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Traffic Noise Technical Report, Revised Final Draft
US-23/US-12 Improvements

Prepared for

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List of Acronyms and Abbreviations

ANSI	American National Standards Institute
CNE	Common Noise Environment
CPBU	Cost Per Benefited Receptor Unit
dB	Decibel (measure of sound pressure level on a logarithmic scale)
dBA	A-weighted decibel (sound pressure level)
DU	Dwelling Unit
DUE	Dwelling Unit Equivalent
FHWA	Federal Highway Administration
Leq	Equivalent sound level (energy averaged sound level)
Leq(1h)	A-weighted, energy average sound level during a 1-hour period
LOS	Level-of-Service
LT	Long-Term
MDOT	Michigan Department of Transportation
Mph	Miles per hour
NAC	Noise Abatement Criteria
NR	Noise Reduction
ROW	Right of Way
ST	Short-Term
TNM	Traffic Noise Model

Executive Summary

This noise analysis was conducted to assess the noise impacts of the US-12/US-23 improvement project in Pittsfield Township, MI. US-12 and US-23 experience a high volume of traffic daily, this project is intended to ease congestion, increase safety, and eliminate turning conflicts. The project includes improvements to both US-12 and US-23. Improvements on US-12 include new travel lanes in both directions beginning outside the Pittsfield police station and extending across US-23 to Carpenter Road. This also includes redesigned intersections, and a new right-hand turn lane from Eastbound US-12 to Southbound Platt Road. At the interchange of US-12 and US-23, new right turns on ramps are being added in the North West and South East quadrants. Last, an auxiliary lane is being added in both directions on US-23 between I-94 and US-12, and the acceleration/de-acceleration lanes South of US-12 are also being extended.

FHWA defines Type I projects as Federal highway projects in a new location, a physical alteration of an existing highway that significantly changes either horizontal or vertical alignment or increases the number of through lanes. This noise study is for a re-evaluation of the 2005 FONSI for the US-12 Improvement Study, from City of Saline to Munger Road. The noise study is required because of the addition of the NB and SB US-23 weave merge lanes north of the US-12 interchange added after the FONSI. 23 CFR 772 requires that the whole project is studied if the project is defined as a Type I. FHWA requires a noise study for all Type I projects to assess potential noise impacts and mitigation options.

This noise study included on site noise measurements in the project vicinity, conducted in November of 2020. Two long term measurements were conducted, one along each highway, along with six short term measurements dispersed across the project area.

A model was developed in the FHWA Traffic Noise Model (TNM) version 2.5 and validated against these field measurements. Noise sensitive receptors were then identified and classified with existing and future levels calculated in TNM 2.5. These predicted levels were checked against FHWA standards to determine impacts in the area. Mitigation for these impacts were analyzed according to MDOT feasibility and reasonableness standards.

The project includes eight Common Noise Environments (CNEs), with impacts identified in six of the eight. Abatement in the form of noise walls were considered in several locations but none were recommended. A summary of these findings is presented in table ES-1 and discussed in more detail in the body of the report.

Table ES-1 Summary of Project Impacts and Proposed Noise Abatement

CNE	Description/Location	2020 Impact	2040 Impacts	Recommended Noise Abatement
CNE-1A	Single Family Homes, South of US-12, West of Platt	5	7	Not Recommended
CNE-1B	Commercial, Vacant, Agricultural North of US-12, West of Platt	0	0	No Impacts
CNE-2	Single and Multi-family Homes South of US-12 Between Platt and US-23	14	29	Not Recommended
CNE-3	Single and Multi-family Homes North of US-12 Between Platt and US-23	15	15	Not Recommended
CNE-4	Single Family Homes, South of US-12, East of Carpenter Rd	0	0	No Impacts
CNE-5	Commercial and Industrial Land Use, East of US-23, North of US-12	0	0	No Impacts
CNE-6	Single Family Home, West of US-23, North of US-12	1	1	Not Recommended

CNE-7	Single Family Homes, West of US-23, South of US-12	3	3	Not Recommended
CNE-8	Single Family Homes, East of US-23, South of US-12	2	2	Not Recommended

1. Introduction and Project Description

1.1 Project Description

This project includes improvements to both US-12 and US-23. Improvements on US-12 include new travel lanes in both directions beginning outside the Pittsfield police station and extending across US-23 to Carpenter Road. This also includes redesigned intersections, and a new right-hand turn lane from Eastbound US-12 to Southbound Platt Road. At the interchange of US-12 and US-23, new right turns on ramps are being added in the North West and South East quadrants. Last, an auxiliary lane is being added in both directions on US-23 between I-94 and US-12, and the acceleration/deacceleration lanes South of US-12 are also being extended. The general project location, project limits and areas of project improvements are shown in Figure 1-1.

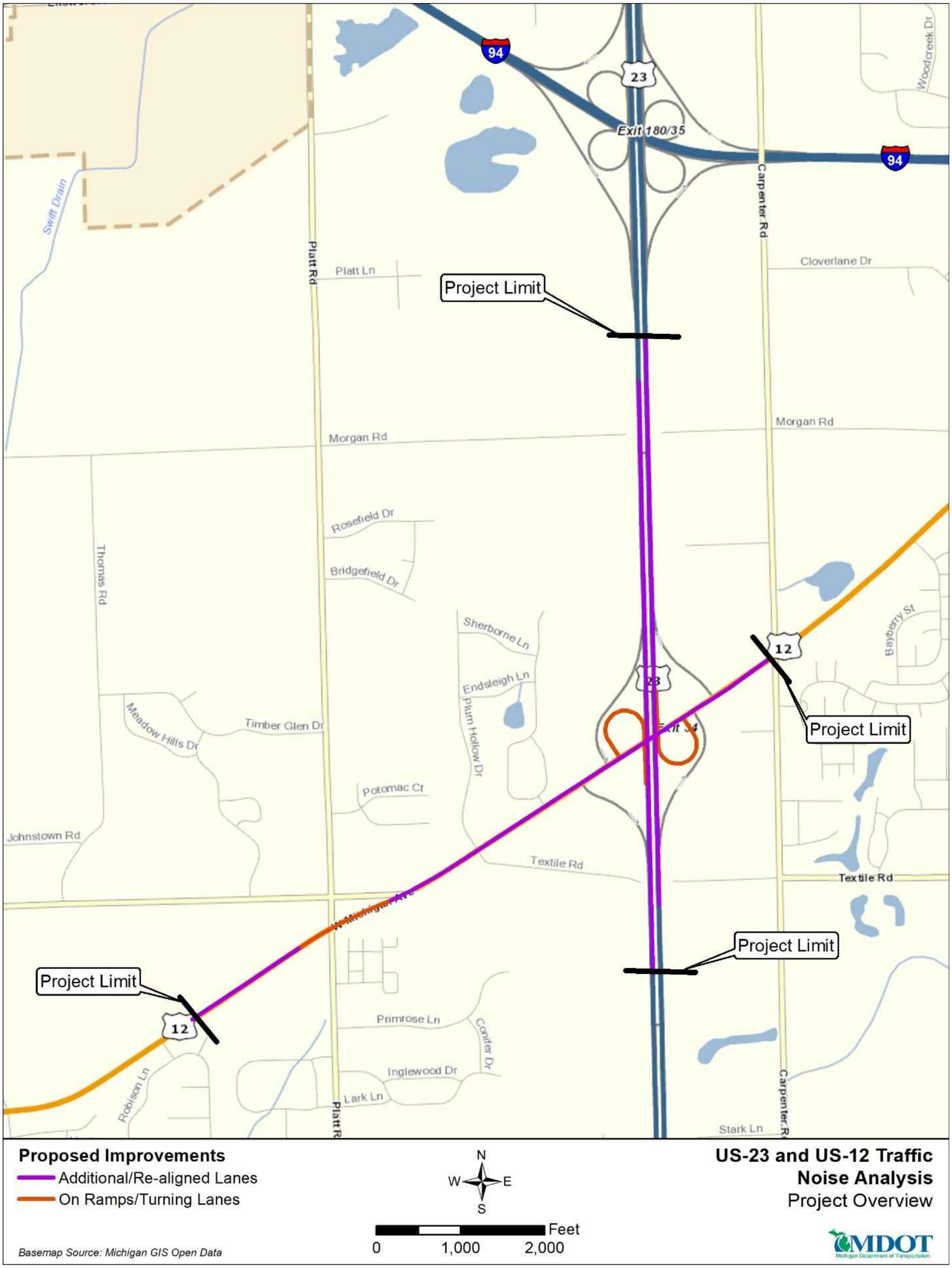
This noise study is for a re-evaluation of the 2005 FONSI for the US-12 Improvement Study, from City of Saline to Munger Road. The noise study is required because of the addition of the NB and SB US-23 weave merge lanes north of the US-12 interchange added after the FONSI. 23 CFR 772 requires that the whole project is studied if the project is defined as a Type I. FHWA requires a noise study for all Type I projects to assess potential noise impacts and mitigation options. FHWA defines a Type I project as a Federal highway project being constructed in a new location, a significant change in horizontal or vertical alignment of an existing roadway, or an increase in the number of through-traffic lanes. As this project includes that addition of new travel lanes along both US-12 and US-23, the project as defined in the environmental document meets the Type 1 project criteria and requires a noise analysis.

