



Transportation Research Synthesis

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Far-Field Testing of Noise Wall Effectiveness: Survey of State Practice and Literature Scan

The purpose of this TRS is to serve as a synthesis of pertinent completed research to be used for further study and evaluation by MnDOT. This TRS does not represent the conclusions of either CTC & Associates or MnDOT.

Introduction

Local Minnesota transportation officials have received complaints that new highway sound walls along I-35W have increased noise, reaching residents 1,500 feet from the highway. MnDOT and local engineers don't believe increased noise is scientifically possible following the installation of noise walls; residents are more likely reacting to the increased noise when a lengthy construction project ceases and full highway traffic is restored. However, neither MnDOT nor local agencies currently conduct actual noise level testing at distances greater than 400 feet from the noise wall.

Before performing a formal investigation involving such "far-field" testing to confirm MnDOT's view that far-field noise levels do not increase with the installation of noise walls, CTC & Associates was asked to review noise wall testing research and guidance, and contact national experts to determine whether such testing has been performed elsewhere. The scope of this investigation also includes determining how other state departments of transportation have responded to similar complaints. This review doesn't include noise generated by reflection between parallel barriers; Minnesota is investigating this issue by other means.

Summary

A thorough search of publications revealed no published far-field measurement results. However, we were referred to a study (Validation of FHWA's Traffic Noise Model) where measurements were taken up to nearly 1,300 feet; this data is available upon request. FHWA guidance provides some cautions for considering atmospheric conditions when taking far-field measurements.

We reviewed a number of other studies and general information documents involving sound wall effectiveness testing to determine whether measurements farther than 500 feet were undertaken or recommended. We have provided some citations where the authors provided a rationale for measurement site selection or other information relevant to our scope. In all cases we found, measured sites were within the range covered by FHWA specifications (that is, not far field). Our citations include two reports from the International Institute of Noise Control Engineering; these findings suggest that far-field noise measurements have not been perceived as a necessary point of inquiry outside of the United States.

We conducted a short survey about experience performing far-field noise testing and strategies for responding to complaints about increased noise levels after the installation of sound walls. The survey was sent to representatives of state DOTs as listed in [the membership roster of the TRB Committee on Transportation-Related Noise and Vibration](#). None of the 18 responses indicated any experience with such testing. Several states shared their strategies for responding to complaints; these chiefly included taking one-off measurements from the complainant's site and citing federal guidelines on recommended maximum noise levels (much as one might respond to a complaint about air or water pollutant levels).

Finally, we extended the query about current or contemplated work being done in this area to contacts listed on relevant organizational sites: U.S. Department of Transportation/FHWA, AASHTO and TRB. This effort did not inform us of additional cases of far-field testing, but may provide consultation contacts for subsequent research that Minnesota may take in this area. Contacts for these organizations are listed at the end of this report.

Guidance and Research

FHWA Traffic Noise Model Version 2.5, Highway Traffic Noise, Federal Highway Administration, undated.

http://www.fhwa.dot.gov/environment/noise/traffic_noise_model/tnm_v25/

This Web page provides documents guiding noise analysis for construction projects. Federal traffic noise level [measurement guidelines](#) do not include far-field testing specifications. In Section 4.1.2 Microphone Location, researchers state that “for receiver distances greater than 100 m (300 ft) from the source, atmospheric effects have a much greater influence on measured sound levels. In such instances, precise [meteorological data](#) will be needed to ensure BEFORE and AFTER equivalence of meteorological conditions.”

Validation of FHWA’s Traffic Noise Model (TNM): Phase 1, Judith L. Rochat and Gregg G. Fleming, U.S. Department of Transportation, John A. Volpe National Transportation Systems Center, 2002.

https://mutcd.fhwa.dot.gov/environment/noise/traffic_noise_model/model_validation/phase_one/tmph1va.pdf

This study to validate the FHWA’s Traffic Noise Model included measurements at distances ranging from 50 feet to “almost 1300 [feet]” (page 9). The report compares these measurements to those predicted by the Traffic Noise Model (pages 51-52). The raw data for the study can be obtained by sending a mailing address to Aaron Hastings at aaron.hastings@dot.gov.

