

FINAL REPORT

# Noise Measurement Field Guide

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U.S. Department of Transportation  
**Federal Highway Administration**

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## List of Abbreviations

AASHTO	American Association of State Highway and Transportation Officials
ANSI	American National Standards Institute
ASA	Acoustical Society of America
ASTM	American Society of Testing and Materials
CTIM	Continuous-Flow Traffic Time-Integrated Method
DAT	Digital Audio Tape
DNL	Day-Night Average Sound Level
DOT	Department of Transportation
EPA	Environmental Protection Agency
FAA	Federal Aviation Administration
FHWA	Federal Highway Administration
FRA	Federal Railroad Administration
FTA	Federal Transit Administration
GPS	Global Positioning System
HT	Heavy Trucks
IL	Insertion Loss
MT	Medium Trucks
NAC	Noise Abatement Criteria
NCHRP	National Cooperative Highway Research Program
OBSI	On-Board Sound Intensity
OINR	Outdoor-Indoor Noise Reduction
PPV	Peak Particle Velocity
REMEL	Reference Energy Mean Emission Level
SAE	Society of Automotive Engineers
SEL	Sound Exposure Level
SHA	State Highway Agency
SIP	Statistical Isolated Pass-By
SLM	Sound Level Meters
SPB	Statistical Pass-By
SPL	Sound Pressure Level
TNM	Traffic Noise Model

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## Introduction

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This field guide provides a series of checklists and steps for the proper development, planning, preparation, and execution of a noise measurement effort for many of the measurement methodologies in the FHWA *Noise Measurement Handbook*. Each chapter is intended to be a standalone set of pages to aid the person(s) conducting noise or vibration measurements. Included for each methodology are sets of steps for pre-trip planning, pre-trip preparations and on-site field data collection and sample data sheets. More information on measurement study planning is in the *Noise Measurement Handbook*, as are details on post-measurement data analysis and reporting. The handbook also contains detailed appendices on equipment and terminology. The information in this field guide is meant to serve as a baseline set of information that includes all the steps to conduct a successful field effort. **This field guide should be viewed as best-practice guidance and not direction as to how the work must be done. Some project sponsors have established and use their own procedures, which typically would be followed in the event of a conflict.**

## **1.0 Determination of Existing Noise Levels**

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The purpose of this type of measurement is to establish existing noise levels within a project study area. Examples of the application of this method include:

- Establishment exist noise levels to evaluate substantial increase determinations as part of the impact assessment for a proposed highway project along new alignment.
- Establish existing noise levels to help determine the effectiveness of noise abatement measures.

The field guidance below includes pre-trip planning, pre-trip preparation, and on-site set-up, data collection, documentation, and storage.

**Determination of Existing Noise Levels (Pre-trip Planning)**

Category	Tasks
Personnel	<ul style="list-style-type: none"> <li><input type="checkbox"/> Identify the personnel that will work on each task:                             <ul style="list-style-type: none"> <li><input type="checkbox"/> Measurement Planning_____</li> <li><input type="checkbox"/> Permissions_____</li> <li><input type="checkbox"/> Field Work_____</li> <li><input type="checkbox"/> Data Review_____</li> </ul> </li> <li><input type="checkbox"/> Brief team members.</li> </ul>
Site Selection	<ul style="list-style-type: none"> <li><input type="checkbox"/> Determine measurement areas</li> <li><input type="checkbox"/> Determine measurement sites</li> <li><input type="checkbox"/> Select primary noise measurement locations using available online aerial imagery and panoramic views.                             <p style="margin-left: 40px;"><i>Tip: Avoid choosing locations with permanent, localized, noise sources (pump houses, generators, HVAC or ventilation fans) that do not represent the general noise environment for project area.</i></p> <p style="margin-left: 40px;"><i>Tip: Consider difficulty in access to the site while choosing locations.</i></p> </li> <li><input type="checkbox"/> Identify secondary or alternative noise measurement locations in the event that local conditions prevent data collection at a primary noise measurement location.                             <p style="margin-left: 40px;"><i>Tip: Be mindful that localized noise sources that interfere with data collection at a primary noise measurement location may influence levels for adjacent properties. Choose secondary locations that are at least one residence or land use away from the primary noise measurement location.</i></p> </li> </ul>
Field review	<ul style="list-style-type: none"> <li><input type="checkbox"/> Visit each planned measurement site to confirm access.</li> <li><input type="checkbox"/> Observe local noise environment and evaluate if there are any potential noise sources that might interfere with data collection.</li> </ul>
Noise Descriptors	<ul style="list-style-type: none"> <li><input type="checkbox"/> Use <math>L_{eq}</math> as primary measurement descriptor.</li> <li><input type="checkbox"/> Consider collecting other descriptors that may help understand the measured noise during post processing (<math>L_{max}</math>, <math>L_{min}</math>, <math>L_{10}</math>, <math>L_{90}</math>).</li> </ul>
Sampling Period	<ul style="list-style-type: none"> <li><input type="checkbox"/> Determine appropriate sampling period for data collection. Periods of 1 minute, repeating intervals are suggested.</li> </ul>
Timing and Duration of Measurements	<ul style="list-style-type: none"> <li><input type="checkbox"/> Determine appropriate time (peak hours or off-peak hours, day or night) and required duration of the noise measurements based on SHA requirements.</li> </ul>



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Category	Tasks
Permissions	<ul style="list-style-type: none"> <li><input type="checkbox"/> Submit preliminary list of all potential addresses and locations for noise measurements to SHA.</li> <li><input type="checkbox"/> Contact owners 1-2 weeks ahead of data collection effort seeking permission for property access.</li> </ul>
Measurement Plan approval	<ul style="list-style-type: none"> <li><input type="checkbox"/> Develop and submit a detailed measurement plan to SHA (if required).</li> </ul>
Documentation	<ul style="list-style-type: none"> <li><input type="checkbox"/> Prepare adequate number of copies of data sheets.</li> <li><input type="checkbox"/> Prepare copies of mapping for note taking in the field.</li> <li><input type="checkbox"/> Prepare equipment pack list.</li> <li><input type="checkbox"/> Prepare contact list that includes SHA contact and local law enforcement.</li> </ul>

**Determination of Existing Noise Levels (Pre-trip Preparation)**

Category	Tasks
Instrumentation	<ul style="list-style-type: none"><li><input type="checkbox"/> Assemble instrumentation, accessories and supplies according to the pack list for this measurement technique.</li><li><input type="checkbox"/> Test the instrumentation that will be used for data collection, adjusting settings as needed.</li></ul>
Permissions	<ul style="list-style-type: none"><li><input type="checkbox"/> Make copies of permission letter from SHA authorizing your work for the project.</li><li><input type="checkbox"/> Contact local law enforcement the day before the measurements.</li></ul> <p style="text-align: center;"><i><b>Tip:</b> Describe planned locations, time(s) of day, vehicle make and model</i></p>

**Determination of Existing Noise Levels (On-site)**

Category	Tasks
Field review (if not conducted during pre-trip planning)	<ul style="list-style-type: none"> <li><input type="checkbox"/> Visit each planned measurement site to confirm access and observe local conditions.</li> </ul>
Site Appropriateness	<ul style="list-style-type: none"> <li><input type="checkbox"/> Determine if there are any localized, non-representative noise sources that interfere with the data collection.</li> <li><input type="checkbox"/> Move to alternative noise measurement location if needed.</li> </ul>
Instrumentation Setup	<ul style="list-style-type: none"> <li><input type="checkbox"/> Attach pre-amp and microphone (with microphone extension, if needed) to sound level meter.</li> <li><input type="checkbox"/> Turn on instrumentation and allow equipment to acclimate to outside conditions for several minutes.</li> <li><input type="checkbox"/> Check and, if needed, set and synchronize the time on all instrumentation (sound level meters, traffic counters, video cameras, cameras, watches).</li> <li><input type="checkbox"/> Check battery power level.</li> <li><input type="checkbox"/> Check that instrumentation settings are correct.</li> <li><input type="checkbox"/> Calibrate instrument before starting data collection (note initial calibration level and time on Field Data Sheet).</li> <li><input type="checkbox"/> Set microphone height at 5 ft (1.5 m) above the ground, unless another height has been specified in the plan.</li> </ul> <p style="text-align: center;"><i>Tip: Make sure the tripod is level and secure. Weigh the tripod down if there is a slope or if breezy wind conditions are expected.</i></p>
Documentation	<ul style="list-style-type: none"> <li><input type="checkbox"/> Fill out general information on the Measurement Summary Sheet (date, measurement site name, identifying information, observer name).</li> <li><input type="checkbox"/> Obtain noise measurement location coordinates using a GPS device or cell phone app.</li> <li><input type="checkbox"/> Note weather conditions on Measurement Summary Sheet:                         <ul style="list-style-type: none"> <li>o Temperature</li> <li>o Cloud cover</li> <li>o Wind speed</li> <li>o Wind direction</li> </ul> </li> <li><input type="checkbox"/> Create site sketch on Measurement Summary Sheet showing noise measurement location and any identifying structures, roadways and noise sources.                         <p style="text-align: center;"><i>Tip: Sketch should be of sufficient detail that another person can return to the site and set up at the same spot.</i></p> </li> <li><input type="checkbox"/> Take photographs of the microphone location (with instrumentation in place) from multiple directions.</li> <li><input type="checkbox"/> Take photographs and/or video documenting dominant noise sources.</li> </ul>

Category	Tasks
Data Collection	<ul style="list-style-type: none"> <li><input type="checkbox"/> Begin data collection.</li> <li><input type="checkbox"/> Note start time of data collection.</li> <li><input type="checkbox"/> Keep minute by minute notes of observed sound levels and sources.  <i>Tip: Develop and use a consistent shorthand for easier note-taking.</i></li> <li><input type="checkbox"/> Note the typical levels for predominant noise sources (man-made and natural sources).</li> <li><input type="checkbox"/> Note any changes in sound levels or weather conditions during the data collection.</li> <li><input type="checkbox"/> Take traffic counts for nearby roadways contributing to noise level (if needed).</li> <li><input type="checkbox"/> End data collection.  <i>Tip: If it is suspected or known that certain unrepresentative minutes' data will need to be eliminated from the result, then extend the data collection for the same number of additional minutes.</i></li> <li><input type="checkbox"/> Save or store the data to the instrument's memory if that is not an automated function.</li> <li><input type="checkbox"/> Note the data file name or number on the Measurement Summary Sheet.</li> <li><input type="checkbox"/> Perform a post-measurement calibration or calibration check before moving or shutting off the instrumentation (note post-measurement calibration level and time on Measurement Summary Sheet).</li> </ul>
Data Storage	<ul style="list-style-type: none"> <li><input type="checkbox"/> Download data files from instrumentation before leaving site.</li> <li><input type="checkbox"/> Create PDFs of all data sheets at the end of the day using phone camera to PDF app.</li> <li><input type="checkbox"/> Download photos from camera or cell phone.</li> <li><input type="checkbox"/> Back-up all data files and photos to thumb drive or external drive or email all files as an alternative backup method.</li> </ul>

**Determination of Existing Levels Pack List**

<p>Instrumentation</p>	<ul style="list-style-type: none"> <li><input type="checkbox"/> Sound level meters (include a spare if possible)</li> <li><input type="checkbox"/> Microphone extensions (if needed)</li> <li><input type="checkbox"/> Microphone mounts (if needed)</li> <li><input type="checkbox"/> Calibrator</li> <li><input type="checkbox"/> Tripods (include at least one spare)</li> <li><input type="checkbox"/> Windscreens (include at least one spare)</li> <li><input type="checkbox"/> Anemometer</li> <li><input type="checkbox"/> Compass</li> </ul>
<p>Equipment</p>	<ul style="list-style-type: none"> <li><input type="checkbox"/> Camera</li> <li><input type="checkbox"/> Laptop</li> <li><input type="checkbox"/> Data storage (USB flash drives or SD cards, if needed)</li> <li><input type="checkbox"/> Clipboards</li> <li><input type="checkbox"/> Cell phone</li> <li><input type="checkbox"/> Radios</li> <li><input type="checkbox"/> Digital watches (one for each field team member)</li> <li><input type="checkbox"/> Headlamps/flashlights</li> <li><input type="checkbox"/> Pocket knife/utility tool</li> <li><input type="checkbox"/> Tape measure</li> <li><input type="checkbox"/> Safety vests</li> <li><input type="checkbox"/> Hardhats</li> <li><input type="checkbox"/> Traffic cones</li> <li><input type="checkbox"/> Ground tarp</li> <li><input type="checkbox"/> Camp chair</li> </ul>
<p>Field Supplies</p>	<ul style="list-style-type: none"> <li><input type="checkbox"/> Data sheets</li> <li><input type="checkbox"/> Mapping</li> <li><input type="checkbox"/> Contact list</li> <li><input type="checkbox"/> Notepads</li> <li><input type="checkbox"/> Batteries (including spares for sound level meters, speed detection instrumentation, count boards and cameras)</li> <li><input type="checkbox"/> Pens</li> <li><input type="checkbox"/> Duct tape</li> <li><input type="checkbox"/> Zip ties</li> </ul>

**Determination of Existing Noise Levels—Measurement Summary Sheet**

Project Name	
Site/Address	
Observer Name	

**General Meteorological Conditions**

Temperature(s)	
Wind Speed(s)	
Wind Direction(s)	

**SLM/Analyzer Information**

SLM Model		SLM Serial #	
Mic. Height		Mic. Serial #	
Mic. Extension?		Data File Name/Number	

**Calibration Information**

	Pre-Measurement	Post-Measurement
Calibration Time		
Calibration Level		

**Site Sketch**

*(plan/profile view, distances, roadways, buildings, reflecting surfaces, ground type as appropriate)* (Indicate North)

The site sketch area consists of a large grid of 20 columns and 20 rows. In the top right corner of the grid, there is a star symbol (a six-pointed star with a central dot) used to indicate North.