1.2 Description of Alternatives

This project includes one future build alternative to be evaluated:

- Future build (includes all proposed improvements and projected traffic volumes for year 2045)

Figure 1-1 Project Overview



2. Traffic Noise Concepts

The following glossary of acoustical terms is intended to help frame discussion of project-generated noises and their potential effects on neighboring communities in the project area.

2.1 Glossary of Acoustical Terms

Noise: Whether something is perceived as a noise event is influenced by the type of sound, the perceived importance of the sound, and its appropriateness in the setting, the time of day, and the type of activity during which the noise occurs, and the sensitivity of the listener. Local jurisdictions may have legal definitions of what constitutes "noise" and such environmental parameters to consider.

Sound: For this analysis, sound is a physical phenomenon generated by vibrations that result in waves that travel through a medium, such as air, and result in auditory perception by the human brain.

Frequency: Sound frequency or "pitch" is measured in hertz (Hz), which is a measure of how many times each second the crest of a sound pressure wave passes a fixed point. For example, when a drummer beats a drum, the skin of the drum vibrates a number of times per second. When the drum skin vibrates 100 times per second, it generates a sound pressure wave that is oscillating at 100 Hz, and this pressure oscillation is perceived by the brain as a tonal pitch of 100 Hz. Sound frequencies between 20 and 20,000 Hz are within the range of sensitivity of the best human ear.

Amplitude or Level: Sound levels are measured in decibels (dB) using a logarithmic scale. A sound level of zero dB is approximately the threshold of human hearing and is barely audible under extremely quiet listening conditions. Normal speech has a sound level of approximately 60 dB. Sound levels above approximately 110 dB begin to be felt inside the human ear as discomfort and eventually as pain at 120 dB and higher levels. The minimum change in the sound level of individual events that the average human ear can detect is about 1 to 2 dB. A 3 to 5 dB change is readily perceived. A change in sound level of about 10 dB usually is perceived by the average person as a doubling (or if decreasing by 10 dB, halving) of the sound's loudness. Table 2-1 shows typical indoor and outdoor sounds and their corresponding dB levels, arranged on what often is referenced as an "acoustic thermometer" to show relative loudness.

Sound pressure: Sound level usually is expressed by reference to a known standard. This report refers to sound pressure level, which is expressed on a logarithmic scale with respect to a reference value of 20 micropascals. Sound pressure level depends not only on the power of the source, but also on the distance from the source and the acoustical characteristics of the space surrounding the source.

A-weighting: Sound from a tuning fork contains a single frequency (a pure tone), but most sounds heard in the environment do not consist of a single frequency; instead, they are composed of a broad band of frequencies, differing in sound levels. The method commonly used to quantify environmental sounds consists of evaluating all frequencies of a sound according to a weighting system that reflects the typical frequency-dependent sensitivity of average healthy human hearing. This is called "A-weighting," and the measured decibel level is referred to as A-weighted decibels (dBA).

Equivalent sound level: Environmental noise levels vary continuously and include a mixture of noise from near and distant sources. A single descriptor, energy-average sound level during a measured time interval (L_{eq}), may be used to describe such sound that is changing in level from one moment to another. L_{eq} is the energy-average sound level during a measured time interval. This is the "equivalent" constant sound level that would have to be produced by a single, steady source to equal the acoustic energy contained in the fluctuating sound level measured.

Day-night level (L_{dn}): The L_{dn} is the energy average of the A-weighted sound levels occurring during a 24-hour period, with 10 dB added to A-weighted sound levels occurring between 10 p.m. and 7 a.m. (nighttime).

Sound transmission loss (TL): The TL is a value representing 10 times the base-10 logarithm of the ratio of sound power incident on one side of a partition to the sound power transmitted through and subsequently emitting from the other side of the partition into an adjoining space (separated from the sound in the "source" space by the partition).

Insertion loss (IL): The IL is the reduction in noise level at a location from noise abatement means, placed in the sound path between that location and a sound source.

2.2 Fundamentals of Traffic Noise Assessment and Control

Sound Propagation

Atmospheric conditions (e.g., wind, temperature gradients, humidity) can change how sound propagates over distance and can affect the level of sound received at a given location. The degree to which the ground surface absorbs acoustical energy also affects sound propagation. Sound traveling over an acoustically absorptive surface (e.g., grass) attenuates at a greater rate than sound traveling over a hard surface (e.g., pavement, expanses of open water). When located near either the sound source or the listener position, physical barriers (e.g., naturally occurring ridgelines or buildings, and other topography that block the line-of-sight between a source and receiver) also increase the attenuation of sound over distance.

Multiple Sound Sources

Because sound pressure levels in decibels are based on a logarithmic scale, they cannot be added or subtracted in an arithmetic fashion. Therefore, sound pressure level dB are logarithmically added on an energy summation basis. In other words, adding a new noise source to an existing noise source, both producing noise at the same level, does not double the noise level. Instead, if the difference between two noise sources is 10 dBA or more, the louder noise source dominates, and the resultant noise level is equal to the noise level of the louder source. In general, if the difference between two noise sources is 0 to 1 dBA, the resultant noise level is 3 dBA higher than the louder noise source, or both sources if they are equal. If the difference between two noise sources is 2 to 3 dBA, the resultant noise level is 2 dBA above the louder noise source. If the difference between two noise sources is 4 to 10 dBA, the resultant noise level is 1 dBA higher than the louder noise source.

How Noise is Measured

Sound can vary over an extremely large range of amplitudes. The decibel (dB) is a logarithmic unit that is the accepted standard unit for measuring the amplitude of sound because it accounts for these large variations in amplitude and reflects the way people perceive changes in sound amplitude. Different sounds may have different frequency content. Frequency content of a sound refers to its tonal quality or pitch. When describing sound and its effect on a human population, A-weighted (dBA) sound levels are typically used to account for the response of the human ear. The term "A weighted" refers to a filtering of the noise signal to emphasize frequencies in the middle of the audible spectrum and to de-emphasize low and high frequencies in a manner corresponding to the way the human ear perceives sound. This filtering network has been established by the American National Standards Institute (ANSI). The A-weighted noise level has been found to correlate well with peoples' judgments of the noisiness of different sounds and has been used for many years as a measure of community noise. Table 2-1 illustrates sound pressure levels in dBA of various sound sources between 0 dBA (threshold of hearing) and 120 dBA (threshold of pain). An increase of 3 dBA in noise level can barely be perceived, while an increase of 5 dBA is readily noticeable and considered a significant noise increase. A 10 dBA increase corresponds to a subjective doubling of loudness. A relationship between changes in noise level and loudness is indicated in Table 2-2. Since noise fluctuates from moment to moment, it is common practice to condense the noise level over a specified period of time into a single number called the Equivalent Noise Level (Leq). Many surveys have shown that the Leq properly predicts annoyance, and thus this metric is commonly used for noise measurements, prediction, and impact assessment.