Highway Traffic Noise in the United States: Problem and Response, Federal Highway Administration, April 2000.

<http://ntl.bts.gov/lib/9000/9200/9220/usprbrsp.pdf>

Relevant to Minnesota’s concern for public complaints about noise barriers increasing noise levels, this general information document summarizes public perception, stating that while public reaction to barriers has generally been positive, there have been negative reactions including loss of air circulation, feeling of confinement and loss of sunlight (page 15). Notably, there is no mention here of any complaints of increased noise nor regarding any effects felt by those far from the barriers.

FHWA Traffic Noise Model: Version 3.0 Software Development, TPF-5(158), Transportation Pooled Fund Program, 2011.

<http://www.pooledfund.org/Details/Study/384>

This appears to be the only pooled fund with a scope that comes close to overlapping the current concern, including some of the same investigators as the Validation of FHWA’s Traffic Noise Model study above (Judy Rochat and Aaron Hastings). According to lead agency contact Mark Ferroni of FHWA, far-field testing is not one of the project activities currently selected by the six participating states.

772.13 Analysis of Noise Abatement, Title 23: Highways, Electronic Code of Federal Regulations, 2012.

[http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?](http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr;sid=1253e5cedf4b79ecfe5150fe9d7d00e7;rgn=div5;view=text;node=23%3A1.0.1.8.44;idno=23;cc=ecfr)

[c=ecfr;sid=1253e5cedf4b79ecfe5150fe9d7d00e7;rgn=div5;view=text;node=23%3A1.0.1.8.44;idno=23;cc=ecfr](http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr;sid=1253e5cedf4b79ecfe5150fe9d7d00e7;rgn=div5;view=text;node=23%3A1.0.1.8.44;idno=23;cc=ecfr)

FHWA Highway Traffic and Construction Noise—Problem and Response, Highway Traffic Noise, FHWA, April 2006.

http://www.fhwa.dot.gov/environment/noise/regulations_and_guidance/probrsp.cfm

Multiple survey respondents (see **DOT Survey Responses** in this report) suggested that a sufficient response to a noise complaint is a measurement at that location to demonstrate that the noise at that time is beneath FHWA-recommended thresholds. This constitutes an alternative approach to a systematic study, which could be used to address isolated complaints if Minnesota officials do not believe there is a recurrent problem.

Effectiveness of Noise Barriers Installed Adjacent to Transverse Grooved Concrete Pavement, Lloyd Herman, Wallace Richardson and Deborah McAvoy, Ohio Research Institute for Transportation and the Environment, 2009.

http://ntl.bts.gov/lib/31000/31300/31383/134365_FR.pdf

On page 7, researchers explain that sites were selected in line with Ohio DOT procedures: “Noise analyses are typically conducted for noise sensitive land uses that are within 600 ft of the edge of the highway pavement.” A potentially useful list of considerations for site selection (such as away from interchanges, road surfaces in good condition and ground surface area level with the road surface) is found on pages 8-10. All of these considerations point to factors that could cause the results of a given far-field test from a complainant’s location to deviate from an expected reading.

Continued Evaluation of Noise Barriers in Florida, R.L. Wayson, J.M. MacDonald, A. El-Aassar and W. Arner, University of Central Florida, Department of Civil and Environmental Engineering, 2002.

<http://ntl.bts.gov/lib/12000/12200/12234/12234.pdf>

One of the goals of this study, which tested the effectiveness of in-situ barriers, was to determine the length of the shadow zones created behind such barriers. As such, measurements were taken beyond those found necessary in this follow-up study,

and meteorological data was collected as well. One conclusion was that “shadow zone benefits, as determined by a 5 dB: L_{Aeq} sound level reduction, generally were limited to under 400 feet ... behind even the taller noise barriers” (page 3).