**Determination of Existing Noise Levels—Field Log**

<b>Period #</b>	<b>Period Start Time</b>	<b>Event Description(s) (include event start and stop)</b>
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**Notes:**

**Determination of Existing Noise Levels—Field Log**

<b>Period #</b>	<b>Period Start</b>	<b>Event Description(s) (include event start and stop)</b>
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**Notes:**



## **2.0 Validation of the FHWA TNM for a Proposed Highway Project on Existing Alignment**

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The purpose of this measurement method is establishing noise levels for use in validating an FHWA TNM model run of the existing condition, which is done by comparison of the predicted existing levels to measured noise levels. The field guidance below includes pre-trip planning, pre-trip preparation, and on-site set-up, data collection, documentation, and storage.

**Validation of the FHWA TNM for a Proposed Highway Project on Existing Alignment  
(Pre-trip Planning)**

Category	Tasks
Personnel	<ul style="list-style-type: none"> <li><input type="checkbox"/> Identify the personnel that will work on each task:               <ul style="list-style-type: none"> <li><input type="checkbox"/> Measurement Planning_____</li> <li><input type="checkbox"/> Permissions_____</li> <li><input type="checkbox"/> Field Work_____</li> <li><input type="checkbox"/> Data Review_____</li> </ul> </li> <li><input type="checkbox"/> Brief team members.</li> </ul>
Site Selection	<ul style="list-style-type: none"> <li><input type="checkbox"/> Determine noise study areas where measurements will be needed.</li> <li><input type="checkbox"/> Determine approximate number of measurement sites.</li> <li><input type="checkbox"/> Select primary noise measurement locations.               <p style="margin-left: 40px;"><i>Tip: Avoid choosing locations with any permanent, localized, noise sources (pump houses, generators, HVAC or ventilation fans) that would interfere with measurement of the roadway noise source.</i></p> <p style="margin-left: 40px;"><i>Tip: Consider difficulty in access to the site while choosing locations.</i></p> </li> <li><input type="checkbox"/> Identify secondary or alternative noise measurement locations in the event that local conditions prevent data collection at a primary noise measurement location.               <p style="margin-left: 40px;"><i>Tip: Be mindful that localized noise sources that interfere with data collection at a primary noise measurement location may influence levels for adjacent properties. Choose secondary locations that are at least one residence or land use away from the primary noise measurement location.</i></p> </li> <li><input type="checkbox"/> Identify primary and secondary locations for collecting traffic counts.</li> <li><input type="checkbox"/> Identify primary and secondary locations for collecting speed data.</li> </ul>
Field review	<ul style="list-style-type: none"> <li><input type="checkbox"/> Visit each planned measurement site to confirm access.</li> <li><input type="checkbox"/> Visit each planned traffic count and speed data collection site to confirm access and visibility.</li> <li><input type="checkbox"/> Observe local noise environment and evaluate if there are any potential noise sources that might interfere with data collection.</li> </ul>
Noise Descriptors	<ul style="list-style-type: none"> <li><input type="checkbox"/> Use <math>L_{eq}</math> as primary measurement descriptor.</li> <li><input type="checkbox"/> Consider collecting other descriptors that may help evaluate the measured noise during post processing (<math>L_{max}</math>, <math>L_{min}</math>, <math>L_{10}</math>, <math>L_{90}</math>).</li> </ul>
Sampling Period	<ul style="list-style-type: none"> <li><input type="checkbox"/> Determine appropriate sampling period for data collection. 1 minute, repeating intervals suggested.</li> </ul>
Timing and Duration of Measurements	<ul style="list-style-type: none"> <li><input type="checkbox"/> Determine appropriate time (peak hours or off-peak hours, day or night) and required duration of the noise measurements based on SHA requirements.</li> </ul>

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Category	Tasks
Permissions	<ul style="list-style-type: none"> <li><input type="checkbox"/> Submit preliminary list of all potential addresses and locations for noise measurements to SHA.</li> <li><input type="checkbox"/> Contact owners 1-2 weeks ahead of data collection effort seeking permission for property access.</li> </ul>
Measurement Plan approval	<ul style="list-style-type: none"> <li><input type="checkbox"/> Submit a detailed measurement plan to SHA (if required).</li> </ul>
Documentation	<ul style="list-style-type: none"> <li><input type="checkbox"/> Prepare adequate number of copies of data sheets.</li> <li><input type="checkbox"/> Prepare copies of mapping for note taking in the field.</li> <li><input type="checkbox"/> Prepare equipment pack list.</li> <li><input type="checkbox"/> Prepare contact list that includes SHA contact and local law enforcement.</li> </ul>

**Validation of the FHWA TNM for a Proposed Highway Project on Existing Alignment  
 (Pre-trip Preparation)**

Category	Tasks
Instrumentation	<ul style="list-style-type: none"> <li><input type="checkbox"/> Assemble instrumentation, accessories and supplies according to the pack list for this measurement technique.</li> <li><input type="checkbox"/> Test the instrumentation that will be used for data collection, adjusting settings as needed.</li> </ul>
Permissions	<ul style="list-style-type: none"> <li><input type="checkbox"/> Make copies of permission letter from SHA authorizing your work for the project.</li> <li><input type="checkbox"/> Contact local law enforcement the day before the measurements.</li> </ul> <p style="text-align: center;"><i><b>Tip:</b> Describe planned locations, time(s) of day, vehicle make and model</i></p>

### Validation of the FHWA TNM for a Proposed Highway Project on Existing Alignment (On-site)

Category	Tasks
Field review (if not conducted during pre-trip planning)	<ul style="list-style-type: none"> <li><input type="checkbox"/> Visit each planned measurement site to confirm access and observe local conditions.</li> <li><input type="checkbox"/> Visit each traffic count location to confirm there is an unobstructed view of traffic.</li> <li><input type="checkbox"/> Visit each speed data collection location and test radar gun at the location.</li> </ul>
Site Appropriateness	<ul style="list-style-type: none"> <li><input type="checkbox"/> Determine if there are any localized, non-representative noise sources that interfere with the data collection.</li> <li><input type="checkbox"/> Move to alternative noise measurement location if needed.</li> </ul>
Instrumentation Setup	<ul style="list-style-type: none"> <li><input type="checkbox"/> Attach pre-amp and microphone (with microphone extension, if needed) to sound level meter.</li> <li><input type="checkbox"/> Turn on instrumentation and allow equipment to acclimate to outside conditions for several minutes.</li> <li><input type="checkbox"/> Check and, if needed, reset and synchronize the time on all instrumentation (sound level meters, traffic counters, video cameras, cameras, watches).</li> <li><input type="checkbox"/> Check battery power level.</li> <li><input type="checkbox"/> Check that instrumentation settings are correct.</li> <li><input type="checkbox"/> Calibrate instrument before starting data collection (note initial calibration level and time on Field Data Sheet).</li> <li><input type="checkbox"/> Set microphone height at 5 ft (1.5 m) above the ground. <i>Tip: Make sure the tripod is level and secure. Weigh the tripod down if there is a slope or if breezy wind conditions are expected.</i></li> <li><input type="checkbox"/> Position speed detection instrumentation and staff at speed data collection station.</li> <li><input type="checkbox"/> Position traffic counting instrumentation and staff (or video camera) at the vehicle count station location.</li> </ul>
Documentation	<ul style="list-style-type: none"> <li><input type="checkbox"/> Fill out general information on the Measurement Summary Sheet (date, measurement site name, identifying information, observer name).</li> <li><input type="checkbox"/> Obtain noise measurement location coordinates using a GPS device or cell phone app.</li> <li><input type="checkbox"/> Note weather conditions on Measurement Summary Sheet. <ul style="list-style-type: none"> <li><input type="checkbox"/> Temperature</li> <li><input type="checkbox"/> Cloud cover</li> <li><input type="checkbox"/> Wind speed</li> <li><input type="checkbox"/> Wind direction</li> </ul> </li> </ul>

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Category	Tasks
	<ul style="list-style-type: none"> <li><input type="checkbox"/> Create site sketch on Measurement Summary Sheet showing noise measurement location and any identifying structures, roadways and noise sources.  <i>Tip: Sketch should be of sufficient detail that another person to return to the site and set up at the same spot</i></li> <li><input type="checkbox"/> Take photographs of the microphone location (with instrumentation in place) from multiple directions.</li> <li><input type="checkbox"/> Take photographs and/or video documenting dominant noise sources.</li> </ul>
Data Collection	<ul style="list-style-type: none"> <li><input type="checkbox"/> Begin data collection.</li> <li><input type="checkbox"/> Note start time of data collection.</li> <li><input type="checkbox"/> Keep minute by minute notes of observed sound levels and sources.</li> <li><input type="checkbox"/> Note the typical levels for predominant noise sources (man-made and natural sources).</li> <li><input type="checkbox"/> Note any changes in sound levels or weather conditions during the data collection.</li> <li><input type="checkbox"/> Take traffic counts for roadways contributing to noise level.  <i>Tip: If traffic is being recorded via video camera make sure to periodically visit the site to confirm that the camera is operating properly.</i></li> <li><input type="checkbox"/> Collect speed data concurrent with sound level data collection.  <i>Tip: Collect speed data for all lanes of traffic and all vehicle types.</i></li> <li><input type="checkbox"/> End data collection.  <i>Tip: If it is suspected or known that certain unrepresentative minutes' data will need to be eliminated from the result, then extend the data collection for the same number of additional minutes.</i></li> <li><input type="checkbox"/> Save or store the data to the instrument's memory if that is not automatically done.</li> <li><input type="checkbox"/> Note the data file name or number on the Field Data Sheet.</li> <li><input type="checkbox"/> Perform a post-measurement calibration or calibration check before moving or shutting off the instrumentation (note post-measurement calibration level and time on Field Data Sheet).</li> </ul>
Data Storage	<ul style="list-style-type: none"> <li><input type="checkbox"/> Download data files from instrumentation before leaving site.</li> <li><input type="checkbox"/> Create PDFs of all data sheets at the end of the day using phone camera to PDF app.</li> <li><input type="checkbox"/> Download photos from camera or cell phone.</li> <li><input type="checkbox"/> Back-up all data files and photos to thumb drive or external drive or email all files as an alternative backup method.</li> </ul>

**Validation Measurements Pack List**

<p>Instrumentation</p>	<ul style="list-style-type: none"> <li><input type="checkbox"/> Integrating sound level meters (include a spare if possible)</li> <li><input type="checkbox"/> Microphone extensions (if needed)</li> <li><input type="checkbox"/> Microphone mounts (if needed)</li> <li><input type="checkbox"/> Calibrator</li> <li><input type="checkbox"/> Tripods for sound level meters, speed detection station and traffic video station (include at least one spare)</li> <li><input type="checkbox"/> Windscreens (include at least one spare)</li> <li><input type="checkbox"/> Vehicle speed detection unit (laser or radar gun)</li> <li><input type="checkbox"/> Vehicle count boards</li> <li><input type="checkbox"/> Camera</li> <li><input type="checkbox"/> Video camera</li> <li><input type="checkbox"/> Anemometer</li> <li><input type="checkbox"/> Compass</li> </ul>
<p>Equipment</p>	<ul style="list-style-type: none"> <li><input type="checkbox"/> Laptop</li> <li><input type="checkbox"/> Data storage (USB flash drives or SD cards, if needed)</li> <li><input type="checkbox"/> Clipboards</li> <li><input type="checkbox"/> Cell phone</li> <li><input type="checkbox"/> Radios</li> <li><input type="checkbox"/> Digital watches (one for each field team member)</li> <li><input type="checkbox"/> Headlamps/flashlights</li> <li><input type="checkbox"/> Pocket knife/utility tool</li> <li><input type="checkbox"/> Tape measure</li> <li><input type="checkbox"/> Safety vests</li> <li><input type="checkbox"/> Hardhats</li> <li><input type="checkbox"/> Traffic cones</li> <li><input type="checkbox"/> Ground tarp</li> <li><input type="checkbox"/> Camp chair</li> </ul>
<p>Field Supplies</p>	<ul style="list-style-type: none"> <li><input type="checkbox"/> Data sheets</li> <li><input type="checkbox"/> Mapping</li> <li><input type="checkbox"/> Contact list</li> <li><input type="checkbox"/> Notepads</li> <li><input type="checkbox"/> Batteries (including spares for sound level meters, speed detection instrumentation, count boards and camera(s))</li> <li><input type="checkbox"/> Pens</li> <li><input type="checkbox"/> Duct tape</li> <li><input type="checkbox"/> Zip ties</li> </ul>

**Validation of Modeled Sound Levels—Measurement Summary Sheet**

Project Name	
Site/Address	
Observer Name	

**General Meteorological Conditions**

Temperature(s)	
Wind Speed(s)	
Wind Direction(s)	

**SLM/Analyzer Information**

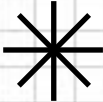
SLM Model/Ser #	
File numbers	
Microphone Ht.	

**Calibration Information**

	Pre-Measurement	Post-Measurement
Calibration Time		
Calibration Level		

**Site Sketch**

*(plan/profile view, distances, roadways, buildings, reflecting surfaces, ground type as appropriate)* (Indicate North)


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**Validation of Modeled Sound Levels—Field Log**

<b>Period #</b>	<b>Start Time</b>	<b>Event Description(s) (include event start and stop)</b>
1		
2		
3		
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**Notes:**

**Validation of Modeled Sound Levels—Field Log**

<b>Period #</b>	<b>Start Time</b>	<b>Event Description(s)</b>
31		
32		
33		
34		
35		
36		
37		
38		
39		
40		
41		
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**Notes:**

### Validation of Modeled Sound Levels—Traffic Speed Data Sheet

Roadway: _____	Roadway: _____
Direction: _____	Direction: _____

	↓	↓	↓	↓	↓	↑	↑	↑	↑	↑
Lane number:										
Distance to lane:										

Log #	Time	Speed	Vehicle type	Lane #	Log #	Time	Speed	Vehicle type	Lane #

Notes:



### **3.0 Including Other Noise Sources for Highway Noise Projects**

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Projects with multimodal noise sources (e.g., sources near a train line or airport) may require consideration or determination of train and aircraft noise levels. Applications include:

- Establish noise levels from other transportation sources for purposes of input to or validation of rail or aircraft noise models or for combining with traffic noise.
- Establish noise levels from other transportation sources to determine their influence on noise abatement measure effectiveness or the general noise environment.