Table 2-1 Common Indoor and Outdoor Noise Levels

Common Outdoor Noise Levels Noise Level	Noise Level (A-weighted decibels)	Common Indoor Noise Levels
	110	Rock Band
Jet Flyover at 1000 feet	100	Inside Subway Train (NY)
Gas Lawn Mower at 3 feet		
Diesel Truck at 50 feet	90	Food Blender at 3 feet
Noisy Urban Daytime	80	Garbage Disposal at 3 feet
Gas Lawn Mower at 100 feet	70	Vacuum Cleaner at 10 feet
Commercial Area		Normal Speech at 3 feet
	60	
		Large Business Office
Quiet Urban Daytime	50	Dishwasher Next Room
Quiet Urban Nighttime	40	Small Theater
Quiet Suburban Nighttime		Library
	30	
Quiet Rural Nighttime		Bedroom at Night
	20	
		Broadcast & Recording Studio
	10	
	0	Threshold of Hearing

Source: Adapted from Guide on Evaluation and Attenuation of Traffic Noise, AASHTO-1974

Table 2-2 Relationship between Changes in Noise Level and Perceived Loudness

Increase (or Decrease) in Noise Level	Loudness Multiplied (or Divided) by
3 decibels	1.2
6 decibels	1.5
10 decibels	2
20 decibels	4

How Highway Noise is Generated

Highway noise is generated from three primary sources: tire/pavement noise, engine noise, and exhaust noise. Tire/pavement noise is the noise generated by the rubber tires rolling over the pavement surface and may vary in intensity and character depending on the type and condition of both the tires and the pavement. For automobiles and light trucks traveling at typical highway speeds (over about 50 mile/hour), tire/pavement noise is generally the dominant noise source. For medium and heavy trucks (like large commercial delivery vehicles and long-haul tractor-trailers) engine and exhaust noise also contribute to the noise that they produce. At typical highway speeds, one large truck can produce as much noise energy as ten automobiles. How highway noise is experienced at nearby homes is controlled by a number of factors, including: the total number of vehicles on the highway, the percentage of large trucks, the average speed of the vehicles, the distance to the highway, obstructions blocking the view of the highway, and meteorological conditions. Generally speaking, the more vehicles, the higher percentage of large trucks or the closer one is to the highway, the greater the noise will be. Intervening obstructions, either manmade (buildings, walls, berms) or natural (such as intervening terrain) will reduce noise levels. Foliage and vegetation can reduce noise levels, but it must be dense (completely obscuring the view of the highway) and thick (on the order of 50 to 100 feet) in order to make a noticeable difference.

How Highway Noise Can Be Reduced

Highway noise can be reduced in several ways. Here are some of the most recognized:

Traffic Controls

The faster vehicles travel, and the higher percentage of large trucks, the louder the noise. Reduced speed limits, or more rigorously enforced existing speed limits, and heavy truck restrictions will reduce noise levels. However, the implementation of such measures is often politically difficult for the sake of lower noise levels alone.

Land Use Controls:

Perhaps the most common sense and fiscally responsible solution to highway noise, and one favored by most highway agencies is to restrict the development of lands near highways. Restricting development of land near new highway corridors to non-noise sensitive land uses, such as commercial or industrial activities can eliminate most noise problems. However, this approach is not suitable for circumstances when land near existing or future highways has already been developed for residential land use.

Quieter Vehicle Noise Sources

Quieter vehicles mean less highway noise. For automobiles this means quieter tires (since tire/pavement noise is the dominant noise source). For large trucks, the EPA has established standards for maximum noise levels for new and in-use trucks. The maximum noise levels for new trucks are lower than those for some older trucks, so as old trucks are phased out and replaced with newer ones the noise produced by the average truck may go down.

Noise Barrier Walls and Berms

Noise barriers, both structural walls and earthen berms, are often constructed specifically for the purpose of reducing highway noise levels. Noise barriers can be very effective for reducing noise levels at nearby homes, often reducing noise levels by as much as 10 decibels at the closest homes (a perceived halving of loudness). Noise barriers can be expensive to build, on the order of $2 million per mile. Because of their cost, the construction of noise barriers is often restricted to large highway improvement or construction projects. Some jurisdictions; however, are quite active in constructing “retrofit” noise barrier on existing highways.

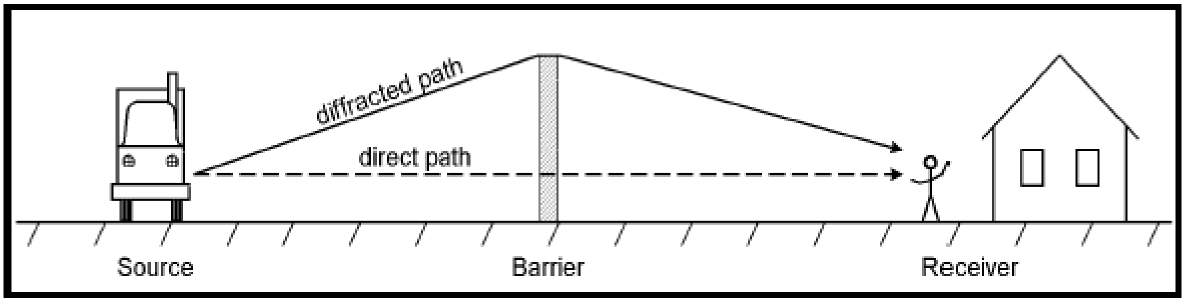
Quieter Pavements

It has long been recognized that some pavement types tend to be quieter than others. White concrete pavement, for example, is typically louder than asphalt blacktop. White concrete with tining (grooves cut into the pavement surface) is louder still. However, white concrete pavement (also known as Portland Concrete Cement, or PCC) is thought to be more durable, and perhaps safer than blacktop pavements (due to better skid resistance and drainage). There is also considerable concern that the low noise advantages of some blacktop pavements may diminish over time. As the tiny “nooks and crannies” in the blacktop pavement that give it acoustical absorption may fill up with silt and sand or become compressed over time, the acoustical benefits are reduced. The quest for quiet, safe and durable highway pavements is currently the focus of a considerable amount of research.