Technical Assessment of the Effectiveness of Noise Walls, International Institute of Noise Control Engineering, *Noise/News International*, 1999: 137-161.

<http://www.i-ince.org/data/iince991.pdf>

This report includes some comparison of different countries’ practices in barrier usage and testing, with a wide scope that summarizes various aspects of barrier configuration, different transportation modalities and information about the science of sound. In Barrier Height and Proximity of Source/Receiver to the Barrier (page 143), researchers state that “barrier protection is greatest for the first row of housing (closest proximity) while reduced protection results for further rows of housing.” Researchers do not indicate an effect—positive or negative—of barriers on far-field measurements or of any country’s measures to address far-field complainants.

Guidelines for Community Noise Impact Assessment and Mitigation, Lawrence S. Finegold, et al., I-INCE Technical Study Group on Community Noise: Environmental Noise Impact Assessment and Mitigation (TSG 6), 2011.

<http://www.i-ince.org/data/iince111.pdf>

The scope of this more recent international synthesis designed to provide practical guidance to policymakers is wider than only highway noise and may provide more comprehensive and current advice than other sources in determining what policies to implement regarding tolerable base noise levels that may be cited in response to complainants. Appendix A (page 25) includes the types of effects that various noise levels may have on the public and relevant metrics.

DOT Survey Responses

An email survey was sent to all state DOT members of the TRB Committee on Transportation-Related Noise and Vibration, Highway Noise Subcommittee, with the following two questions:

1. Does your agency conduct far-field (i.e., at 1,500 feet away or greater) noise level testing before and after installation of noise walls? If so, can you share this data with us?
2. Have you received complaints from residents that noise levels surrounding a highway actually increased after installation of a noise wall? If so, how did you respond to these complaints?

None of the 19 respondents had experience with far-field testing, and a few provided cautionary words against this sort of testing, as in the response from Bruce Rymer of Caltrans. Eleven respondents, however, had received complaints of sound levels increasing after sound wall installation and dealt with the problem generally by performing on-site measurements and/or by explaining the science involved. According to Terry Smith of New York DOT, “What [residents] are perceiving as a difference is a change in the character of the sound.”

The complete survey responses from 17 state DOTs (two Caltrans representatives responded) and one Canadian province follow.

California

Contact: Bruce Rymer, Caltrans, (916) 653-6073, bruce_rymer@dot.ca.gov.

1. This is never or rarely done—particularly at that great of a distance; meteorology and ground effects kick in and significantly impact highway noise levels. Also FHWA TNM has only been validated to 500 feet.
2. A few, mostly related to the perception that the walls were raising noise levels due to reflection at a point opposite of the new barrier. We respond on a case-by-case basis. Reflected noise might be an issue under certain conditions, but it is too small to even measure, especially at larger distances because meteorology and ground effects kick in and significantly impact highway noise levels. Absorptive sound wall material can be used by project design, if we think it will be a problem.

Contact: Tony Louka, Caltrans, (909) 383-6385, tony_louka@dot.ca.gov.

1. We usually do not conduct noise readings for areas 1500 feet from the freeway/highway for several reasons. The most important reason is that TNM does not predict correctly above 500 feet and normally sound walls don’t help for receivers that far.
2. As far as the complaints, we tell them that because of the noise reduction the vibration is less that is why you feel the noise.

Florida

Contact: Mariano Berrios, Florida Department of Transportation, (850) 414-5250, mariano.berrios@dot.state.fl.us.

1. No, but we did a couple of near field measurements behind a couple of constructed walls just to get an idea of what is happening at 400'-500' many years ago.
2. We have received a couple. We normally ask our noise specialists at the District level to contact the person complaining. Many times they go out and take measurements at the property in question.

Maryland

Kenneth Polcak, Maryland State Highway Administration, (410) 545-8601, kpolcak@sha.state.md.us.