Field guidance in relation to train and aircraft noise targets: 1) awareness of these sources when measuring existing noise, or 2) measuring isolated train or aircraft noise events. For the former, log train or aircraft events as part of notes taken during noise measurements. Include the start and stop time of hearing the train or aircraft event and a description of the source in the event log. The description could include general train type (e.g., light rail, commuter rail, freight rail, etc.) or aircraft type (e.g., commercial jet, small propeller aircraft, helicopter, etc.) and other relevant details such as direction of travel. Also, optimize sample size for data collection to properly identify train and aircraft events and potentially remove them from the measured data. A one-minute sample size is well suited for both train and aircraft events. For trains, a light rail event may last only a few seconds, and a freight train event may last several minutes. For aircraft, typical flyover events last about 30 seconds.

For measuring isolated train events, follow measurement guidance in the FTA's Transit Noise and Vibration Impact Assessment guidance manual. As with other methods in this field guide, proper pre-trip planning and preparation is recommended, as well as completing all field data sheets and properly storing/backing up data. For aircraft, it is suggested to extract measured levels from noise contours or airport monitoring systems rather than conducting field measurements.

## 4.0 Building Noise Level Reduction Measurements and Interior Noise Measurements

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The purpose of this measurement method is to establish an outdoor-indoor noise reduction (OINR) or to evaluate interior noise from exterior noise sources. Applications include the following:

- Type I highway project noise studies where a more accurate OINR is desired for a specific building in lieu of using typical noise reductions or where an interior noise level is needed for impact assessment.
- Possibly, construction noise studies where interior noise levels are of concern or when the effectiveness of a construction noise abatement measure such as sound insulation is being evaluated.
- In rare cases, studies where the effectiveness of a traffic noise abatement measure such as sound insulation is being evaluated.

The field guidance below includes pre-trip planning, pre-trip preparation, and on-site set-up, data collection, documentation, and storage.

**Building Noise Level Reduction Measurements and Interior Noise Measurements  
 (Pre-trip Planning)**

Category	Tasks
Personnel	<ul style="list-style-type: none"> <li><input type="checkbox"/> Identify the personnel that will work on each task:                             <ul style="list-style-type: none"> <li><input type="checkbox"/> Measurement Planning_____</li> <li><input type="checkbox"/> Permissions_____</li> <li><input type="checkbox"/> Field Work_____</li> <li><input type="checkbox"/> Data Review_____</li> </ul> </li> <li><input type="checkbox"/> Brief team members.</li> </ul>
Site Selection	<ul style="list-style-type: none"> <li><input type="checkbox"/> Determine noise study location(s) where measurements will be needed.</li> <li><input type="checkbox"/> Determine approximate number of measurement sites for exterior and interior for each location.</li> <li><input type="checkbox"/> Select interior noise measurement locations that face the existing or proposed highway.</li> <li><input type="checkbox"/> Select exterior noise measurement locations using available online aerial imagery and panoramic views.                             <p style="margin-left: 40px;"><i>Tip: Avoid choosing exterior locations with a permanent, localized, noise sources (pump houses, generators, HVAC or ventilation fans) that do not represent the subject noise source</i></p> <p style="margin-left: 40px;"><i>Tip: Consider difficulty in access to the site while choosing locations.</i></p> </li> <li><input type="checkbox"/> Identify secondary or alternative exterior noise measurement locations in the event that local conditions prevent data collection at a primary noise measurement location.                             <p style="margin-left: 40px;"><i>Tip: Be mindful that localized noise sources that interfere with data collection at a primary noise measurement location may influence levels for adjacent properties. Choose secondary locations that are at least one residence or land use away from the primary noise measurement location.</i></p> </li> </ul>
Field review	<ul style="list-style-type: none"> <li><input type="checkbox"/> Visit each planned measurement site to confirm access.</li> <li><input type="checkbox"/> Confirm that interior background levels are at least 10dB below expected maximum level for pass-by vehicles.                             <p style="margin-left: 40px;"><i>Tip: Bring a sound level meter along on the field review to confirm this.</i></p> </li> <li><input type="checkbox"/> Determine appropriate number of microphones and approximate locations for interior and exterior locations                             <ul style="list-style-type: none"> <li>o Interior                                     <ul style="list-style-type: none"> <li>&lt; 5,300 ft<sup>3</sup> (1 mic)</li> <li>&gt;5,300 ft<sup>3</sup> (2 mics)</li> </ul> </li> <li>o Exterior Position 1</li> </ul> </li> </ul>

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Category	Tasks
	<p>at least 10 ft (3.0 m) from side of the building same height above road as the interior mic (but not less than 5 ft (1.5 m) above ground)</p> <ul style="list-style-type: none"> <li>○ Exterior Position 2 6.6 ft (2 m) from the façade in the middle of facade same height above road as the interior mic (but not less than 5 ft (1.5 m) above ground)</li> <li>○ Exterior Position 3 At the approximate center of the façade and close to but not touching the façade</li> </ul> <ul style="list-style-type: none"> <li><input type="checkbox"/> Determine loudspeaker location (if applicable).</li> <li><input type="checkbox"/> Observe local noise environment and evaluate if there are any potential noise sources that might interfere with data collection.</li> <li><input type="checkbox"/> Confirm that there are no reflecting surfaces within 100 ft (30.5 m) of the vehicle path or microphone locations.</li> </ul>
Noise Descriptors	<ul style="list-style-type: none"> <li><input type="checkbox"/> Use <math>L_{eq}</math> as primary measurement descriptor.</li> <li><input type="checkbox"/> For evaluation of noise reduction for single pass-by events consider collecting SEL(LAE) and <math>L_{AFmax}</math>.</li> </ul>
Sampling Period	<ul style="list-style-type: none"> <li><input type="checkbox"/> Determine appropriate sampling period for data collection.</li> <li><input type="checkbox"/> For highway noise, periods of 1 minute, repeating intervals is suggested.</li> <li><input type="checkbox"/> For single event pass-by noise reduction evaluation 1 second repeating intervals is suggested.</li> </ul>
Timing and Duration of Measurements	<ul style="list-style-type: none"> <li><input type="checkbox"/> Determine appropriate time (peak hours or off-peak hours, day or night) and required duration (or minimum number of events) for the noise measurements.</li> </ul>
Permissions	<ul style="list-style-type: none"> <li><input type="checkbox"/> Submit preliminary list of all potential addresses and locations for noise measurements to SHA.</li> <li><input type="checkbox"/> Contact owners 1-2 weeks ahead of data collection effort seeking permission for property access.</li> </ul>
Measurement Plan approval	<ul style="list-style-type: none"> <li><input type="checkbox"/> Develop and submit a detailed measurement plan to SHA (if required).</li> </ul>
Documentation	<ul style="list-style-type: none"> <li><input type="checkbox"/> Prepare adequate number of copies of data sheets.</li> <li><input type="checkbox"/> Prepare copies of mapping for note taking in the field.</li> <li><input type="checkbox"/> Prepare equipment pack list.</li> <li><input type="checkbox"/> Prepare contact list that includes SHA contact and local law enforcement.</li> </ul>



**Building Noise Level Reduction Measurements and Interior Noise Measurements  
(Pre-trip Preparation)**

<b>Category</b>	<b>Tasks</b>
Instrumentation	<ul style="list-style-type: none"><li><input type="checkbox"/> Assemble instrumentation, accessories and supplies according to the pack list for this measurement technique.</li><li><input type="checkbox"/> Test the instrumentation that will be used for data collection, adjusting settings as needed.</li></ul>
Permissions	<ul style="list-style-type: none"><li><input type="checkbox"/> Make copies of permission letter from SHA authorizing your work for the project.</li><li><input type="checkbox"/> Contact local law enforcement the day before the measurements.</li></ul> <p><i>Tip: Describe planned locations, time(s) of day, vehicle make and model</i></p>

### Building Noise Level Reduction Measurements and Interior Noise Measurements (On-site)

Category	Tasks
Field review (if not conducted during pre-trip planning)	<input type="checkbox"/> Visit each planned measurement site to confirm access and observe local conditions.
Site Appropriateness	<input type="checkbox"/> Determine if there are any localized, non-representative, exterior noise sources that will interfere with the data collection. <input type="checkbox"/> Move to alternative noise measurement location if needed.
Instrumentation Setup	<input type="checkbox"/> Attach pre-amp and microphone (with microphone extension, if needed) to sound level meter. <input type="checkbox"/> Turn on instrumentation and allow equipment to acclimate to outside conditions for several minutes. <input type="checkbox"/> Check and, if needed, reset and synchronize the time on all instrumentation (sound level meters, video cameras, cameras, watches). <input type="checkbox"/> Check battery power level. <input type="checkbox"/> Check that instrumentation settings are correct. <input type="checkbox"/> Calibrate instrument before starting data collection (note initial calibration level and time on Field Data Sheet). <input type="checkbox"/> Place and test loudspeaker before data collection. <input type="checkbox"/> Set microphone height at 5 ft (1.5 m) above the ground.
Microphone Placement	<input type="checkbox"/> Place microphones for interior and exterior locations <ul style="list-style-type: none"> <li>○ Interior Mics 1 and 2 (if necessary): at least 5 ft (1.5 m) above floor at least 3 ft (0.9 m) from any wall</li> <li>○ Exterior Position 1 at least 10 ft (3.0 m) from side of the building same height above road as the interior mic (but not less than 5 ft (1.5 m) above ground)</li> <li>○ Exterior Position 2 6.6 ft (2 m) from the façade in the middle of facade same height above road as the interior mic (but not less than 5 ft (1.5 m) above ground)</li> <li>○ Exterior Position 3 Approximately in the middle of the façade and close but not touching the façade</li> </ul>

Category	Tasks
Documentation	<ul style="list-style-type: none"> <li><input type="checkbox"/> Fill out general information on the Measurement Summary Sheet (date, measurement site name, identifying information, observer name).  <i>Tip: All boxes on Field Data Sheet should be completed by the end of the measurement.</i></li> <li><input type="checkbox"/> Obtain noise measurement location coordinates using a GPS device or cell phone app.</li> <li><input type="checkbox"/> Note weather conditions on Measurement Summary Sheet: <ul style="list-style-type: none"> <li><input type="checkbox"/> Temperature</li> <li><input type="checkbox"/> Cloud cover</li> <li><input type="checkbox"/> Wind speed</li> <li><input type="checkbox"/> Wind direction</li> </ul> </li> <li><input type="checkbox"/> Create site sketch on Measurement Summary Sheet showing noise measurement locations, subject noise sources, distance to the subject noise sources and any identifying structures or roadways.  <i>Tip: Sketch should be of sufficient detail that another person to return to the site and set up at the same spot</i></li> <li><input type="checkbox"/> Take photographs of the microphone location (with instrumentation in place) from multiple directions.</li> <li><input type="checkbox"/> Take photographs and/or video documenting each noise source.</li> </ul>
Data Collection	<ul style="list-style-type: none"> <li><input type="checkbox"/> Begin data collection.</li> <li><input type="checkbox"/> Note start time of data collection.</li> <li><input type="checkbox"/> Keep minute by minute notes of observed sound levels and sources.</li> <li><input type="checkbox"/> Keep single event pass-by notes (if necessary) including start time, end time and <math>L_{max}</math>.</li> <li><input type="checkbox"/> Note <math>L_{max}</math> for any exterior or interior events.</li> <li><input type="checkbox"/> Note any data periods when an interior noise source interferes with the measurement.</li> <li><input type="checkbox"/> Note background levels (when there is no traffic or speaker noise source) for both interior and exterior locations.</li> <li><input type="checkbox"/> Note any changes in sound levels or weather conditions during the data collection.</li> <li><input type="checkbox"/> End data collection.</li> <li><input type="checkbox"/> Save or store the data to the instrument's memory if that is not an automated function.</li> <li><input type="checkbox"/> Note the data file name or number on the Measurement Summary Sheet.</li> </ul>

<b>Category</b>	<b>Tasks</b>
	<ul style="list-style-type: none"><li><input type="checkbox"/> Perform a post-measurement calibration or calibration check before moving or shutting off the instrumentation (note post-measurement calibration level and time on Measurement Summary Sheet).</li></ul>
Data Storage	<ul style="list-style-type: none"><li><input type="checkbox"/> Download data files from instrumentation before leaving site.</li><li><input type="checkbox"/> Create PDFs of all data sheets at the end of the day using phone camera to PDF app.</li><li><input type="checkbox"/> Download photos from camera or cell phone.</li><li><input type="checkbox"/> Back-up all data files and photos to thumb drive or external drive or email all files as an alternative backup method.</li></ul>