How Noise Barriers Work

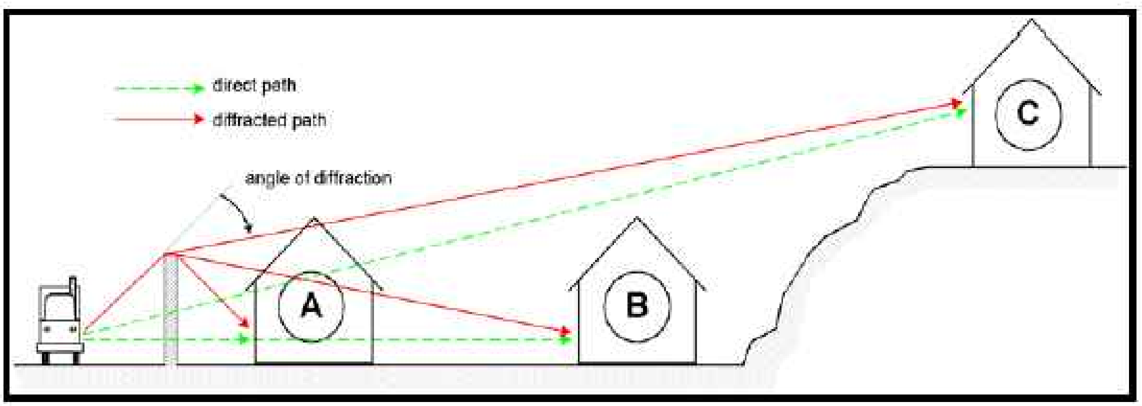
Noise barriers reduce noise levels by interrupting or lengthening the path that the noise takes between the source and the receiver. In order to be effective at reducing noise, noise barriers must be able to block the “line of sight” between the object producing the noise (like vehicles on the highway) and the person subjected to the noise (like residents living near the highway). The amount that the noise will be reduced is related to the path length difference between the “direct path” that the uninterrupted sound would take between the source and receiver (with no barrier) and the “diffracted path” that the sound must take going over or around the barrier, as illustrated in Figure 2-1

Figure 2-1 Simple Noise Barrier Geometry



Noise barriers may work better for some homes than for others. In Figure 2-2, below, home “A” is relatively close to the highway where the noise barrier can provide a large path length difference between the direct and diffracted paths, resulting in a substantial noise reduction (perhaps as much as 10 to 15 decibels). Home “B” is further from the barrier and the path length difference is not as great, resulting in less noise reduction (perhaps 7 to 10 decibels). Home “C” is even further from the highway, and also elevated above the highway level, providing an even smaller path length difference (resulting in a noise reduction of perhaps 3 to 5 decibels). In general, for a given barrier height and location, the further the receiver is from the barrier or the higher the receiver is elevated, the smaller the path length difference (or angle of diffraction) and the smaller the resulting noise reduction.

Figure 2-2 Path Length Difference for Varying Receiver Geometry



2.3 Regulatory Overview

2.3.1 Federal Regulations

The FHWA noise policy is contained within The Code of Federal Regulations, Title 23, Part 772 (23 CFR 772) which provides procedures for preparing operational and construction noise studies and evaluating noise abatement considered for federal and federal-aid highway projects. The code was recently updated in July of 2010. Under the current version of 23 CFR 772.5, projects are categorized as Type I, Type II or Type III projects. The FHWA defines a Type I project as a proposed federal or federal-aid highway project for the construction of a highway on a new location, or the physical alteration of an existing highway which significantly changes either the horizontal or vertical alignment, or increases the number of through-traffic lanes. The proposed project is a Type I project as defined by the FHWA.

Type I projects include those that create a completely new noise source, as well as those that increase the volume or speed of traffic or move the traffic closer to a receptor. Type I projects include the addition of an interchange, ramp, auxiliary lane, or truck-climbing lane to an existing highway, or the widening of an existing ramp by a full lane width for its entire length. Projects unrelated to increased noise levels, such as lighting, signing, and landscaping, are not normally considered Type I projects.

Under 23 CFR 772.13, noise abatement must be considered for Type I projects if the project is predicted to result in a traffic noise impact. In such cases, 23 CFR 772 requires that the project sponsor "consider" noise abatement before adoption of the final NEPA document. This process involves identification of noise abatement measures that are reasonable, feasible, and likely to be incorporated into the project, and of noise impacts for which no apparent solution is available.

Traffic noise impacts, as defined in 23 CFR 772.5, occur when the design year condition noise levels approach or exceed the noise abatement criteria (NAC) specified in 23 CFR 772, or design year condition noise levels create a substantial noise increase over existing noise levels. 23 CFR 772 does not specifically define the terms "substantial increase" or "approach"; these criteria are defined in the MDOT Noise Analysis and Abatement Handbook (July 13, 2011), as described in the following section.

Table 2-3 summarizes the FHWA NAC corresponding to various defined land use activity categories. Activity categories and related traffic noise impacts are determined based on the actual land use in a given area.

In identifying noise impacts, primary consideration is given to exterior areas of frequent human use. Interior noise impacts will only be addressed for land uses listed with Activity Category D.

Table 2-3 FHWA Noise Abatement Criteria

Activity Category	Activity Criteria		Evaluation Location	Activity description
	Leq(h)	L10(h)		
A	57	60	Exterior	Lands on which serenity and quiet are of extraordinary significance and serve an important public need and where the preservation of those qualities is essential if the area is to continue to serve its intended purpose.
B	67	70	Exterior	Residential
C	67	70	Exterior	Active sport areas, amphitheaters, auditoriums, campgrounds, cemeteries, day care centers, hospitals, libraries, medical facilities, parks, picnic areas, places of worship, playgrounds public meeting rooms, public or nonprofit institutional structures, radio studios, recording studios, recreation areas, Section 4(f) sites, schools, television studios, trails, and trail crossings.
D	52	55	Interior	Auditoriums, day care centers, hospitals, libraries, medical facilities, places of worship, public meeting rooms, public or nonprofit institutional structures, radio stations recording studios, schools, and television studios.
E	72	75	Exterior	Hotels, motels, offices, restaurants/bars, and other developed lands, properties or activities not included in A-D or F.
F	--	--	--	Agriculture, airports, bus yards, emergency services, industrial, logging, maintenance facilities, manufacturing, mining, rail yards, retail facilities, shipyards, utilities (water resources, water treatment, electrical), and warehousing.
G	--	--	--	Undeveloped lands that are not permitted.

1 Either Leq(h) or L10(h) (but not both) may be used on a project.

2 The Leq(h) and L10(h) Activity Criteria values are for impact determination only, and are not design standards for noise

3 Includes undeveloped lands permitted for this activity

2.3.2 State Regulations and Policies

MDOT has published the noise policy which provides guidelines in the analysis of highway traffic noise and the evaluation of noise mitigation measures. Effective July 13, 2011, the MDOT *Highway Noise Analysis and Abatement Handbook* (hereafter referred to as "the MDOT handbook") also includes current policies, procedures, and practices to be used by agencies that sponsor new construction or reconstruction of federal or federal-aid highway projects. The MDOT noise handbook defines that a noise impact occurs when the sound level approaches or exceeds the assigned NAC level for a specific category, which is defined as an Leq(h) sound level 1 dBA less than the NAC identified in 23 CFR 772. This means that for an Activity Category B land use (residential), a peak hour noise level of 66 dBA is considered to approach the NAC of 67 dBA and is identified as an impact. The MDOT noise handbook defines a noise increase as substantial when the predicted traffic noise levels with project implementation exceed existing noise levels by 10 dBA. The MDOT noise handbook provides detailed technical guidance for the evaluation of highway traffic noise. This includes field measurement methods, noise modeling methods, and report preparation guidelines. In addition to the NAC criteria above, the MDOT noise handbook also specifies the following definitions and policies:

Benefited Receptor is the recipient of an abatement measure that receives a noise reduction at or above the minimum threshold of 5 dBA.

Feasible Noise Abatement Measure is a mitigation measure that is acoustically feasible and meets engineering requirements for constructability. A noise abatement measure is considered feasible when it can provide at least a 5 dBA reduction to at least 75% of impacted noise receptors, and meets constructability, safety, access, utility, and drainage requirements.

Reasonable Noise Abatement Measure is an abatement measure that has been determined to be cost effective if it costs at or below the allowable cost per benefited receptor unit (CPBU) of $49,301.00 , and is considered acceptable to the majority of residents and property owners who benefit from the noise abatement. The MDOT design year attenuation requirement requires that a minimum of one benefited receptor achieve a 10 dBA noise reduction, and that 50% of benefited receptors must achieve a 7dBA reduction.