1. We do not as a practice test far-field receptors, particularly behind barriers, nor have we received any requests to do so. Too many atmospheric variables make potential conclusions full of caveats and qualifiers.
2. No. The biggest issue we've encountered from "far-field" receptors is basically audibility-related. On those occasions there was no barrier, levels were found to be well below criteria, but individual vehicle events (i.e., loud truck, jake-braking, motorcycles, etc.) were clearly discernible over the background.

Michigan

Thomas Hanf, Michigan Department of Transportation, (517) 241-2445, hanft@michigan.gov.

1. No, Michigan DOT does not conduct far-field noise level testing before and/or after installation of noise barrier.
2. We have received complaints from residents of perceived noise increase after the installation of a noise barrier. We would review the highway noise and abatement analysis technical report keeping in mind the location of the resident who has lobbied the complaint. The analysis will provide the information needed to respond to the complainant. We would review the change in average annual daily traffic at the time of completion of the barrier and the date of the complaint if an extended period of time (5 years or more depending on the situation) has passed since the completion of the barrier. The timing of the complaint is an important factor in formulating a response. Field measurements would be conducted only if the analysis was deemed questionable or the situation warranted it. However, if field measurements are done, the complainant will be told that no abatement activity would follow, even if there is an impact according to FHWA Noise Abatement Criteria (NAC), because there is no Federal or State of Michigan funding program for abatement in such a case, and there are no Federal regulations requiring a State Transportation Agency (STA) to provide noise abatement in such a situation (unless the STA has a program of their own).

The words "actually increased" in your question presume field measurements were done according to FHWA protocol to identify an increase. If the complainant is reporting sound levels based on a sound meter, they must be informed that the sound meter must be a Type I or Type II meter and the FHWA method must have been used. Often the complainant has used a less expensive meter without A-weighting and only records and reports the L_{max} rather than the L_{eq} .

Missouri

Robert Meade, Missouri Department of Transportation, (573) 526-6677, robert.meade@modot.mo.gov.

1. No.
2. Yes. We have explained that bounce back is usually very minimal. In other cases, we have taken noise readings to demonstrate the point.

Nevada

Daniel Harms, Nevada Department of Transportation, (775) 888-7685, dharms@dot.state.nv.us.

1. No. Given policy requirements and available tools, our experiences have validated the FHWA statement: “Highway traffic noise is not usually a serious problem for people who live more than 500 feet from heavily traveled freeways or more than 100 to 200 feet from lightly traveled roads.”
2. Not that I recall. Any traffic noise “complaint,” related to an NDOT facility, is addressed by offering to conduct a 24-hour measurement, where possible, and evaluate according to conditions and policy.

New York

Terry Smith, New York State Department of Transportation, (518) 457-2385, tcsmith@dot.state.ny.us.

1. We do not.
2. Yes. These are tricky to respond to. If they are within the study area for the noise analysis we sometimes will go out and measure noise levels and do traffic counts to see if it differed from the modeled result. Usually we are very close. We are dealing with perceptions here, so often we explain that the dBA is not higher. What they are perceiving as a difference is a change in the character of the sound. Typically more longer-wavelength sound. If the complaint is outside the study area (500 or more feet) we may take measurements, but information and education is often all we can offer.

Ohio

Noel Alcalá, Ohio Department of Transportation, (614) 466-5222, noel.alcala@dot.state.oh.us.

1. No, but we have done some near-field post-installation testing at the benefitted receiver locations.
2. We have received a few. We went out and performed a noise reading at their request and found that the level was well below the FHWA NAC, and that seemed to address the complaint.

Ontario, Canada

Chris Blaney, Ontario Ministry of Transportation, (416) 235-5561, chris.blaney@ontario.ca.

1. We have not performed these kinds of measurement for over 25 years. In the 25 to 35 year ago period my Ministry did a great deal of field measurements, but the majority were at distances less than 250 meters from the walls. We now rely entirely on predictions.
2. We have received some complaints and if one looks into the science and some of the noise modeling for that matter, it may be true. The loss of ground absorption may be greater than the noise barrier insertion loss and that all assumes that there are no other features on the site such as homes. We never construct noise barriers for non-urban areas, thus the propagation over the homes already causes the highway noise to have a high source height for more distant homes. Also, urban areas usually don't have highly absorptive ground surfaces. Another factor one must also consider is that noise barriers don't attenuate all frequencies equally, and thus there may be a change in the tone of the highway noise at greater distances. Responding to the complaint would depend on the site characteristics. In most cases, even if there were a slight increase in sound levels it would be very minor.