**Building Noise Level Reduction and Interior Noise Measurements Pack List**

<p>Instrumentation</p>	<ul style="list-style-type: none"> <li><input type="checkbox"/> Integrating sound level meters (include a spare if possible)</li> <li><input type="checkbox"/> Microphone extensions (if needed)</li> <li><input type="checkbox"/> Microphone mounts (if needed)</li> <li><input type="checkbox"/> Calibrator</li> <li><input type="checkbox"/> Loudspeaker (if needed)</li> <li><input type="checkbox"/> Tripods for sound level meters (include at least one spare)</li> <li><input type="checkbox"/> Windscreens (include at least one spare)</li> <li><input type="checkbox"/> Camera</li> <li><input type="checkbox"/> Video camera</li> <li><input type="checkbox"/> Anemometer</li> <li><input type="checkbox"/> Compass</li> </ul>
<p>Equipment</p>	<ul style="list-style-type: none"> <li><input type="checkbox"/> Laptop</li> <li><input type="checkbox"/> Data storage (USB flash drives or SD cards, if needed)</li> <li><input type="checkbox"/> Clipboards</li> <li><input type="checkbox"/> Cell phone</li> <li><input type="checkbox"/> Radios</li> <li><input type="checkbox"/> Digital watches (one for each field team member)</li> <li><input type="checkbox"/> Headlamps/flashlights</li> <li><input type="checkbox"/> Pocket knife/utility tool</li> <li><input type="checkbox"/> Tape measure</li> <li><input type="checkbox"/> Safety vests</li> <li><input type="checkbox"/> Hardhats</li> <li><input type="checkbox"/> Traffic cones</li> <li><input type="checkbox"/> Ground tarp</li> <li><input type="checkbox"/> Camp chair</li> </ul>
<p>Field Supplies</p>	<ul style="list-style-type: none"> <li><input type="checkbox"/> Data sheets</li> <li><input type="checkbox"/> Mapping</li> <li><input type="checkbox"/> Contact list</li> <li><input type="checkbox"/> Notepads</li> <li><input type="checkbox"/> Batteries (including spares for sound level meters, speed detection instrumentation, count boards and camera(s))</li> <li><input type="checkbox"/> Pens</li> <li><input type="checkbox"/> Duct tape</li> <li><input type="checkbox"/> Zip ties</li> </ul>

### Building Noise Level Reduction and Interior Noise Measurements—Measurement Summary Sheet

Project Name	
Site/Address	
Observer Name	

#### **General Meteorological Conditions**

Temperature(s)	
Wind Speed(s)	
Wind Direction(s)	

#### **SLM/Analyzer Information**

SLM Model/Ser #		Location (circle one)	Interior/Exterior
Mic. Ht.		Mic. Ht. above Roadway	
Data File.		Source (circle one)	Traffic/Speaker

#### **Calibration Information**

	Pre-Measurement	Post-Measurement
Calibration Time		
Calibration Level		

#### **Site Sketch**

*(plan/profile view, distances, roadways, buildings, reflecting surfaces, ground type as appropriate)* (Indicate North)

	
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**Building Noise Level Reduction and Interior Noise Measurements—Field Log**

<b>Period #</b>	<b>Start Time</b>	<b>Event Description(s) (include event start and stop)</b>
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2		
3		
4		
5		
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**Notes:**

## 5.0 Existing Vibration Measurements

This section describes field measurement of groundborne vibration. The purpose of this measurement is to document the existing ground vibration levels near highway projects. Existing vibration may be desired for highly vibration sensitive structures, if the project causes train tracks to move within FTA<sup>1</sup> screening distance of the receptors, or if the highway is close and has irregularities. The field guidance below includes pre-trip planning, pre-trip preparation, and on-site set-up, data collection, documentation, and storage.

### Existing Vibration Levels (Pre-trip Planning)

Category	Tasks
Personnel	<ul style="list-style-type: none"> <li><input type="checkbox"/> Identify the personnel that will work on each task:               <ul style="list-style-type: none"> <li><input type="checkbox"/> Measurement Planning_____</li> <li><input type="checkbox"/> Public Outreach_____</li> <li><input type="checkbox"/> Field Work_____</li> <li><input type="checkbox"/> Data Review_____</li> </ul> </li> <li><input type="checkbox"/> Brief team members.</li> </ul>
Site Selection	<ul style="list-style-type: none"> <li><input type="checkbox"/> Identify vibration sensitive receptors and vibration sources.</li> <li><input type="checkbox"/> Determine approximate number of measurement sites.</li> <li><input type="checkbox"/> Consult aerial photos, maps/mapping software to identify candidate vibration measurement locations.</li> <li><input type="checkbox"/> Conduct field reconnaissance to review measurement sites.</li> <li><input type="checkbox"/> Select primary vibration measurement locations.</li> <li><input type="checkbox"/> Identify secondary or alternative vibration measurement locations in the event that local conditions prevent data collection.</li> </ul>
Sensor Placement	<ul style="list-style-type: none"> <li><input type="checkbox"/> Identify any vibration sources at each site (i.e., highway vehicles, railway vehicles, construction equipment, other machinery).</li> <li><input type="checkbox"/> Select preferred placement of sensor, relative to nearby receptors and vibration sources.</li> <li><input type="checkbox"/> Identify type of ground and appropriate mounting for sensor (i.e., soil/groundstake, pavement/plate and epoxy).</li> </ul>

<sup>1</sup> Hanson, et al., *Transit Noise and Vibration Impact Assessment*, Report No. FTA-VA-90-1003-06, Federal Transit Administration, Washington, DC, 2006.



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Category	Tasks
Timing and Duration of Measurements	<ul style="list-style-type: none"> <li><input type="checkbox"/> Determine descriptor for data collection, if other than <math>L_{eq}</math>.</li> <li><input type="checkbox"/> Determine appropriate sampling period for data collection.</li> <li><input type="checkbox"/> Determine appropriate time (peak hours or off-peak hours, day or night) and required duration of the vibration measurements. Consult with SHA.</li> </ul>
Permissions	<ul style="list-style-type: none"> <li><input type="checkbox"/> Submit preliminary list of all potential addresses and locations for vibration measurements to SHA.</li> <li><input type="checkbox"/> Contact owners/tenants 1-2 weeks ahead of data collection effort seeking permission for property access.</li> </ul>
Measurement Plan approval	<ul style="list-style-type: none"> <li><input type="checkbox"/> Submit a detailed measurement plan to SHA (if required).</li> </ul>
Documentation	<ul style="list-style-type: none"> <li><input type="checkbox"/> Prepare Field Data Sheets.</li> <li><input type="checkbox"/> Prepare copies of mapping for note taking in the field (prior to field review).</li> <li><input type="checkbox"/> Prepare equipment pack list.</li> <li><input type="checkbox"/> Prepare contact list that includes SHA contact and local law enforcement.</li> </ul>

**Existing Vibration Levels (Pre-trip Preparation)**

Category	Tasks
Instrumentation	<ul style="list-style-type: none"> <li><input type="checkbox"/> Assemble instrumentation, accessories and supplies according to the pack list for this measurement technique.</li> <li><input type="checkbox"/> Adjust settings for instrumentation to the expected field use.</li> <li><input type="checkbox"/> Test the instrumentation that will be used for data collection.</li> </ul>
Documentation	<ul style="list-style-type: none"> <li><input type="checkbox"/> Prepare adequate number of copies of Field Data Sheets.</li> </ul>
Permissions	<ul style="list-style-type: none"> <li><input type="checkbox"/> Make copies of permission letter from SHA authorizing your work for the project.</li> <li><input type="checkbox"/> Contact local law enforcement the day before the measurements.</li> </ul> <p style="text-align: center;"><i>Tip: Describe planned locations, time(s) of day, vehicle make and model</i></p>

### Existing Vibration Levels (On-site)

Category	Tasks
Field review (if not conducted during pre-trip planning)	<ul style="list-style-type: none"> <li><input type="checkbox"/> Identify any vibration sources at each site (i.e., highway vehicles, railway vehicles, construction equipment, other machinery).</li> <li><input type="checkbox"/> Select preferred placement of sensor, relative to nearby receptors and vibration sources.</li> <li><input type="checkbox"/> Identify type of ground and appropriate mounting for sensor (i.e., soil/groundstake, pavement/plate and epoxy).</li> </ul>
Site Appropriateness	<ul style="list-style-type: none"> <li><input type="checkbox"/> Determine if there are any localized, non-representative vibration sources that interfere with the data collection.</li> <li><input type="checkbox"/> Move to alternative vibration measurement location if needed.</li> </ul>
Instrumentation Setup	<ul style="list-style-type: none"> <li><input type="checkbox"/> Mount sensor to ground using appropriate method.</li> <li><input type="checkbox"/> Attach sensor to data recorder.</li> <li><input type="checkbox"/> Turn on instrumentation and allow equipment to acclimate to outside conditions for several minutes.</li> <li><input type="checkbox"/> Set the time on the instrumentation.</li> <li><input type="checkbox"/> Check battery power level.</li> <li><input type="checkbox"/> Check that instrumentation settings are correct.</li> </ul> <p style="margin-left: 40px;"><i>Tip: Power or current supply settings for geophones and accelerometers may be different from standard microphones.</i></p> <p style="margin-left: 40px;"><i>Tip: Accelerometers must have their signal integrated to vibration velocity. Check that the data recorder can do this, or indicate that it will be on during data processing.</i></p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Verify that the signals from sensor are operating.</li> </ul>
Documentation	<ul style="list-style-type: none"> <li><input type="checkbox"/> Fill out general information on the Field Data Sheet (date, measurement site name, identifying information, observer name).</li> </ul> <p style="margin-left: 40px;"><i>Tip: All boxes on Field Data Sheet should be completed by the end of the measurement.</i></p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Obtain vibration measurement location coordinates using a GPS device or cell phone app.</li> <li><input type="checkbox"/> Create site sketch on Field Data Sheet showing vibration measurement location and any identifying structures, roadways and vibration sources.</li> </ul> <p style="margin-left: 40px;"><i>Tip: Sketch should be of sufficient detail that another person to return to the site and set up at the same spot</i></p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Take photographs of the sensor location (with instrumentation in place) from multiple directions.</li> <li><input type="checkbox"/> Take photographs and/or video documenting dominant vibration sources.</li> </ul>

Category	Tasks
Data Collection	<ul style="list-style-type: none"> <li><input type="checkbox"/> Begin data collection.</li> <li><input type="checkbox"/> Note start time of data collection.</li> <li><input type="checkbox"/> Keep minute by minute notes of observed vibration levels and sources.</li> <li><input type="checkbox"/> Note the typical levels for predominant vibration sources (man-made and natural sources).</li> <li><input type="checkbox"/> Take traffic counts for nearby roadways contributing to vibration level (if needed).</li> <li><input type="checkbox"/> End data collection.</li> <li><input type="checkbox"/> Save or store the data to the instrument's memory if that is not automatically done.</li> <li><input type="checkbox"/> Note the data file name or number on the Field Data Sheet.</li> </ul>
Data Storage	<ul style="list-style-type: none"> <li><input type="checkbox"/> Download data files from instrumentation before leaving site.</li> <li><input type="checkbox"/> Create PDFs of all data sheets at the end of the day using phone camera to PDF app.</li> <li><input type="checkbox"/> Download photos from camera or cell phone.</li> <li><input type="checkbox"/> Back-up all data files and photos to thumb drive or external drive or email all files as an alternative backup method.</li> </ul>

**Existing Vibration Levels Measurement Pack List**

<p>Instrumentation</p>	<ul style="list-style-type: none"> <li><input type="checkbox"/> Vibration Sensor(s) (geophone or accelerometer)</li> <li><input type="checkbox"/> Vibration digital signal recorder</li> <li><input type="checkbox"/> Vibration calibrator (shaker)</li> <li><input type="checkbox"/> Museum wax, earthquake gel, or epoxy to mount sensor</li> <li><input type="checkbox"/> Ground stake(s) (for mounting transducer in soil)</li> <li><input type="checkbox"/> Plate or block (for mounting transducer on hard surface)</li> <li><input type="checkbox"/> Integrating sound level meter(s)</li> <li><input type="checkbox"/> Sound level meter calibrator</li> <li><input type="checkbox"/> Tripod(s) (include at least one spare)</li> <li><input type="checkbox"/> Vehicle speed detection unit (laser or radar gun), if needed</li> <li><input type="checkbox"/> Vehicle count boards, if needed</li> <li><input type="checkbox"/> Camera</li> <li><input type="checkbox"/> Video camera</li> <li><input type="checkbox"/> Anemometer</li> <li><input type="checkbox"/> Compass</li> </ul>
<p>Equipment</p>	<ul style="list-style-type: none"> <li><input type="checkbox"/> Laptop</li> <li><input type="checkbox"/> Data storage (USB flash drives or SD cards, if needed)</li> <li><input type="checkbox"/> Clipboards</li> <li><input type="checkbox"/> Cell phone</li> <li><input type="checkbox"/> Radios</li> <li><input type="checkbox"/> Digital watches (one for each field team member)</li> <li><input type="checkbox"/> Headlamps/flashlights</li> <li><input type="checkbox"/> Pocket knife/utility tool</li> <li><input type="checkbox"/> Tape measure</li> <li><input type="checkbox"/> Safety vests</li> <li><input type="checkbox"/> Hardhats</li> <li><input type="checkbox"/> Ground tarp</li> </ul>
<p>Field Supplies</p>	<ul style="list-style-type: none"> <li><input type="checkbox"/> Data sheets</li> <li><input type="checkbox"/> Mapping</li> <li><input type="checkbox"/> Contact list</li> <li><input type="checkbox"/> Notepads</li> <li><input type="checkbox"/> Batteries (including spares for all instrumentation and equipment)</li> <li><input type="checkbox"/> Pens</li> <li><input type="checkbox"/> Duct tape</li> <li><input type="checkbox"/> Zip ties</li> </ul>

**Determination of Existing Vibration Levels—Measurement Summary Sheet**

Project Name	
Site/Address	
Observer Name	
Date	

**Vibration System Information**

Data Recorder Type		Sensor Channel	
Data Recorder Model		Sensor Type	
Data Recorder ID/SN		Sensor Model	
Verified signals? (circle)	yes / no	Sensor ID/SN	
		Sensor Mounting	

**Data Collection**

Description	Data File Name/Number	Start Time	End Time/Duration

**Site Sketch**

*(plan/profile view, distances, roadways, buildings, reflecting surfaces, ground type as appropriate)* (Indicate North)

**Determination of Existing Vibration Levels—Field Log**

<b>Period #</b>	<b>Period Start Time</b>	<b>Event Description(s) (include event start and stop)</b>
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		
21		
22		
23		
24		
25		
26		
27		
28		
29		
30		

**Notes:**

**Existing Vibration—Traffic Speed Data Sheet**

Roadway: _____	Roadway: _____
Direction: _____	Direction: _____

	↓	↓	↓	↓	↓	↑	↑	↑	↑	↑
Lane number:										
Distance to lane:										

Log #	Time	Speed	Vehicle type	Lane #	Log #	Time	Speed	Vehicle type	Lane #

Notes:



**Existing Vibration—Traffic Count Data Sheet**

Roadway: _____	Roadway: _____
Direction: _____	Direction: _____

Time Start	Auto	MT	HT	Bus	MC	Auto	MT	HT	Bus	MC

**Notes:**

## **6.0 Construction Equipment Noise and Vibration Measurements**

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This section describes field measurement of construction equipment noise and vibration. The purpose of this measurement is to establish construction equipment noise and vibration levels to help predict construction operational impacts or to determine compliance with local ordinances, other regulations, or construction contract specifications or special provisions. The field guidance below includes pre-trip planning, pre-trip preparation, and on-site set-up, data collection, documentation, and storage.