3. Methods of Noise Analysis

3.1 Defining Area or Potential Impact

The extent of the noise study analysis area should include all receptors potentially impacted by the project. The FHWA does not establish a fixed distance to define the noise impact analysis area. Historically, absolute noise impacts (those areas with noise levels approaching or exceeding the NAC – 66 dBA for residential land uses) rarely exist beyond about 500 feet from the roadway. The MDOT noise handbook defines the study zone to be a minimum of 500 feet, including all noise-sensitive receptors on all sides of the highway. If an impact is identified at 500 feet, the next closest receptor would need to be analyzed until a distance where impacts are no longer identified is reached. If no receptors are located within the 500-foot zone, then the closest receptor(s) should be analyzed.

3.2 Field Measurement Procedures

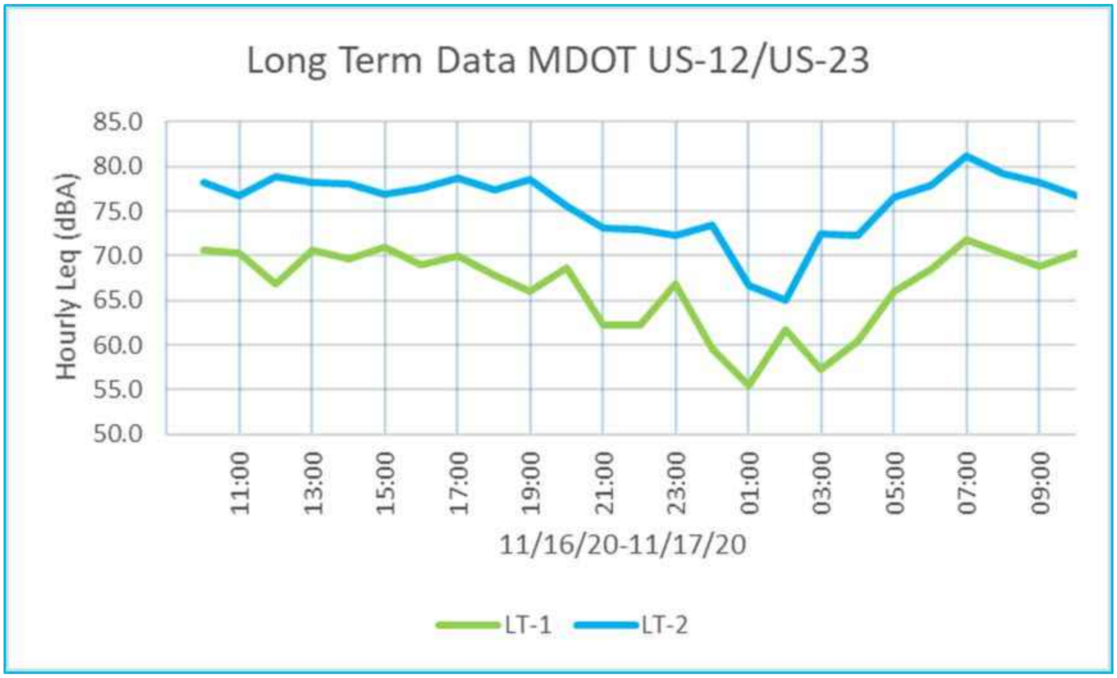
A number of field noise measurements were conducted for this project. In general, the noise measurement procedures in the field follow recommended standard procedures, including those outlined in the FHWA's Measurement of Highway Related Noise, May 1996, and the MDOT noise handbook. Specifically, the following practices and procedures were used.

The short-term noise measurements (typically 15-25 minutes) were conducted at actual or representative receptor locations and were used primarily to validate noise models (at locations where traffic noise was dominant).

Short-term noise measurements were generally conducted at exterior areas of frequent human use and were only conducted during periods of free-flowing traffic, dry roadways, and low to moderate wind speeds (less than 12 mph to avoid extraneous wind noise).

Two long-term measurements (consecutive 24-hour periods) were also deployed outside the Pittsfield Police Dept along US-12 and at 3858 Bestech Dr along US-23 in order to help determine the loudest noise hour. Based upon the collected data, the loudest noise hour was from 7:00 AM to 8:00 AM for both US-12 and US 23. A graph of the long-term measurement data (LT-1 and LT-2) is shown in Figure 3-1.

Figure 3-1 Long-Term Noise Measurement Data



Only ANSI (American National Standards Institute) Class I sound level meters were used for both short-term and long-term measurements. The meters were subjected to a field calibration check before and after each measurement period. Calibration certificates for each meter used in the Project can be found in Appendix A.

Concurrent traffic counts (classified in auto, medium and heavy trucks, buses, and motorcycles) for the acoustically dominant road were conducted for each short-term measurement. Traffic was videotaped during the measurements and counted. The traffic counts can be found in Table 3-3.

All field data was recorded on field data sheets, which included the time, name and location of the measurement, instrumentation data, observed meteorological data, field calibration data, a measurement site diagram, GPS coordinates, and notes as to the dominant noise sources and any other observed acoustically relevant events (such as aircraft over-flights, emergency vehicle pass bys, etc.). Field sheets and photographs of measurement sites developed in this project can be found in Appendix A.

3.3 Analysis Objectives

The purpose of this noise analysis report is to identify, and document potential noise impacts associated with the proposed future Project and to identify feasible and reasonable abatement. The general analysis procedure for the Project noise study includes the following steps:

1. **Review Project Description:** Review the project description and project data to be analyzed and collect additional required data (including roadway design files, existing and future traffic data, land use data, etc.). Consider all alternatives, design options, and construction phasing scenarios. This information is presented in Section 1 of this report.

2. **Identify Regulatory Framework:** Investigate and establish the regulatory framework to be followed for the noise analysis, including federal, state and local regulations and ordinances applicable to the Project. This information is presented in Section 2 of this report.

3. **Noise Analysis Methodology and Establish Existing Land Use and Noise Environment:** Investigate and document the existing noise environment for the Project area, including existing noise sensitive land uses and existing noise levels in the Project area. These were accomplished with a careful review of local zoning information, review of aerial photography and a site visit to the Project area. This information is presented in Section 3 of this report.

4. **Predict Future Noise Levels and Assess Noise Impacts:** Future noise levels at noise sensitive land uses for the future build alternative are predicted using the FHWA Traffic Noise Model (TNM) Version 2.5. For each alternative, compare future noise levels (as well as increases in future noise levels over existing noise levels) to appropriate identified noise impact criteria and quantify resulting noise impacts. This information is presented in Section 4 of this report.

5. **Evaluate Noise Abatement:** Where noise impacts are identified, evaluate potential noise abatement measures. Abatement measures are evaluated for feasibility and reasonableness according to FHWA and MDOT standards. This information is presented in Section 5 of this report.

6. **Construction Noise Considerations:** Analyze potential construction noise impacts and discuss available mitigation options. This information is presented in Section 6 of this report.

7. **Information for Public Officials:** Provide or identify appropriate information for local public officials to help avoid future noise impacts. This information is presented in Section 7 of this report.

A more detailed accounting of the specific procedures involved in each of the above analysis steps is provided in the indicated report section.

3.4 Selection of Noise-Sensitive Receptors

In general, noise-sensitive receptors are selected to represent potentially impacted land uses within the Project area. A common noise environment, or CNE, is generally defined as a group of receptors within the same Activity Category in Table 2-3 that are exposed to similar noise sources and levels; traffic volumes, traffic mix, and speed; and topographic features. Generally, common noise environments occur between two secondary noise sources, such as interchanges, intersections, cross-roads. The delineated CNEs for this Project are described in Section 3 of this report. Within each CNE, representative noise measurements and noise prediction locations are identified. Typically, each CNE would have one short-term measurement location and multiple noise prediction locations. The number and locations of the receptors (measurement and modeling locations) within each CNE are selected to adequately represent all of the noise-sensitive property units (dwellings) within that CNE, and these properties may include Activity Categories A through E and G in Table 2-3 (including residential, noise sensitive commercial, parks, schools, hotels, and undeveloped lands.). Activity Category F (agriculture, retail, industrial, transportation, and utilities), may still be located within a CNE, but would be considered a noise compatible land use and would not require noise analysis. For residential properties, more isolated residences would generally be modeled as individual receptors, while residences in multi-family buildings and dense neighborhoods may be modeled with one modeled receptor location representing multiple dwelling units or homes (receptors).