Oregon

Carole Newvine, Oregon Department of Transportation, (503) 986-3447, carole.newvine@odot.state.or.us.

1. No—unless there is a complaint.
2. Yes—responded with letter citing info from published literature—basically in their particular case that it was unlikely that their noise levels increased by 3 dBA.

Washington

Larry Magnoni, Washington State Department of Transportation, (206) 440-4544, magnonil@wsdot.wa.gov.

1. In my 20 years of measuring this distant sound level from those complaining it always fell below the abatement criteria. Even in my recent experience at using the TNM Model 2.5 and the lowest background measurement in rural areas of Washington State to determine at where a 10 dB increase impact could occur the model seems to show that the sound level increase will drop to below the 10 dB increase at about 500 to 600 feet for the low volume SR302 highway. This could change depending on the volume of the highway to be realigned in rural areas.
2. I also would add that some of the complaints from distant receivers are across bodies of water such as Bow Arts from the I-90 East Chanel Bridge, and the Laurelhurst Neighborhood from SR520 Floating Bridge and even those were below the NAC.

Wisconsin

Jay Waldschmidt, Wisconsin Department of Transportation, (608) 267-9806, jay.waldschmidt@dot.wi.gov.

1. No, WisDOT does not conduct far-field measurements.
2. Yes, we did get complaints. We now have an absorptive noise barrier policy. We still get complaints at times, but the absorptive policy is referenced and we do not go out and do additional measurements.

Additional Survey Respondents

The following respondents answered in the negative to both questions, with no elaboration except where indicated:

- Fred Garcia, Arizona Department of Transportation, (602) 712-8635, fgarcia@dot.state.az.us
- Tom Koos, Kentucky Transportation Cabinet, (502) 564-7250, tom.koos@ky.gov
- Elton Holloway, Mississippi Department of Transportation, (601) 359-7685, eholloway@mdot.state.ms.us: Only two noise barriers in the state.
- Sean Schulz, Nebraska Department of Roads, (402) 479-4696, sean.schulz@nebraska.gov: They only test to 500'.
- Pamela Springer, Rhode Island Department of Transportation, (401) 222-2023, ext. 4660, pspringer@dot.ri.gov: No noise barriers in the state.
- Ray Umscheid, Texas Department of Transportation, (512) 416-3025, ray.umscheid@txdot.gov: He has not heard complaints post construction, but voiced when barriers are proposed.

Other Organizational Contacts

We also reviewed noise-related information on several organizations' websites and found no mention of far-field testing beyond what has already been listed in this report. We contacted the following individuals at these organizations to ask for additional insight into relevant research, practices, guidance or agency discussions, with no additional results:

- **Transportation Research Board**, Committee on Transportation-Related Noise and Vibration, <http://www.adc40.org>
Contact: Christine Gerencher, TRB Staff Representative, (202) 334-2968, cgerencher@nas.edu
- **AASHTO Standing Committee on the Environment**
<http://scoe.transportation.org>
Contact: Kate Kurgan, Senior Program Manager for Environment, (202) 624-3635, kkurgan@aaashto.org
- **U.S. Department of Transportation**, John A. Volpe National Transportation Systems Center, <http://www.volpe.dot.gov>

Contact:

Aaron Hastings, (617) 494-3220, aaron.hastings@dot.gov
Gregg Fleming, (617) 494-2018, gregg.fleming@dot.gov

- **Federal Highway Administration**
<http://www.fhwa.dot.gov/environment/noise>
Contact: Mark Ferroni, (202) 366-3233, mark.ferroni@dot.gov