**Construction Noise and Vibration Levels (Pre-trip Planning)**

Category	Tasks
Personnel	<ul style="list-style-type: none"> <li><input type="checkbox"/> Identify the personnel that will work on each task:               <ul style="list-style-type: none"> <li><input type="checkbox"/> Measurement Planning _____</li> <li><input type="checkbox"/> Permissions _____</li> <li><input type="checkbox"/> Field Work _____</li> <li><input type="checkbox"/> Data Review _____</li> </ul> </li> <li><input type="checkbox"/> Brief team members</li> </ul>
Site Selection	<ul style="list-style-type: none"> <li><input type="checkbox"/> Determine equipment for which measurements will be needed.</li> <li><input type="checkbox"/> Determine the mode of operation that each piece of equipment will be used in.</li> <li><input type="checkbox"/> Select primary measurement locations based on equipment location and mode of operation.               <ul style="list-style-type: none"> <li><input type="checkbox"/> Flat open space with no reflecting surfaces within 100 ft (30.5 m).</li> <li><input type="checkbox"/> The ground surface within the measurement area acoustically representative of hard or soft surfaces, and free of snow.</li> <li><input type="checkbox"/> Line of site from microphones unobscured for 150°.</li> <li><input type="checkbox"/> Background level 10 dB below lowest anticipated equipment operation levels.</li> <li><input type="checkbox"/> Located away from other noise/vibration sources.</li> </ul> </li> </ul> <p style="text-align: center;"><i>Tip: Consider access to the site.</i></p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Identify secondary or alternative vibration measurement locations in the event that local conditions prevent data collection at a primary noise measurement location.</li> <li><input type="checkbox"/> Conduct field reconnaissance to review measurement sites, if possible.</li> </ul>

Category	Tasks
Sensor Placement	<ul style="list-style-type: none"> <li><input type="checkbox"/> Stationary Noise, Active and Passive               <ul style="list-style-type: none"> <li>○ Microphones 50 ft (15.2 m) from equipment.</li> <li>○ Microphone 5 ft (1.5 m) high.</li> <li>○ 4 positions separated by 90°.</li> </ul> </li> <li><input type="checkbox"/> Mobile Noise, Active and Passive               <ul style="list-style-type: none"> <li>○ Microphone 5 ft (1.5 m) high.</li> <li>○ Microphone 50 ft (15.2 m) from center of travel of equipment.</li> <li>○ 1 position to measure right-to-left and left-to-right operation.</li> </ul> </li> <li><input type="checkbox"/> Stationary Vibration (if needed)               <ul style="list-style-type: none"> <li>○ 1 position 50 ft (15.2 m) from equipment</li> </ul> </li> <li><input type="checkbox"/> Mobile Vibration (if needed)               <ul style="list-style-type: none"> <li>○ 1 position 50 ft (15.2 m) from equipment</li> </ul> </li> </ul> <p><i>Tip: Vibration is typically measured on the ground directly below the microphone for the same type of measurement.</i></p>
Timing and Duration of Measurements	<ul style="list-style-type: none"> <li><input type="checkbox"/> Determine descriptor for data collection, depending on mode of operation               <ul style="list-style-type: none"> <li>○ Stationary operation 30-second <math>L_{eq}</math>.</li> <li>○ Mobile operation <math>L_{max}</math>.</li> </ul> </li> <li><input type="checkbox"/> Determine appropriate sampling period for data collection.</li> <li><input type="checkbox"/> Determine appropriate time (peak hours or off-peak hours, day or night) and required duration of the vibration measurements.</li> </ul>
Permissions	<ul style="list-style-type: none"> <li><input type="checkbox"/> Arrange measurement and operation of equipment with relevant parties (site owner, foreman, etc.).</li> </ul>
Measurement Plan approval	<ul style="list-style-type: none"> <li><input type="checkbox"/> Submit a detailed measurement plan to SHA (if required).</li> </ul>
Documentation	<ul style="list-style-type: none"> <li><input type="checkbox"/> Prepare Field Data Sheets.</li> <li><input type="checkbox"/> Prepare copies of mapping for note taking in the field (prior to field review, if applicable).</li> <li><input type="checkbox"/> Prepare equipment pack list.</li> <li><input type="checkbox"/> Prepare contact list that includes relevant parties.</li> </ul>

**Construction Noise and Vibration Levels (Pre-trip Preparation)**

Category	Tasks
Instrumentation	<ul style="list-style-type: none"> <li><input type="checkbox"/> Assemble instrumentation, accessories and supplies according to the pack list for this measurement technique.</li> <li><input type="checkbox"/> Adjust settings for instrumentation to the expected field use.</li> <li><input type="checkbox"/> Test the instrumentation that will be used for data collection.</li> </ul>
Documentation	<ul style="list-style-type: none"> <li><input type="checkbox"/> Prepare adequate number of copies of Field Data Sheets.</li> </ul>
Permissions	<ul style="list-style-type: none"> <li><input type="checkbox"/> Make copies of permission letter from SHA authorizing your work for the project, if applicable.</li> <li><input type="checkbox"/> Make copies of any agreements with construction equipment owner or operator.</li> <li><input type="checkbox"/> Contact local law enforcement the day before the measurements, if required.</li> </ul> <p style="text-align: center;"><i><b>Tip:</b> Describe planned locations, time(s) of day, vehicle make and model</i></p>

### Construction Noise and Vibration Levels (On-site)

Category	Tasks
Site Appropriateness	<ul style="list-style-type: none"> <li><input type="checkbox"/> Determine if there are any localized, non-representative noise or vibration sources that interfere with the data collection.</li> <li><input type="checkbox"/> Move to alternative measurement location if needed.</li> <li><input type="checkbox"/> Verify that equipment can be operated in the desired mode.</li> </ul>
Instrumentation Setup	<ul style="list-style-type: none"> <li><input type="checkbox"/> Attach sensor (microphone, geophone, or accelerometer) to data recorder</li> <li><input type="checkbox"/> Turn on instrumentation and allow equipment to acclimate to outside conditions for several minutes.</li> <li><input type="checkbox"/> Check and, if needed, set the time on the instrumentation.</li> <li><input type="checkbox"/> Check battery power level.</li> <li><input type="checkbox"/> Check that instrumentation settings are correct.</li> <li><input type="checkbox"/> Calibrate instrument before starting data collection (note initial calibration level and time on Field Data Sheet).</li> <li><input type="checkbox"/> Deploy microphone to appropriate position, depending on mode of operation.</li> </ul> <p>Verify that background levels are sufficiently low (10 dB below lowest expected levels of equipment).</p>
Documentation	<ul style="list-style-type: none"> <li><input type="checkbox"/> Fill out general information on the Field Data Sheet (date, measurement site name, identifying information, observer name)</li> <li><input type="checkbox"/> Obtain noise measurement location coordinates using a GPS device or cell phone app</li> <li><input type="checkbox"/> Note weather conditions on Field Data Sheet               <ul style="list-style-type: none"> <li><input type="checkbox"/> Temperature</li> <li><input type="checkbox"/> Cloud cover</li> <li><input type="checkbox"/> Wind speed</li> <li><input type="checkbox"/> Wind direction</li> </ul> </li> <li><input type="checkbox"/> Create site sketch on Field Data Sheet showing noise measurement location and any identifying structures, roadways and noise sources               <p style="margin-left: 40px;"><i>Tip: Sketch should be of sufficient detail that another person to return to the site and set up at the same spot</i></p> </li> <li><input type="checkbox"/> Take photographs of the sensor locations (with instrumentation in place) from multiple directions.</li> <li><input type="checkbox"/> Take photographs and/or video documenting dominant noise sources.</li> </ul>

Category	Tasks
Data Collection	<ul style="list-style-type: none"> <li><input type="checkbox"/> Without construction equipment operating, begin background noise and vibration data collection. Sample at least 10 seconds, longer if the levels are fluctuating.</li> <li><input type="checkbox"/> End background level data collection and document.</li> <li><input type="checkbox"/> Begin operating construction equipment in appropriate mode.</li> <li><input type="checkbox"/> Begin data collection.</li> <li><input type="checkbox"/> Note start time of data collection.</li> <li><input type="checkbox"/> Note any changes weather conditions during the data collection.</li> <li><input type="checkbox"/> End data collection.</li> <li><input type="checkbox"/> Save or store the data to the instrument's memory if that is not automatically done.</li> <li><input type="checkbox"/> Note the data file name or number on the Field Data Sheet.</li> <li><input type="checkbox"/> Perform a post-measurement calibration or calibration check before moving or shutting off the instrumentation (note post-measurement calibration level and time on Field Data Sheet).</li> </ul>
Data Storage	<ul style="list-style-type: none"> <li><input type="checkbox"/> Download data files from instrumentation before leaving site.</li> <li><input type="checkbox"/> Create PDFs of all data sheets at the end of the day using phone camera to PDF app.</li> <li><input type="checkbox"/> Download photos from camera or cell phone.</li> <li><input type="checkbox"/> Back-up all data files and photos to thumb drive or external drive or email all files as an alternative backup method.</li> </ul>

**Construction Noise and Vibrations Levels Measurement Pack List**

<p>Instrumentation</p>	<ul style="list-style-type: none"> <li><input type="checkbox"/> Vibration sensor(s) (geophone or accelerometer)</li> <li><input type="checkbox"/> Vibration digital signal recorder</li> <li><input type="checkbox"/> Vibration calibrator (shaker)</li> <li><input type="checkbox"/> Museum wax, earthquake gel, or epoxy to mount sensor</li> <li><input type="checkbox"/> Ground stake(s) (for mounting transducer in soil)</li> <li><input type="checkbox"/> Plate or block (for mounting transducer on hard surface)</li> <li><input type="checkbox"/> Sound level meters (include a spare if possible)</li> <li><input type="checkbox"/> Microphone extensions (if needed)</li> <li><input type="checkbox"/> Microphone mounts (if needed)</li> <li><input type="checkbox"/> Sound level meter calibrator</li> <li><input type="checkbox"/> Tripods (include at least one spare)</li> <li><input type="checkbox"/> Windscreens (include at least one spare)</li> <li><input type="checkbox"/> Vehicle count boards</li> <li><input type="checkbox"/> Camera</li> <li><input type="checkbox"/> Video camera</li> <li><input type="checkbox"/> Anemometer</li> <li><input type="checkbox"/> Compass</li> </ul>
<p>Equipment</p>	<ul style="list-style-type: none"> <li><input type="checkbox"/> Laptop</li> <li><input type="checkbox"/> Data storage (USB flash drives or SD cards, if needed)</li> <li><input type="checkbox"/> Clipboards</li> <li><input type="checkbox"/> Cell phone</li> <li><input type="checkbox"/> Radios</li> <li><input type="checkbox"/> Digital watches (one for each field team member)</li> <li><input type="checkbox"/> Headlamps/flashlights</li> <li><input type="checkbox"/> Pocket knife/utility tool</li> <li><input type="checkbox"/> Tape measure</li> <li><input type="checkbox"/> Safety vests</li> <li><input type="checkbox"/> Hardhats</li> <li><input type="checkbox"/> Traffic cones</li> <li><input type="checkbox"/> Ground tarp</li> </ul>
<p>Field Supplies</p>	<ul style="list-style-type: none"> <li><input type="checkbox"/> Data sheets</li> <li><input type="checkbox"/> Mapping</li> <li><input type="checkbox"/> Contact list</li> <li><input type="checkbox"/> Notepads</li> <li><input type="checkbox"/> Batteries (including spares)</li> <li><input type="checkbox"/> Pens</li> <li><input type="checkbox"/> Duct tape</li> <li><input type="checkbox"/> Zip ties</li> </ul>



**Construction Equipment Noise—Measurement Summary Sheet**

Project Name	
Site/Address	
Observer Name	
Date	

**General Meteorological Conditions**

Temperature(s)	
Wind Speed(s)	
Wind Direction(s)	
Cloud Cover	

**Noise System Information**

SLM/Analyzer Model		Mic. Model	
SLM/Analyzer ID/SN		Mic. ID/SN	
		Mic. Height (ft)	

**Vibration System Information**

Data Recorder Type		Sensor Channel	
Data Recorder Model		Sensor Type	
Data Recorder ID/SN		Sensor Model	
Verified signals?	yes / no	Sensor ID/SN	
		Sensor Mounting	

**Construction Equipment Information**

Type	
Make/Model	
Operation Model (circle)	Stationary / Mobile    Active / Passive
Notes	

**Data Collection**

Description	Data File Name/Number	Start Time	End Time/Duration	Level
Pre-Meas. Calibration				
Background				
Measurement 1				
Measurement 2				
Measurement 3				
Measurement 4				
Post-Meas.				