All noise prediction locations are placed to represent an exterior area of frequent human use. For residential properties, this would normally be an exterior activity area between the structure and the proposed project roadway, such as a pool or play area.

3.5 Loudest Hour Noise Conditions

When determining noise impacts, traffic noise predictions must be made for the loudest noise hour (generally during level of service [LOS] C or D with high heavy truck volumes and speeds close to the posted speed limit or design speed). The loudest hour noise is typically either the peak vehicular truck hour or the peak vehicular volume hour (with LOS A through D conditions).

3.6 Noise Abatement Requirements

According to FHWA policy and the MDOT noise handbook, once a noise impact has been identified, feasible and reasonable noise abatement measures must be considered. For noise abatement, primary consideration is given to the exterior areas of frequent human use.

When traffic noise impacts are identified, noise barrier walls, at a minimum, are required to be considered. In addition to noise walls, other abatement elements may also be considered, if appropriate and applicable, including the following:

- Traffic management measures.

- Alteration of horizontal and vertical alignments.
- Acquisition of property to serve as a buffer to preempt development that would be adversely impacted by traffic noise; and
- Noise insulation (NAC D Only).

When noise barriers are considered, a noise barrier design analysis must show that the barrier is feasible. This typically requires that the barrier provides a minimum required level of noise reduction. According to the MDOT noise handbook, feasible noise barriers must provide at least 5 dBA of noise reduction to at least 75% of impacted receptors. In addition to meeting minimum noise reduction requirements, noise barriers must also meet engineering and constructability feasibility requirements in terms of safety, property and emergency access, drainage control, overhead and underground utilities clearance, and other issues.

Noise barrier reasonableness is generally related to cost effectiveness and benefited receptors. The MDOT noise handbook expresses barrier cost effectiveness by a quotient formula called the Cost Per Benefited Receptor Unit (CPBU), which divides the total square-foot cost of the barrier (at a rate of $45.00/ft^2) by the number of dwelling units that receive benefits. To maintain reasonableness, the total CPBU cannot exceed $49,301.00 (for FY 2021). Barriers must also achieve the MDOT noise reduction design goal of 10 dBA reduction for at least one benefited receptor, and 7dBA reduction at 50% of benefitted receptors.

If noise barriers are determined to be reasonable and feasible as defined above, then the viewpoints of property owners and residences should be taken into consideration. Approval by a simple majority (greater than 50%) of all responding benefited owners and residences is needed to implement noise abatement. Public votes should occur during final design and could happen during the Context Sensitive Design aesthetic public input phase..

3.7 Noise Modeling Methodology

Future build noise levels, along with existing noise levels, were predicted using the FHWA TNM Version 2.5, the most recent version available at the time of the analysis. All conventional modeling techniques and recommendations for TNM by both FHWA and MDOT were implemented. These included the following modeling procedures and conventions:

- TNM roadways were generally modeled as bundled roadways with no more than three lanes per roadway.
- All roadway pavement types were modeled as “Average”.
- Traffic speeds and volumes for peak traffic hour as provided in the traffic data were modeled to predict worst case noise levels. Traffic speeds and volumes used in this analysis were based on the predicted traffic data included in Table 3-1.
- Existing terrain lines (topography) and buildings were modeled where appropriate.
- All TNM model runs were detail checked for accuracy by an independent noise analyst.
- All TNM model runs are available upon request

3.8 Project Traffic Data

Predicted traffic data for the existing and Future Build were provided by the Michigan Department of Transportation. A summary of the traffic data used for this analysis can be found in Table 3-1

Table 3-1 Existing and Future Peak Hour Traffic Volumes

	Existing Traffic (vehicles per hour)				Future Traffic (vehicles per hour)			
	2020 AM Peak				2045 AM Peak			
	US-23		US-12		US-23		US-12	
	NB	SB	EB	WB	NB	SB	EB	WB
Speed (mpg)[1]	70/65/65	70/65/65	45/45/45	45/45/45	70/65/65	70/65/65	45/45/45	45/45/45
Total	3025	1795	1383	1149	3565	2115	1501	1354
Auto and Light Trucks	2719	1613	1298	1078	3056	1901	1408	1271
Medium Duty Trucks	25	15	14	11	28	18	15	14
Heavy Duty Tucks	281	167	71	59	316	197	77	70

Notes
1. posted speeds or for Autos/Medium Trucks/ Heavy Trucks
Source: MDOT Traffic Memo

3.9 Existing Condition and Common Noise Environments

3.9.1 Existing Land Use and Zoning

Land uses within the Project study area are a mix of residential (single and multi-family), commercial, industrial and undeveloped land. Undeveloped areas are primarily for future residential development, with some areas reserved for future commercial development as well.

3.9.2 Common Noise Environments

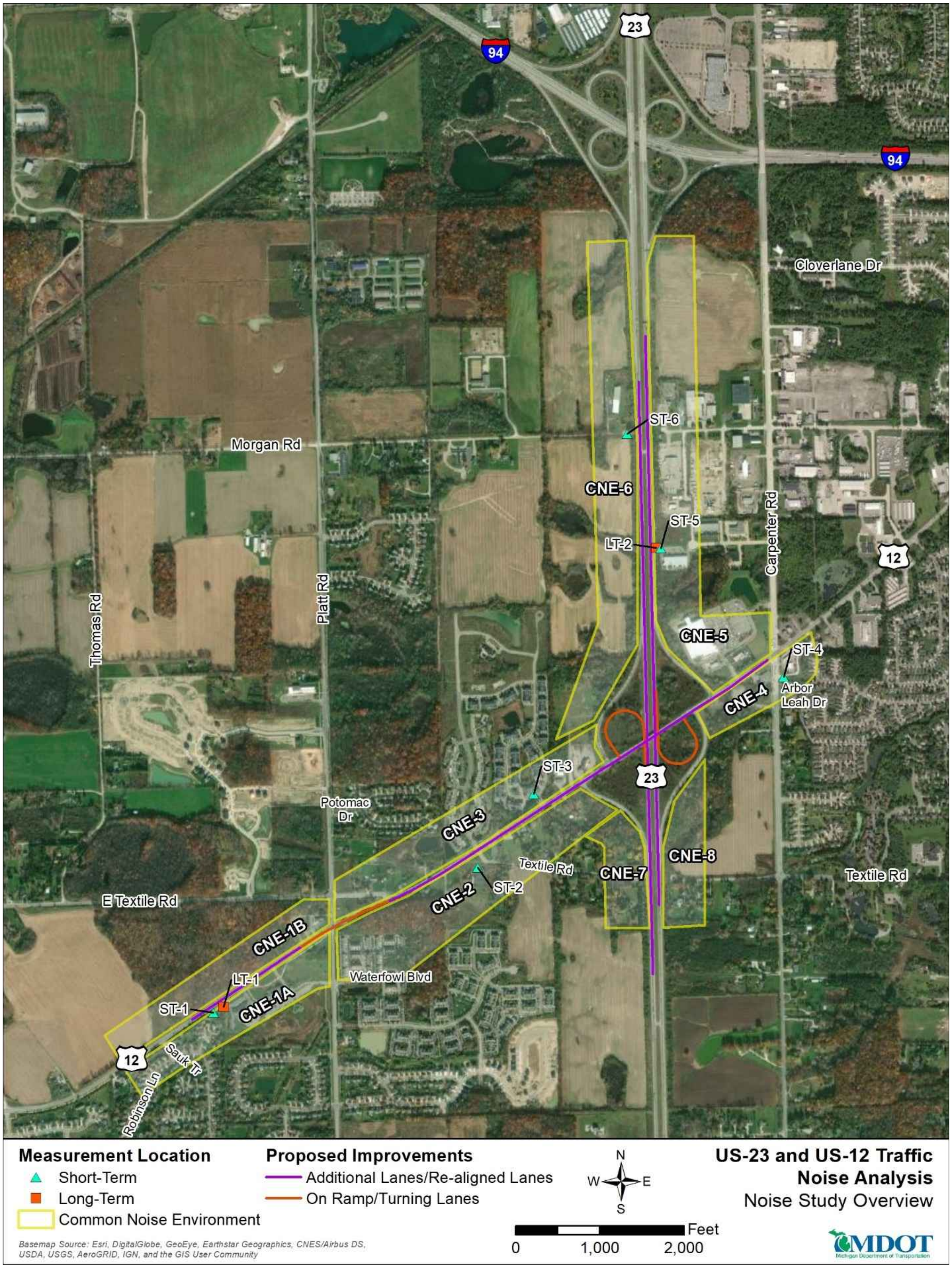
To better categorize the potential noise impacts and evaluate noise abatement for the various project alternatives, all of the potentially impacted, noise-sensitive receptors have been organized into Common Noise Environments (CNEs). A CNE is defined as an area containing land uses which share a common highway traffic noise influence. Descriptions of delineated CNEs, including location, primary land use and type of noise-sensitive receptors are listed in Table 3-2. Figure 3-2 shows an overview of the Project area illustrating all the defined CNEs.

