. Such a technique may be applicable to projects with parking lots, covered roadways, tunnels, transit facilities, extreme rough surface pavements, open-grated bridge decks, and parallel or multiple noise barriers, etc. This technique shall be used in coordination with the Region and Lansing Offices.

2.5 Noise Modeling (Prediction of Existing and Future Conditions)

2.5.1 FHWA Model

Noise modeling of existing and future roadways is an effective tool for predicting noise levels, noise impacts, and the potential benefits of noise abatement. The noise-modeling process includes several steps, which are outlined below. Generally, the modeling process includes noise model validation, modeling of worst-case traffic noise existing conditions, and modeling of future build-conditions associated with a proposed transportation improvement project.

The currently approved FHWA TNM2.5® is the required tool for the prediction of existing and future noise levels associated with transportation improvement projects. The FHWA TNM should be used only after a thorough understanding of this document and only by qualified individuals that have a thorough understanding of how to use the FHWA TNM, as defined in the Introduction section of this Handbook.

2.5.2 Traffic Speed Determination

23 CFR 772.9(d) states, "In predicting noise levels and assessing noise impacts, traffic characteristics that would yield the worst traffic noise impact for the design year shall be used." The posted speed or operating speed may be used to predict highway traffic noise levels on Type I and Type II projects. It is required to use the operating speed if it has been determined to be consistently faster than the posted speed limit. For proposed roadways, it may be difficult to determine the potential operating speed of the future roadway. In these situations, it is recommended to use the design speed.

Under no circumstances should any speed below posted be used for noise modeling purposes, even if congestion and slower speeds are anticipated in the peak travel hour(s). In congested corridors, it may be more appropriate to model off-peak travel hours, representing the balance of maximum vehicle volume traveling at maximum speeds. Refer to Section 2.4.2 - Worst-Case Highway Traffic Noise Hour to address this issue. According to FHWA Guidance, "loudest noise hour" usually occurs at a time when truck volume and vehicle speeds are the greatest, typically when traffic is at or near generally free-flowing conditions.

2.5.3 Field Measurement and Modeled Noise Levels Comparison

2.5.3.1 Purpose

Existing field measurement noise levels need to be compared with the FHWA TNM noise level predictions for the traffic conditions observed during the monitoring period, thereby verifying the accuracy of the computer model. This comparison of measured and modeled noise levels must be documented in the noise analysis report. The noise report must contain the measured and modeled noise level for each noise monitoring location in table format, with reported changes in noise level between the monitored and modeled value.

The monitoring methodology for the determination of existing conditions should be consistent with measurement procedures as stated in FHWA's *Measurements of Highway-Related Noise*, May 1996, and supplemented by professional judgment. Short-term noise field measurements, for modeling verification purposes, can be taken at any time with all noise measurements occurring under generally free-flow traffic conditions.

2.5.3.2 Limitations

These procedures are not applicable in situations where the existing acoustical environment is not dominated by an existing highway traffic noise source. TNM is not capable of accurately determining existing noise levels where highway traffic noise is not the dominant contributing acoustical characteristic. Generally, the procedures are intended for sites that are currently influenced by highway traffic noise and will be similarly affected by the proposed transportation improvement project. In areas dominated by background (non-roadway) noise sources, monitored noise levels should be used to determine existing worst-case noise levels in place of modeled noise levels, thereby accurately representing the existing noise environment. Professional judgment should be used when selecting sites to be used for determining worst-case noise levels in such areas.

2.5.3.3 Procedure

The noise modeling validation procedure typically is as follows.

1. Obtain short–term (15 minute) traffic noise level field measurements along the project corridor at the MDOT right-of-way line at one or two locations within a CNE depending on its length. Observe and record traffic volumes on all influencing roadways (classifying the appropriate vehicular types based on FHWA vehicle types) and determine the average vehicular speed (can be performed using radar equipment, driving through the project area, distance/time calculations, etc.).

2. Calculate the noise levels using the computer modeling software after having input the traffic characteristics witnessed during noise monitoring (expanded to one hour), site geometry, and any other pertinent existing features.

3. Compare the field-observed values to the predicted values. If the difference between the two values is less than ±3 dB(A), this is an indication that the model is within the accepted level of accuracy. If observed noise levels differ from modeled noise levels by greater than ±3 dB(A), a careful examination of the observed data and predicted data should be undertaken to determine the reason(s) for this margin of error. The qualified professional is required to reexamine the input parameters and look for obvious differences such as meteorology, pavement conditions, obstructions, reflections, non-traffic (background) noise sources, ground type, etc. In the event a logical explanation for the difference cannot be made, the field measurements at that location(s) should be repeated.

4. If the observed noise levels differ from the modeled noise levels by greater than ±3 dB(A), and after thorough examination of the observed and predicted data, it may be practical to establish an "adjustment factor" to be applied to modeling results in certain cases. Adjustment factors could also be applied if the difference between observed and modeled noise levels is less than ±3 dB(A). Adjustment factors should be used sparingly and not applied globally unless every measurement is off in the same direction by a similar amount. If that occurs, the issue is most likely due to an environmental factor. If adjustment factors are used, they must be discussed and documented. Contact the Lansing Office prior to establishing or implementing adjustment factors.

2.5.4 Determining Worst-Case Existing Conditions

Once the validation model is deemed accurate, the noise analyst must develop worst-case existing TNM data to predict worst-case existing noise levels within the project area. This step is accomplished by replacing the witnessed traffic data (during the monitoring phase) with worst-case existing traffic data derived from traffic engineers and applying these data to the existing roadway geometry.

Model receptor sites should be placed throughout the project area as described in Section 2.4.1. The existing worst-case noise levels then serve as a basis for the MDOT "substantial increase" noise abatement criteria. However, exclude measurements in areas dominated by extraneous, non-highway noises, such as: air compressors, barking dogs, leaf blowers, construction equipment, etc. Please refer to model validation limitations for more information.

2.5.5 Design Year Build Conditions

The final step of the noise impact modeling process (before abatement modeling) is the development of the future design year build conditions noise model. This assessment can include single or multiple build alternatives, depending on the magnitude of the environmental project (i.e., CE, EA, or EIS). Typically, CE assessments present one build alternative, EA documents can present one or multiple build alternatives, and EIS documents typically present multiple build alternatives. When multiple build alternatives are analyzed in an environmental document, noise levels, noise impacts, and potential noise abatement measures for each build alternative must be documented to the same level of detail.

In areas of a proposed project build alternative that contain no noise-sensitive receptors, noise modeling may not be necessary. However, in areas that contain noise-sensitive receptors, noise modeling should be detailed enough to identify all noise impacts and to thoroughly evaluate noise abatement feasibility and reasonableness (see Section 3.0). Future condition noise modeling is an evolving process, and noise model refinements are typically necessary throughout the process to determine the extent and locations of noise impacts, the number of impacted receptors, the effectiveness of noise abatement, and the number of benefited receptors. Additional modeling sites are often added throughout the modeling process to clearly define the depth of noise impact, the number of impacted receptors, and the number of benefited receptors.

The design year noise levels for each alternative can then be compared to the FHWA/MDOT noise abatement criteria and to existing noise levels to determine if noise impacts will occur for each project alternative. The FHWA/MDOT noise abatement criteria are discussed in detail in Section 2.3. If noise impacts occur, noise abatement must be considered.

NOTE – *MDOT's Definition of a Noise Impact*

MDOT identifies a noise impact as:

- a 10 dB(A) increase between the existing noise level to the design year predicted noise level, or
- a predicted design year noise level that is 1 dB(A) less than the NAC levels as shown in Table 1.

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