**Site Sketch***(plan/profile view, meas. locations, distances, reflecting surfaces, ground type as appropriate)*

(Indicate North)



List of general ground types between source and receiver: dirt road, field grass, gravel, lawn, pavement, soil (hard), soil (loose), snow (powder), water

**Measurement 1 Parameters and Notes**

Distance to Source (ft)	Observations and Notes
Distance to Reflective Surface	
Predominant Ground Type	

**Measurement 2 Parameters and Notes**

Distance to Source (ft)	Observations and Notes
Distance to Reflective Surface	
Predominant Ground Type	

**Measurement 3 Parameters and Notes**

Distance to Source (ft)	Observations and Notes
Distance to Reflective Surface	
Predominant Ground Type	

**Measurement 4 Parameters and Notes**

Distance to Source (ft)	Observations and Notes
Distance to Reflective Surface	
Predominant Ground Type	

## 7.0 Noise Barrier Insertion Loss Measurements

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This section outlines the field measurement procedures for the measurement of noise barrier insertion loss (IL). IL is the difference in sound level at a receptor location with and without the presence of a noise barrier, assuming no change in the sound level of the source. The following project types could use noise barrier IL measurement procedures:

- Post-installation evaluation of the effectiveness of a Type I highway project noise barrier.
- Pre-installation and post-installation evaluation of the effectiveness of a Type II noise barrier.
- Evaluation of the effectiveness of construction site noise barriers, including barriers for stationary pieces of equipment (with appropriate procedure modifications).
- Evaluation of noise barrier effectiveness for highway facilities such as rest areas or truck weigh stations (with appropriate procedure modifications).

### Noise Barrier Insertion Loss Measurements (Pre-trip Planning)

Category	Tasks
Personnel	<ul style="list-style-type: none"> <li><input type="checkbox"/> Identify the personnel that will work on each task:               <ul style="list-style-type: none"> <li><input type="checkbox"/> Measurement Planning_____</li> <li><input type="checkbox"/> Permissions_____</li> <li><input type="checkbox"/> Field Work_____</li> <li><input type="checkbox"/> Data Review_____</li> </ul> </li> <li><input type="checkbox"/> Brief team members.</li> </ul>
Site Selection	<ul style="list-style-type: none"> <li><input type="checkbox"/> Determine candidate sites for measurements.</li> <li><input type="checkbox"/> Determine approximate number of measurement locations for each site.</li> <li><input type="checkbox"/> Obtain elevation or contour mapping for the candidate sites.</li> <li><input type="checkbox"/> Select primary noise measurement locations.               <p style="margin-left: 40px;"><i>Tip: Avoid choosing locations with any permanent, localized, noise sources (pump houses, generators, HVAC or ventilation fans) that would interfere with measurement of the roadway noise source.</i></p> <p style="margin-left: 40px;"><i>Tip: Consider difficulty in access to the site while choosing locations.</i></p> </li> <li><input type="checkbox"/> Identify secondary or alternative noise measurement locations in the event that local conditions prevent data collection at a primary noise measurement location.               <p style="margin-left: 40px;"><i>Tip: Be mindful that localized noise sources that interfere with data collection at a primary noise measurement location may influence levels for adjacent properties. Choose secondary locations that are at least one residence or land use away from the primary noise measurement location.</i></p> </li> <li><input type="checkbox"/> Evaluate geometric conditions for site equivalency (if the Indirect Measured method is used).</li> <li><input type="checkbox"/> Identify primary and secondary locations for collecting traffic counts.</li> <li><input type="checkbox"/> Identify primary and secondary locations for collecting speed data.</li> </ul>
Field review	<ul style="list-style-type: none"> <li><input type="checkbox"/> Visit each planned measurement site to confirm access.</li> <li><input type="checkbox"/> Observe local noise environment and evaluate if there are any potential noise sources that might interfere with data collection.</li> <li><input type="checkbox"/> Locate reference and study microphone locations.</li> <li><input type="checkbox"/> Use elevation and contour mapping and field observations to estimate height above ground for reference microphone.</li> <li><input type="checkbox"/> Confirm access path to the barrier location.</li> </ul>
Noise Descriptors	<ul style="list-style-type: none"> <li><input type="checkbox"/> Use <math>L_{eq}</math> as primary measurement descriptor.</li> <li><input type="checkbox"/> Consider collecting other descriptors that may help evaluate the measured noise during post processing (<math>L_{max}</math>, <math>L_{min}</math>, <math>L_{10}</math>, <math>L_{90}</math>).</li> </ul>

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Category	Tasks
Sampling Period	<input type="checkbox"/> Determine appropriate sampling period for data collection. 1 minute, repeating intervals is suggested.
Timing and Duration of Measurements	<input type="checkbox"/> Determine appropriate time (peak hours or off-peak hours, day or night) and required duration of the noise measurements based on SHA requirements.
Permissions	<input type="checkbox"/> Submit preliminary list of all potential addresses and locations for noise measurements to SHA. <input type="checkbox"/> Contact owners 1-2 weeks ahead of data collection effort seeking permission for property access.
Measurement Plan approval	<input type="checkbox"/> Submit a detailed measurement plan to SHA (if required).
Documentation	<input type="checkbox"/> Prepare adequate number of copies of data sheets. <input type="checkbox"/> Prepare copies of mapping for note taking in the field. <input type="checkbox"/> Prepare equipment pack list. <input type="checkbox"/> Prepare contact list that includes SHA contact and local law enforcement.

**Noise Barrier Insertion Loss Measurements (Pre-trip Preparation)**

Category	Tasks
Instrumentation	<ul style="list-style-type: none"> <li><input type="checkbox"/> Assemble instrumentation, accessories and supplies according to the pack list for this measurement technique.</li> <li><input type="checkbox"/> Test the instrumentation that will be used for data collection, adjusting settings as needed.</li> </ul>
Permissions	<ul style="list-style-type: none"> <li><input type="checkbox"/> Make copies of permission letter from SHA authorizing your work for the project.</li> <li><input type="checkbox"/> Contact local law enforcement the day before the measurements.</li> </ul> <p style="text-align: center;"><i>Tip: Describe planned locations, time(s) of day, vehicle make and model</i></p>

### Noise Barrier Insertion Loss Measurements (On-site)

Category	Tasks
Field review (if not conducted during pre-trip planning)	<ul style="list-style-type: none"> <li><input type="checkbox"/> Visit each planned measurement site to confirm access and observe local conditions.</li> <li><input type="checkbox"/> Confirm site equivalency for the Indirect Measured method, if necessary.</li> <li><input type="checkbox"/> Visit each traffic count location to confirm there is an unobstructed view of traffic.</li> <li><input type="checkbox"/> Visit each speed data collection location and test laser/radar gun to ensure locations provide adequate site lines for speed data collection.</li> </ul>
Site Appropriateness	<ul style="list-style-type: none"> <li><input type="checkbox"/> Determine if there are any localized, non-representative noise sources that interfere with the data collection.</li> <li><input type="checkbox"/> Move to alternative noise measurement location if needed.</li> </ul>
Instrumentation Setup	<ul style="list-style-type: none"> <li><input type="checkbox"/> Attach pre-amp and microphone (with microphone extension, if needed) to sound level meter.</li> <li><input type="checkbox"/> Turn on instrumentation and allow equipment to acclimate to outside conditions for several minutes.</li> <li><input type="checkbox"/> Check and, if needed, set and synchronize the time on all instrumentation (sound level meters, traffic counters, meteorological instrumentation, video cameras, cameras, watches).</li> <li><input type="checkbox"/> Check battery power level.</li> <li><input type="checkbox"/> Check that instrumentation settings are correct.</li> <li><input type="checkbox"/> Calibrate instrument before starting data collection (note initial calibration level and time on Field Data Sheet).</li> <li><input type="checkbox"/> Deploy reference microphone(s).</li> <li><input type="checkbox"/> Set microphone height at 5 ft (1.5 m) above the ground for study microphone locations.</li> </ul> <p style="text-align: center;"><i>Tip: Make sure the tripod is level and secure. Weigh the tripod down if there is a slope or if breezy wind conditions are expected.</i></p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Position speed detection instrumentation and staff at speed data collection station.</li> <li><input type="checkbox"/> Position traffic counting instrumentation and staff (or video camera) at the vehicle count station location.</li> <li><input type="checkbox"/> Deploy meteorological instrumentation.</li> </ul>
Documentation	<ul style="list-style-type: none"> <li><input type="checkbox"/> Fill out general information on the Measurement Summary Sheet (date, measurement site name, identifying information, observer name).</li> <li><input type="checkbox"/> Obtain noise measurement location coordinates using a GPS device or cell phone app.</li> <li><input type="checkbox"/> Note weather conditions on Measurement Summary Sheet <ul style="list-style-type: none"> <li><input type="checkbox"/> Temperature</li> </ul> </li> </ul>

Category	Tasks
	<ul style="list-style-type: none"> <li>○ Cloud cover</li> <li>○ Wind speed</li> <li>○ Wind direction</li> <li><input type="checkbox"/> Create site sketch on Measurement Summary Sheet showing noise measurement location and any identifying structures, roadways and noise sources.           <p style="margin-left: 40px;"><i>Tip: Sketch should be of sufficient detail that another person to return to the site and set up at the same spot</i></p> </li> <li><input type="checkbox"/> Take photographs of the microphone location (with instrumentation in place) from multiple directions.</li> <li><input type="checkbox"/> Take photographs and/or video documenting dominant noise sources.</li> </ul>
Data Collection	<ul style="list-style-type: none"> <li><input type="checkbox"/> Begin data collection.</li> <li><input type="checkbox"/> Note start time of data collection.</li> <li><input type="checkbox"/> Keep minute by minute notes of observed sound levels and sources.</li> <li><input type="checkbox"/> Note the typical levels for predominant noise sources (man-made and natural sources).</li> <li><input type="checkbox"/> Note any changes in sound levels or weather conditions during the data collection.</li> <li><input type="checkbox"/> Take notes on meteorological conditions every 15 minutes using the Meteorological Observations Sheet</li> <li><input type="checkbox"/> Take traffic counts for roadways contributing to noise level.</li> <li><input type="checkbox"/> End data collection.</li> <li><input type="checkbox"/> Save or store the data to the instrument's memory if that is not automatically done.</li> <li><input type="checkbox"/> Note the data file name or number on the Measurement Summary Sheet.</li> <li><input type="checkbox"/> Perform a post-measurement calibration or calibration check before moving or shutting off the instrumentation (note post-measurement calibration level and time on Measurement Summary Sheet).</li> </ul>
Data Storage	<ul style="list-style-type: none"> <li><input type="checkbox"/> Download data files from instrumentation before leaving site.</li> <li><input type="checkbox"/> Create PDFs of all data sheets at the end of the day using phone camera to PDF app.</li> <li><input type="checkbox"/> Download photos from camera or cell phone.</li> <li><input type="checkbox"/> Back-up all data files and photos to thumb drive or external drive or email all files as an alternative backup method</li> </ul>



**Noise Barrier Insertion Loss Measurements Pack List**

Category	Tasks
Instrumentation	<ul style="list-style-type: none"> <li><input type="checkbox"/> Sound level meters (include a spare if possible)</li> <li><input type="checkbox"/> Microphone extensions (if needed)</li> <li><input type="checkbox"/> Microphone mounts (if needed)</li> <li><input type="checkbox"/> Calibrator</li> <li><input type="checkbox"/> Meteorological station(s)</li> <li><input type="checkbox"/> Tripods for sound level meters, speed detection station and traffic video station (include at least one spare)</li> <li><input type="checkbox"/> Extension poles or telescoping tall tripod for elevating reference microphone above noise barrier</li> <li><input type="checkbox"/> Windscreens (include at least one spare)</li> <li><input type="checkbox"/> Vehicle speed detection unit (laser or radar gun)</li> <li><input type="checkbox"/> Vehicle count boards</li> <li><input type="checkbox"/> Camera</li> <li><input type="checkbox"/> Video camera</li> <li><input type="checkbox"/> Audio recorder(s) (if needed)</li> <li><input type="checkbox"/> Meteorological station</li> <li><input type="checkbox"/> Handheld anemometer</li> <li><input type="checkbox"/> Compass</li> </ul>
Equipment	<ul style="list-style-type: none"> <li><input type="checkbox"/> Laptop</li> <li><input type="checkbox"/> Data storage (USB flash drives or SD cards, if needed)</li> <li><input type="checkbox"/> Clipboards</li> <li><input type="checkbox"/> Cell phone</li> <li><input type="checkbox"/> Radios</li> <li><input type="checkbox"/> Digital watches (one for each field team member)</li> <li><input type="checkbox"/> Headlamps/flashlights</li> <li><input type="checkbox"/> Pocket knife/utility tool</li> <li><input type="checkbox"/> Tape measure</li> <li><input type="checkbox"/> Safety vests</li> <li><input type="checkbox"/> Hardhats</li> <li><input type="checkbox"/> Ladder (if access to top of barrier is needed for a reference microphone)</li> <li><input type="checkbox"/> Traffic cones</li> <li><input type="checkbox"/> Ground tarp(s)</li> <li><input type="checkbox"/> Guy-wires</li> <li><input type="checkbox"/> Stakes (to anchor guy wires for mast/pole assembly or meteorological station)</li> <li><input type="checkbox"/> Camp chair(s)</li> </ul>

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Field Supplies	<ul style="list-style-type: none"><li><input type="checkbox"/> Data sheets</li><li><input type="checkbox"/> Mapping</li><li><input type="checkbox"/> Contact list</li><li><input type="checkbox"/> Notepads</li><li><input type="checkbox"/> Batteries (including spares for sound level meters, speed detection instrumentation, count boards and camera(s))</li><li><input type="checkbox"/> Pens</li><li><input type="checkbox"/> Duct tape</li><li><input type="checkbox"/> Zip ties</li></ul>
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**Highway Barrier Insertion Loss—Measurement Summary Sheet**

Project Name	
Site/Address	
Observer Name	

**General Meteorological Conditions**

Temperature(s)	
Wind Speed(s)	
Wind Direction(s)	