Table 3-2 Common Noise Environments

CNE	Description	Land Use	Measurement ID
CNE-1A	Area south of US-12, west of Platt Rd.	Single Family Residential, municipal, park	ST-1, LT-1
CNE-1B*	Area north of US-12, west of Platt Rd.	Commercial, undeveloped, agricultural	None
CNE-2	Area south of US-12, Platt to US-23	Single and Multi-family Residential, Undeveloped	ST-2
CNE-3	Area north of US-12, Platt to US-23	Single and Multi-family Residential, Undeveloped	ST-3
CNE-4	Area south of US-12, east of US-23	Single Family Residential	ST-4
CNE-5	Area East of US-23, north of US-12	Commercial, undeveloped	ST-5, LT-2
CNE-6	Area East of US-23, north of US-12	Single Family Residential, undeveloped	ST-6
CNE-7*	Area West of US-23, South of US-12	Single Family Residential, undeveloped	None
CNE-8*	Area East of US-23, South of US-12	Single Family Residential, undeveloped	None

*Note: CNE-1B, CNE-7 and CNE-8 were identified and added to the project area after the noise measurement survey was completed, so no noise measurements are available for those areas.

Figure 3-2. Common Noise Environments and Noise Measurement Sites



3.9.3 Existing Noise Environment

3.9.3.1 Field Noise Measurements

Multiple noise measurements were conducted for this project on November 16th and 17th, 2020. Noise measurements were conducted to provide information for noise model validation (short-term measurements with accompanying classified traffic counts) and to establish the loudest traffic noise hour. Noise measurements were conducted as described in Section 2.3. Appendix A includes measurement-related materials.

A total of six short-term (ST) noise measurements were conducted as summarized in Table 3-3. Figure 3-2 contains an aerial figure of the Project area showing each measurement location.

3.9.3.2 Noise Model Validation and Results

The FHWA TNM Version 2.5 (TNM) was used to predict noise levels for the future build alternative as well as existing noise levels at receptor locations where noise levels are dominated by traffic noise on project roadways. To demonstrate that the noise model is predicting noise levels within a reasonable margin of error, the noise model runs are validated by comparing predicted noise levels to measured noise levels for similar traffic conditions. However, since the TNM only predicts noise levels associated with traffic noise, the model runs can only be validated at measurement locations where current noise levels are dominated by project roadways. For this project, noise model validation was possible for all six short- term noise measurement locations. Noise models are considered to be validated if the difference between measured and modeled noise levels for comparable conditions is 3 dBA or less. The successful results of the noise validation effort are presented in Table 3-3.

Table 3-3 TNM Validation Summary

Measurement ID and Location	Traffic			Measured Leq, dBA	Modeled Leq, dBA	Difference
ST-1, 6227 W Michigan Ave	**Type**	**US-12 EB**	**US-12 WB**	73.8	71.4	-2.4
	Auto	696	736			
	Medium Trucks	0	20			
	Heavy Trucks	48	28			
ST-2, 3350 Textile Road	**Type**	**US-12 EB**	**US-12 WB**	64.4	65.3	0.9
	Auto	868	820			
	Medium Trucks	36	16			
	Heavy Trucks	52	32			
ST-3, 5807 Hampshire Ln	**Type**	**US-12 EB**	**US-12 WB**	63.2	63.5	0.3
	Auto	740	792			
	Medium Trucks	16	36			
	Heavy Trucks	32	36			
ST-4, 5495 W Michigan Ave	**Type**	**US-12 EB**	**US-12 WB**	63.5	64.4	0.9
	Auto	721	788			
	Medium Trucks	20	24			
	Heavy Trucks	36	40			
ST-5, 3858 Bestech Dr.	**Type**	**US-23 NB**	**US-23 SB**	75.0	75.6	0.6
	Auto	1124	1204			
	Medium Trucks	36	36			
	Heavy Trucks	412	264			
ST-6, 3667 E Morgan Rd	**Type**	**US-23 NB**	**US-23 SB**	72.2	74.6	2.4
	Auto	2064	1584			
	Medium Trucks	48	120			
	Heavy Trucks	288	264			

As shown in Table 3-3, all calculated differences between modeled and measured noise levels are less than 3.0 dBA, therefore the noise models for those locations are considered validated.

TNM validation runs developed for this Project are digitally archived and will be made available upon request.

4. Noise Impact Analysis

4.1 Future Noise Levels and Impacts

This section presents predicted noise levels and noise impacts (or noise impact distances for both identified CNE areas and general undeveloped areas).

4.1.1 Predicted Noise Levels and Noise Impacts

Traffic noise impacts, as defined in 23 CFR 772.5, occur when the design year condition noise levels approach or exceed the noise abatement criteria (NAC) specified in 23 CFR 772, or design year condition noise levels create a substantial noise increase over existing noise levels. 23 CFR 772 does not specifically define the terms “substantial increase” or “approach”; these criteria are defined in the MDOT Noise Analysis and Abatement Guidelines (July 13, 2011), as described in the following section. Table 2-3 summarizes the FHWA NAC corresponding to various defined land use activity categories.

MDOT noise handbook defines that a noise impact occurs when the sound level approaches or exceeds the NAC level, which is defined as an Leq(h) sound level 1 dBA less than the NAC identified in 23 CFR 772. This means that a peak hour noise level of 66 dBA is considered to approach the NAC for Category B of 67 dBA and is identified as an impact. The MDOT noise handbook defines a noise increase as substantial when the predicted traffic noise levels with project implementation exceed existing noise levels by 10 dBA.

Future build alternative noise levels, along with existing noise levels, were predicted using the FHWA TNM Version 2.5. All conventional modeling techniques and recommendations for TNM by both FHWA and MDOT were implemented, as described in Section 3.7.

Table 4-1 below contains a summary of the predicted noise levels and noise impacts at all modeled CNE locations in the Project. Figures 5-1 (CNE-1), 5-2 (CNE-2 and CNE-3), 5-3 (CNE-3 Noise Wall Detail), 5-4 (CNE-4, CNE-5 and CNE-6), and 5-5 (CNE-7, CNE-8) contain detailed aerial-based figures of the Project area showing all modeled receptor locations and predicted future build impacts. Due to the large number of modeled receptors and CNEs within the Project area, prediction information for individual receptors is presented in detail in Appendix C.