**SLM/Analyzer Information**

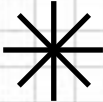
SLM Model		SLM Serial #	
Mic. Height		Mic. Serial #	
Mic. Extension?		Data File Name/Number	

**Calibration Information**

	Pre-Measurement	Post-Measurement
Calibration Time		
Calibration Level		

**Site Sketch**

*(plan/profile view, distances, roadways, buildings, reflecting surfaces, ground type as appropriate)* (Indicate North)


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**Highway Barrier Insertion Loss—Meteorological Measurement Summary Sheet**

Project Name	
Site/Address	
Observer Name	

**Meteorological Instrumentation Information**

Serial #		Serial #	
Height (circle one)	5 ft / 15 ft	Height (circle one)	5 ft / 15 ft
Data File Name/Number		Data File Name/Number	

**Site Sketch**

*(plan/profile view, distances, roadways, buildings)*

(Indicate North)

**Notes:**

**Highway Barrier Insertion Loss—Meteorological Observations Sheet**

Project Name	
Site/Address	
Observer Name	

**Meteorological Observations**

Hour	Minute	Wind Direction	Wind Condition (C=calm; LB= light breeze; G=gusty; MW= moderately windy; VW=very windy)	Cloud Cover Class
	:00			
	:15			
	:30			
	:45			
	:00			
	:15			
	:30			
	:45			
	:00			
	:15			
	:30			
	:45			
	:00			
	:15			
	:30			
	:45			
	:00			
	:15			
	:30			
	:45			

**Notes:****Cloud Cover Class Descriptions**

Cloud Class	Description
1	Heavily overcast
2	Lightly overcast (with continuous sun or the sun obscured intermittently by clouds 20 to 80% of time)
3	Sunny (sun essentially unobscured by clouds at least 80% of the time)
4	Clear night (less than 50% cloud cover)
5	Overcast night (50% or more cloud cover)

**Noise Barrier Insertion Loss—Field Log**

<b>Period #</b>	<b>Period Start Time</b>	<b>Event Description(s) (include event start and stop)</b>
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		
21		
22		
23		
24		
25		
26		
27		
28		
29		
30		

**Notes:**

**Noise Barrier Insertion Loss—Field Log**

<b>Period #</b>	<b>Period Start</b>	<b>Event Description(s) (include event start and stop)</b>
31		
32		
33		
34		
35		
36		
37		
38		
39		
40		
41		
42		
43		
44		
45		
46		
47		
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49		
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57		
58		
59		
60		

**Notes:**

### Noise Barrier Insertion Loss—Traffic Speed Data Sheet

Roadway: _____	Roadway: _____
Direction: _____	Direction: _____

	↓	↓	↓	↓	↓	↑	↑	↑	↑	↑
Lane number:										
Distance to lane:										

Log #	Time	Speed	Vehicle type	Lane #	Log #	Time	Speed	Vehicle type	Lane #

Notes:



**Noise Barrier Insertion Loss—Traffic Count Data Sheet**

Roadway: _____	Roadway: _____
Direction: _____	Direction: _____

Time Start	Auto	MT	HT	Bus	MC	Auto	MT	HT	Bus	MC

**Notes:**

## **8.0 Vehicle Noise Emission Level Measurements**

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This section outlines the field measurement procedures for vehicle noise emission levels. These procedures should not be used in the determination of existing sound levels or model validation as part of a traffic noise study done under 23 CFR 772. Instead, use these specialized procedures to accomplish the following:

- Characterize the sound generated by vehicles traveling on different pavement types as part of a research study.
- Create user-defined vehicles for input into the FHWA TNM, which is used to predict sound levels from traffic and to design traffic noise barriers

### Vehicle Noise Emission Level Measurements (Pre-trip Planning)

Category	Tasks
Personnel	<ul style="list-style-type: none"> <li><input type="checkbox"/> Identify the personnel that will work on each task:                             <ul style="list-style-type: none"> <li><input type="checkbox"/> Measurement Planning_____</li> <li><input type="checkbox"/> Permissions_____</li> <li><input type="checkbox"/> Field Work_____</li> <li><input type="checkbox"/> Data Review_____</li> </ul> </li> <li><input type="checkbox"/> Brief team members.</li> </ul>
Site Selection	<ul style="list-style-type: none"> <li><input type="checkbox"/> Determine approximate number of measurement sites.</li> <li><input type="checkbox"/> Select primary noise measurement locations.                             <p style="margin-left: 40px;"><i>Tip: Avoid choosing locations with any permanent, localized, noise sources (pump houses, generators, HVAC or ventilation fans) that would interfere with measurement of the roadway noise source.</i></p> <p style="margin-left: 40px;"><i>Tip: Consider difficulty in access to the site while choosing locations.</i></p> </li> <li><input type="checkbox"/> Identify secondary or alternative noise measurement locations in the event that local conditions prevent data collection at a primary noise measurement location.                             <p style="margin-left: 40px;"><i>Tip: Be mindful that localized noise sources that interfere with data collection at a primary noise measurement location may influence levels for adjacent properties. Choose secondary locations that are at least one residence or land use away from the primary noise measurement location.</i></p> </li> <li><input type="checkbox"/> Identify primary and secondary locations for the vehicle observer and speed data collection.</li> </ul>
Field review	<ul style="list-style-type: none"> <li><input type="checkbox"/> Visit each planned measurement site to confirm access.</li> <li><input type="checkbox"/> Locate and identify the minimum vehicle separation distances in the field.</li> <li><input type="checkbox"/> Observe local noise environment and evaluate if there are any potential noise sources that might interfere with data collection.</li> </ul>
Noise Descriptors	<ul style="list-style-type: none"> <li><input type="checkbox"/> Use <math>L_{eq}</math> and <math>L_{AFmax}</math> as primary measurement descriptors with fast response exponential time averaging.</li> </ul>
Sampling Period	<ul style="list-style-type: none"> <li><input type="checkbox"/> Determine appropriate sampling period for data collection. Continuous or repeating 1 second intervals suggested.</li> </ul>
Timing and Duration of Measurements	<ul style="list-style-type: none"> <li><input type="checkbox"/> Determine appropriate time (peak hours or off-peak hours, day or night).</li> </ul>
Permissions	<ul style="list-style-type: none"> <li><input type="checkbox"/> Submit preliminary list of all locations for noise measurements to SHA.</li> <li><input type="checkbox"/> Contact any property owners 1-2 weeks ahead of data collection effort seeking permission for property access.</li> </ul>

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<b>Category</b>	<b>Tasks</b>
Measurement Plan approval	<input type="checkbox"/> Submit a detailed measurement plan to SHA (if required).
Documentation	<input type="checkbox"/> Prepare adequate number of copies of data sheets. <input type="checkbox"/> Prepare copies of mapping for note taking in the field. <input type="checkbox"/> Prepare equipment pack list. <input type="checkbox"/> Prepare contact list that includes SHA contact and local law enforcement.

**Vehicle Noise Emission Level Measurements (Pre-trip Preparation)**

Category	Tasks
Instrumentation	<ul style="list-style-type: none"> <li><input type="checkbox"/> Assemble instrumentation, accessories and supplies according to the pack list for this measurement technique.</li> <li><input type="checkbox"/> Test the instrumentation that will be used for data collection, adjusting settings as needed.</li> </ul>
Permissions	<ul style="list-style-type: none"> <li><input type="checkbox"/> Make copies of permission letter from SHA authorizing personnel to be on right-of-way.</li> <li><input type="checkbox"/> Contact local law enforcement the day before the measurements.</li> </ul> <p style="text-align: center;"><i><b>Tip:</b> Describe planned locations, time(s) of day, vehicle make and model</i></p>

**Vehicle Noise Emission Level Measurements (On-site)**

<b>Category</b>	<b>Tasks</b>
Field review (if not conducted during pre-trip planning)	<ul style="list-style-type: none"><li><input type="checkbox"/> Visit each planned measurement site to confirm access and observe local conditions.</li><li><input type="checkbox"/> Visit each vehicle observation and speed data collection location and test radar gun at the location.</li></ul>
Site Appropriateness	<ul style="list-style-type: none"><li><input type="checkbox"/> Determine if there are any localized, non-representative noise sources that interfere with the data collection.</li><li><input type="checkbox"/> Move to alternative noise measurement location if needed.</li></ul>

Category	Tasks
Instrumentation Setup	<ul style="list-style-type: none"> <li><input type="checkbox"/> Attach pre-amp and microphone (with microphone extension, if needed) to sound level meter.</li> <li><input type="checkbox"/> Turn on instrumentation and allow equipment to acclimate to outside conditions for several minutes.</li> <li><input type="checkbox"/> Check and, if needed, reset and synchronize the time on all instrumentation (sound level meters, traffic counters, video cameras, cameras, watches).</li> <li><input type="checkbox"/> Check battery power level.</li> <li><input type="checkbox"/> Check that instrumentation settings are correct.</li> <li><input type="checkbox"/> Calibrate instrument before starting data collection (note initial calibration level and time on Field Data Sheet).</li> <li><input type="checkbox"/> Set microphone height at 5 ft (1.5 m) above the roadway surface.           <p style="margin-left: 40px;"><i>Tip: Make sure the tripod is level and secure. Weigh the tripod down if there is a slope or if breezy wind conditions are expected.</i></p> </li> <li><input type="checkbox"/> Setup traffic cones upstream and downstream from microphone position to indicate minimum separation distance.</li> <li><input type="checkbox"/> Position speed detection instrumentation and staff at speed data collection station.           <p style="margin-left: 40px;"><i>Tip: Conduct a “dry run” of data collection and communication procedure after instrumentation is setup.</i></p> </li> <li><input type="checkbox"/> Setup meteorological station, if needed.</li> </ul>
Documentation	<ul style="list-style-type: none"> <li><input type="checkbox"/> Fill out general information on the Measurement Summary Sheet (date, measurement site name, identifying information, observer name).</li> <li><input type="checkbox"/> Obtain noise measurement location coordinates using a GPS device or cell phone app.</li> <li><input type="checkbox"/> Note weather conditions on Field Data Sheet           <ul style="list-style-type: none"> <li><input type="checkbox"/> Temperature</li> <li><input type="checkbox"/> Cloud cover</li> <li><input type="checkbox"/> Wind speed</li> <li><input type="checkbox"/> Wind direction</li> </ul> </li> <li><input type="checkbox"/> Create site sketch on Measurement Summary Sheet showing noise measurement location and any identifying structures, roadways and noise sources.           <p style="margin-left: 40px;"><i>Tip: Sketch should be of sufficient detail that another person to return to the site and set up at the same spot</i></p> </li> <li><input type="checkbox"/> Take photographs of the microphone location (with instrumentation in place) from multiple directions.</li> <li><input type="checkbox"/> Take photographs and/or video documenting background noise sources.</li> </ul>

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Category	Tasks
Data Collection	<ul style="list-style-type: none"> <li><input type="checkbox"/> Begin data collection.</li> <li><input type="checkbox"/> Note start time of data collection.</li> <li><input type="checkbox"/> Note the background level when no traffic is audible.</li> <li><input type="checkbox"/> Keep detailed notes for each potential pass-by event.</li> <li><input type="checkbox"/> Indicate the quality of each pass-by event based on the rise and fall above the background level.</li> <li><input type="checkbox"/> Note any changes in background sound levels or weather conditions during the data collection.</li> <li><input type="checkbox"/> Obtain the recommended minimum number of samples for each speed range, if possible.</li> <li><input type="checkbox"/> Save or store the data to the instrument's memory if that is not automatically done.</li> <li><input type="checkbox"/> Note the data file name or number on the Field Data Sheet.</li> <li><input type="checkbox"/> Perform a post-measurement calibration or calibration check before moving or shutting off the instrumentation (note post-measurement calibration level and time on Measurement Summary Sheet).</li> </ul>
Data Storage	<ul style="list-style-type: none"> <li><input type="checkbox"/> Download data files from instrumentation before leaving site.</li> <li><input type="checkbox"/> Create PDFs of all data sheets at the end of the day using phone camera to PDF app.</li> <li><input type="checkbox"/> Download photos from camera or cell phone.</li> <li><input type="checkbox"/> Back-up all data files and photos to thumb drive or external drive or email all files as an alternative backup method.</li> </ul>



**Vehicle Noise Emissions Level Measurements Pack List**

<p>Instrumentation</p>	<ul style="list-style-type: none"> <li><input type="checkbox"/> Integrating one third octave band sound level meters (include a spare if possible)</li> <li><input type="checkbox"/> Microphone extensions (if needed)</li> <li><input type="checkbox"/> Microphone mounts (if needed)</li> <li><input type="checkbox"/> Calibrator</li> <li><input type="checkbox"/> Tripods for sound level meters, speed detection station and traffic video station (if needed). Include at least one spare tripod.</li> <li><input type="checkbox"/> Windscreens (include at least one spare)</li> <li><input type="checkbox"/> Vehicle speed detection unit (laser or radar gun)</li> <li><input type="checkbox"/> Vehicle count boards</li> <li><input type="checkbox"/> Camera</li> <li><input type="checkbox"/> Video camera</li> <li><input type="checkbox"/> Meteorological station or hand-held anemometer</li> <li><input type="checkbox"/> Compass</li> </ul>
<p>Equipment</p>	<ul style="list-style-type: none"> <li><input type="checkbox"/> Laptop</li> <li><input type="checkbox"/> Data storage (USB flash drives or SD cards, if needed)</li> <li><input type="checkbox"/> Clipboards</li> <li><input type="checkbox"/> Cell phone</li> <li><input type="checkbox"/> Radios</li> <li><input type="checkbox"/> Digital watches (one for each field team member)</li> <li><input type="checkbox"/> Headlamps/flashlights</li> <li><input type="checkbox"/> Pocket knife/utility tool</li> <li><input type="checkbox"/> Tape measure</li> <li><input type="checkbox"/> Safety vests</li> <li><input type="checkbox"/> Hardhats</li> <li><input type="checkbox"/> Traffic cones</li> <li><input type="checkbox"/> Ground tarp(s)</li> <li><input type="checkbox"/> Camp chair(s)</li> </ul>
<p>Field Supplies</p>	<ul style="list-style-type: none"> <li><input type="checkbox"/> Data sheets</li> <li><input type="checkbox"/> Mapping</li> <li><input type="checkbox"/> Contact list</li> <li><input type="checkbox"/> Notepads</li> <li><input type="checkbox"/> Batteries (including spares for sound level meters, speed detection instrumentation and camera(s))</li> <li><input type="checkbox"/> Pens</li> <li><input type="checkbox"/> Duct tape</li> <li><input type="checkbox"/> Zip ties</li> </ul>

**Vehicle Noise Emission Level Measurements—Measurement Summary Sheet**

Project Name	
Site/Address	
Observer Name	

**General Meteorological Conditions**

Temperature(s)	
Wind Speed(s)	
Wind Direction(s)	

**SLM/Analyzer Information**

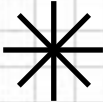
SLM Model		SLM Serial #	
Mic. Height		Mic. Serial #	
Mic. Extension?		Data File Name/Number	

**Calibration Information**

	Pre-Measurement	Post-Measurement
Calibration Time		
Calibration Level		

**Site Sketch**

(plan/profile view, distances, roadways, buildings, reflecting surfaces, ground type as appropriate) (Indicate North)


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## 9.0 Determining the Influence of Pavement on Tire-Pavement Noise

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The purpose of this measurement is to determine the influence of pavement on tire-pavement noise. Applications include:

- Help to validate FHWA TNM (if model is not validating well, pavement may be the cause).
- Gain understanding of influence of pavement on a project.
- Allow mapping of noise levels along roadways.
- Allow for pavement ranking (loudest to quietest).
- Help to establish longevity of noise reducing benefits of pavement.
- Help to choose measurement sites for pavement influence wayside methods (e.g., SPB, SIP, CTIM, etc.)

There are two standardized methods of directly measuring tire-pavement noise source levels:

- ISO 11819-1, Acoustics—Measurement of influence of road surfaces on traffic noise—Part 2: The close-proximity [CPX] method.
- AASHTO T360-6 Standard Method of Test for Measurement of Tire/Pavement Noise Using the OBSI Method. (Related, SAE J2920 Measurement of Tire/Pavement Noise Using Sound Intensity, based on the OBSI method, is currently being developed and is focused on characterizing tires rather than pavements).

These procedures isolate tire noise generation from other sources of the exterior vehicle noise. They use a vehicle or vehicle with trailer to collect data on in-service highway lanes or test roadways, which allows for acquisition of data at any desired location along a roadway, or any travel lane, assuming all method criteria are met.

Specifics on the procedures for CPX and OBSI can be found in documentation for those methods. Here is a review of the key steps in conducting associated measurements:

- Pre-trip planning.
  - Screen for possible study areas and measurement sites using online or other resources.
  - If possible, conduct site visit to confirm measurement locations.
  - Write test plan, including personnel duties (recommended minimum of 2 people), schedule, and data collection procedures.
  - Prepare equipment list.
  - Make travel arrangements, if applicable.
- Pre-trip preparation.
  - Assemble and test instrumentation/equipment.
  - Pack/ship equipment, if applicable.
- On-site set-up.
  - Deploy stationary instrumentation/equipment, as appropriate (may include markers alongside road for start of test sections).
  - Prepare vehicle/trailer for testing.

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- Complete appropriate portions of field data sheets (would include site information, calibration of systems, tire parameters, etc.).
- Data collection.
  - Deploy vehicle/trailer and collect data at appropriate locations.
  - Complete data collection portions of field data sheets.
- Documentation and storage.
  - Finalize field data sheets with any remaining information.
  - Backup all electronic files.
  - Note any equipment difficulties or failures and tag equipment as appropriate.

## 10.0 Determining the Influence of Pavement on Highway Vehicle Noise

---

The purpose of this measurement is to determine the influence of pavement on highway vehicle noise. Applications include:

- Help to validate FHWA TNM (if model is not validating well, pavement may be the cause).
- Gain understanding of influence of pavement on a project.
- Allow for pavement ranking (loudest to quietest).
- Help to establish longevity of noise reducing benefits of pavement.

There are multiple standardized methods of measuring highway vehicle noise in relation to pavements, each involving measurement of single vehicle pass-by events, either isolated in existing traffic or controlled. The methods include:

- ISO 11819-1, Acoustics—Measurement of influence of road surfaces on traffic noise—Part 1: Statistical pass-by (SPB) method. Related, ISO-11819-4 is the same as SPB but with a backing board placed behind the microphone.
- AASHTO TP 98 (this number designation may change when it becomes a full specification) Standard method of test for determining the influence of road surfaces on vehicle noise using the statistical isolated pass-by (SIP) method.
- SAE J2805\_201511 Measurement of noise emitted by accelerating road vehicles (same as ISO 362-1:2015).
- These are pass-by methods that focus on tire-pavement noise: SAE J57\_201405 Sound level of highway truck tires, ISO 13325:2003 Coast-by methods for measurement of tyre-to-road sound emission.

These procedures measure noise on the side of the road as vehicles drive by passing over the pavement of interest.

Specifics on the procedures can be found in documentation for the various methods. Here is a review of the key steps in conducting associated measurements:

- Pre-trip planning.
  - Screen for possible study areas and measurement sites using online or other resources.
  - If possible, conduct site visit to confirm measurement locations.
  - Write test plan, including personnel duties (recommended minimum of 2 people), schedule, and data collection procedures.
  - Obtain site access permissions.
  - Prepare equipment list.
  - Make travel arrangements, if applicable.
- Pre-trip preparation.
  - Assemble and test instrumentation/equipment.
  - Pack/ship equipment, if applicable.

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- On-site set-up.
  - Deploy instrumentation/equipment (may include sound measurement systems, meteorological system, speed instrumentation, etc.).
  - Complete appropriate portions of field data sheets (would include site information, calibration of systems, etc.).
- Data collection.
  - Collect data, including vehicle pass-by time, identification, and speed and maximum pass-by sound levels.
  - Complete data collection portions of field data sheets.
- Documentation and storage.
  - Finalize field data sheets with any remaining information.
  - Backup all electronic files.
  - Note any equipment difficulties or failures and tag equipment as appropriate.



## 11.0 Determining the Influence of Pavement on Highway Traffic Noise

---

The purpose of this measurement is to determine the influence of pavement on highway traffic noise. Applications include:

- Help to validate FHWA TNM (if model is not validating well, pavement may be the cause).
- Gain understanding of influence of pavement on a project.
- Help with pavement ranking (loudest to quietest).
- Help to establish longevity of noise reducing benefits of pavement.

There are different types of standardized method of measuring highway vehicle noise in relation to pavements. The methods include:

- AASHTO TP 99 (this number designation may change when it becomes a full specification) Standard method of test for determining the influence of road surfaces on traffic noise using the continuous-flow traffic time-integrated method (CTIM).
- ISO 11819-1, Acoustics—Measurement of influence of road surfaces on traffic noise—Part 1: Statistical pass-by (SPB) method. Related, ISO-11819-4 is the same as SPB but with a backing board placed behind the microphone.

CTIM involves measurement of free-flowing highway traffic. The ISO methods, statistical pass-by with and without a backing board, involve measurement of single vehicle pass-by events. These procedures measure noise on the side of the road as vehicles/traffic drive by passing over the pavement of interest.

Specifics on the procedures can be found in documentation for the various methods. Here is a review of the key steps in conducting associated measurements:

- Pre-trip planning.
  - Screen for possible study areas and measurement sites using online or other resources.
  - If possible, conduct site visit to confirm measurement locations.
  - Write test plan, including personnel duties (recommended minimum of 2 people, 3 people being far more efficient), schedule, and data collection procedures.
  - Obtain site access permissions.
  - Prepare equipment list.
  - Make travel arrangements, if applicable.
- Pre-trip preparation.
  - Assemble and test instrumentation/equipment.
  - Pack/ship equipment, if applicable.
- On-site set-up.
  - Deploy instrumentation/equipment (may include sound measurement systems, meteorological system, video camera(s), speed instrumentation, etc.).

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- Complete appropriate portions of field data sheets (would include site information, calibration of systems, etc.).
- Data collection.
  - Collect data
    - includes continuous data collection with potential noise intrusions logged.
    - includes vehicle pass-by time, identification, and speed and maximum pass-by sound levels for single vehicle pass-by events.
  - Complete data collection portions of field data sheets.
- Documentation and storage.
  - Finalize field data sheets with any remaining information.
  - Backup all electronic files.
  - Note any equipment difficulties or failures and tag equipment as appropriate.

## 12.0 Determining the Influence of Ground or Pavement Surface on Sound Propagation

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The purpose of this measurement is to determine the influence of ground or pavement surface on sound propagation. Applications include:

- Help to validate FHWA TNM (if model is not validating well, ground type or pavement type may be the cause).
- Gain understanding of influence of ground/pavement surface on a project.
- Gain understanding of influence of ground/pavement surface on measured emission noise levels.
- Gain understanding of influence of ground type on barrier insertion loss (loss of soft ground effect).
- Gain understanding of influence of ground/pavement surface on sound propagation for the purpose of determining pavement effects.

There are several different types of standardized methods that measure absorption parameters of ground or pavement surfaces. The main types are in-situ methods and laboratory methods. The former methods are done on ground and pavement surfaces found at/near the highway sites of interest; these include:

- ANSI/ASA S1.18, American National Standard Method of Test for Determining the Acoustic Impedance of Ground Surfaces (previously known as Template Method for Ground Impedance). (This method could be used in a laboratory if the sample is large enough and the room has proper acoustical absorption.)
- Loudspeaker intensity method (described in Judith L. Rochat, Paul Donovan, Andrew Seybert, and Tyler Dare, “Pavement sound absorption measurements in the U.S.,” Proceedings of Inter-Noise 2012).
- ISO 13472-1, Acoustics—Measurement of sound absorption properties of road surfaces in situ—Part 1: Extended surface method.
- ISO 13472-2, Acoustics—Measurement of sound absorption properties of road surfaces in situ—Part 2: Spot method for reflective surfaces.

The laboratory methods analyze a sample extracted from the field or constructed in a lab; these include:

- ISO 10534-1, Acoustics—Determination of sound absorption coefficient and impedance in impedance tubes—Part 1: Method using standing wave ratio.
- ISO 10534-2, Acoustics—Determination of sound absorption coefficient and impedance in impedance tubes—Part 2: Transfer-function method.
- ASTM E1050, Standard test method for impedance and absorption of acoustical materials using one tube, two microphones, and a digital frequency analysis system.
- ASTM C384, Standard test method for impedance and absorption of acoustical materials by impedance tube method.

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- A laboratory method adapted from ANSI S1.18 (described in Judith L. Rochat, Paul Donovan, Andrew Seybert, and Tyler Dare, “Pavement sound absorption measurements in the U.S.,” Proceedings of Inter-Noise 2012).

Specifics on the procedures can be found in documentation for the various methods. Here is a review of the key steps in conducting associated measurements:

- Pre-trip planning.
  - Screen for possible study areas and measurement sites using online or other resources. (Alternate for laboratory methods, determine where/how to obtain sample.)
  - If possible, conduct site visit to confirm measurement locations. (Alternate for laboratory methods, obtain sample from field, where applicable).
  - Write test plan, including personnel duties (recommended minimum of 2 people for efficiency), schedule, and data collection procedures. (For laboratory methods, 1 person possible).
  - Obtain site access permissions; note that active highway pavement data collection requires lane closure.
  - Prepare equipment list.
  - Make travel arrangements, if applicable.
- Pre-trip preparation.
  - Assemble and test instrumentation/equipment.
  - Pack/ship equipment, if applicable.
- On-site (in field or in laboratory) set-up.
  - Deploy instrumentation/equipment (may include sound measurement systems, meteorological system, etc.).
  - Complete appropriate portions of data sheets (would include site information for field data collection, calibration of systems, etc.).
- Data collection.
  - Data collection, including received sound levels associated with a sound source.
  - Complete data collection portions of data sheets.
- Documentation and storage.
  - Finalize data sheets with any remaining information.
  - Backup all electronic files.
  - Note any equipment difficulties or failures and tag equipment as appropriate.

## 13.0 Vehicle Interior Noise Measurements

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The purpose of this measurement is to determine the vehicle interior. Applications include:

- Evaluate the effect of road surfaces on interior noise.
- Evaluate the effect of pavement surface modifications, such as rumble strips, on interior noise.

There are two standardized methods for measuring vehicle interior noise:

- SAE J1447 Measurement of interior sound levels of light vehicles.
- ISO 5128:1980, Acoustics—Measurement of noise inside motor vehicles.

These procedures measure noise inside a vehicle with specified microphone locations and operating speeds.

Specifics on the procedures can be found in documentation for the methods. Here is a review of the key steps in conducting associated measurements:

- Pre-trip planning.
  - Screen for possible study areas and measurement sites using online or other resources.
  - If possible, conduct site visit to confirm measurement locations.
  - Write test plan, including personnel duties (recommended minimum of 2 people), schedule, and data collection procedures.
  - Prepare equipment list.
  - Make travel arrangements, if applicable.
- Pre-trip preparation.
  - Assemble and test instrumentation/equipment.
  - Pack/ship equipment, if applicable.
- On-site set-up.
  - Deploy stationary instrumentation/equipment, as appropriate (may include markers alongside road for start of test sections and meteorological instrumentation).
  - Prepare vehicle for testing.
  - Complete appropriate portions of field data sheets (would include site information, calibration of systems, road conditions, etc.).
- Data collection.
  - Deploy vehicle and collect data at appropriate locations.
  - Complete data collection portions of field data sheets.
- Documentation and storage.
  - Finalize field data sheets with any remaining information.
  - Backup all electronic files.
  - Note any equipment difficulties or failures and tag equipment as appropriate.