Table 4-1 Summary of Predicted Noise Levels by CNE

CNE	**No. of Modeled Receptors**	**Total Dwelling Units**	**Predicted Noise Level (Range), Leq (1h)**		**Total Number of Noise Impacted Units**		
			Existing	Future Build	Approach or Exceed NAC	Significant Increase	Total Impacted DU
CNE-1A	24	23	52.8 - 69.8	52.9 - 69.9	7	0	7
CNE-1B	0	0	NA	NA	0	0	0
CNE-2	58	58	45.2 - 72.2	46.3 - 72.4	29	0	29
CNE-3	180	180	51.2 - 71.4	51.8 - 71.6	15	0	15
CNE-4	5	5	58.3 - 60.5	58.3 - 60.5	0	0	0
CNE-5	0	0	NA	NA	0	0	0
CNE-6	1	1	67.9 - 67.9	67.9 - 67.9	1	0	1
CNE-7	5	5	63.8 - 74.6	64.3 - 75.1	3	0	3
CNE-8	3	2	64.1 - 66.9	64.7 - 67.5	2	0	2

Figures showing all receiver locations along with evaluated noise abatement elements are included in section 5.

5. Noise Abatement Evaluation

5.1 Noise Abatement Measures

According to FHWA and MDOT policies, when noise impacts are identified, noise barriers (at a minimum) must be considered as noise abatement. Other potential noise abatement measures might include heavy truck or speed restrictions, alignment changes, and depressed roadways. Of these alternatives, the Project alignment was evaluated and compared for noise impacts (as presented in section 4), but truck restrictions and speed restrictions below proposed speed limits would significantly reduce the value of the roadway. Noise barriers were evaluated for each CNE with noise impacts for feasibility and reasonableness. The following section describes the results of the barrier assessments for each evaluated CNE.

5.2 Feasible and Reasonable Criteria and Requirements

In order for mitigation to be recommended, the barrier must meet certain feasibility and reasonableness requirements established by MDOT in the Noise Analysis and Abatement Guidelines.

When noise barriers are considered, a preliminary noise barrier design analysis must show that the barrier is feasible. According to the MDOT noise handbook, feasible noise barriers must provide at least 5 dBA of noise reduction to 75% of the impacted receptors. In addition to meeting minimum noise reduction requirements, noise barriers must also meet engineering and constructability feasibility requirements in terms of safety, property and emergency access, drainage control, overhead and underground utilities clearance, and other issues.

Noise barrier reasonableness is generally related to cost effectiveness and benefited receptors, where a benefited receptor receives at least 5 dBA of noise reduction (NR), and cost effectiveness is driven by a Cost per Benefited Receptor Unit (CPBU) value. The handbook identifies a CPBU of $49,301, which is a final quotient resulting from dividing the total cost of abatement (at a rate of $45.00 ft^2) by the total number of benefited receptors. Additionally, The MDOT design year attenuation requirement requires that a minimum of one benefited receptor achieve a 10 dBA noise reduction, and that 50% of benefited receptors must achieve a 7dBA reduction for noise abatement to be reasonable.

To summarize, for a barrier to be considered feasible and reasonable, it must have:

- A noise reduction of at least 5 dBA must be achieved at 75% of impacted receptors
- A noise reduction of 10 dBA must be achieved for at least one receptor
- A noise reduction of 7 dBA must be achieved at 50% of benefitted receptors

For a noise barrier to be considered reasonable in addition to the requirements listed above, the viewpoints of benefited property owners and residents must be taken into consideration. Greater than 50% in favor of all responding benefited owners and residents is needed to construct noise abatement. Public viewpoints and votes of benefited receptors are not part of this noise analysis but are collected during the Preliminary Engineering Phase and are recorded in the environmental documentation.

5.3 Findings and Recommendations for Noise Abatement

Noise abatement was considered for each CNE with identified noise impacts. Initially, noise abatement was checked for feasibility (5 dBA reduction and at least 75% of impacted receptors and access restrictions). If abatement was determined to be feasible, the abatement was analyzed for cost effectiveness and other reasonableness factors. For all impacted receptors meeting feasibility requirements, preliminary barrier designs were evaluated using TNM. If the abatement was found to be both reasonable and feasible, it would be recommended for inclusion in the project pending a polling of viewpoints from benefited receptors. A summary of the barrier's locations and resulting sound levels are provided in Table 5-1. The details of the barrier analysis including feasibility and reasonableness results are included in Table 5-2. The narrative results of abatement evaluations for each impacted CNE are summarized in subsequent sub-sections.

Table D-1 in Appendix D lists the existing and predicted future build noise levels as well as the noise levels with barrier per modeled receptor location. The table also includes the information regarding benefited receptors and barrier design goal achievement.

Table 5-1 Evaluated Barrier Descriptions

Barrier ID	Location	Existing Leq (dBA)	Future Leq Range (dBA)		Noise Reduction (dBA)	Barrier Descriptions (feet)	
			No Wall	With Wall		Length	Avg Height
Wall 1A	Directly South of the existing sidewalk along US-12, between Sauk Trail and the Police Station	53-70	53-70	52-61	5-10	650	11.00
Wall 1B	Directly South of the existing sidewalk along US-12, extending 380 feet Southwest of Sauk Trail	57-64	60-66	58-61	5-7	374	15.95
Wall 2	Along Platt Rd, South of US-12, with gaps to allow access	45 - 72	46- 72	46-68	5-10	615	20.00
Wall 3A	Along the ROW line North of US-12, West of Plum Hollow Dr	51-68	56-68	53-61	5-9	341	20.00
Wall 3B	Directly North of US-12, along the shoulder, Extending 490 feet Northeast of Plum Hollow Dr	53-70	54-70	52-62	5-10	666	15.53
Wall 7	Along the ROW line West of US-23, extending South from the US-12 interchange	64-75	64-75	58-62	7-13	1393	20.00
Wall 8	Along the ROW line East of US-23, extending South from the US-12 Interchange	64-71	65-71	58-61	6-10	1637	16.00

Table 5-2 Barrier Analysis Results

Barrier ID	Number of Attenuated Locations[1]					Cost[2]	Cost/Benefitted	Feasible	Reasonable	Recommended
	≥ 10 dBA	≥ 7 dBA		≥ 5 dBA (Benefitted Receptors)						
		#	% of Benefit	#	% of Impacts					
Wall 1A	1	4	57%	7	100%	$321,750.	$45,964	No	Yes	No
Wall 1B	0	2	50%	4	100%	$268,439	$67,110	No	No	No
Wall 2	7	20	91%	22	100%	$553,500	$25,173	No	Yes	No
Wall 3A	0	2	25%	8	100%	$306,900	$38,363	Yes	No	No
Wall 3B	1	18	82%	22	100%	$465,435	$21,156	No	Yes	No
Wall 7	1	4	100%	4	100%	$1,253,700	$313,425	No	No	No
Wall 8	1	3	100%	3	100%	$1,178,640	$392,880	No	No	No

Note:
1) MDOT policy requires that reasonable and feasible noise walls must be constructable, provide at least 10 dBA noise reduction at one impacted receptor, at least 7 dBA noise reduction for at-least 50% of benefited receptors, at least 5 dBA noise reduction for at least 50% of impacted receptors, and be constructed at an estimated cost of no more than $49,301 per benefited receptor.
2) Wall costs reported here are based on wall area in square feet as calculated by TNM times MDOT unit cost of $45.00/square foot.

5.3.1 CNE-1A Noise Abatement Analysis

CNE-1A, south of US-12, contains 24 modeled receiver locations representing a total of 23 individual single-family homes with each home representing one dwelling unit and a township office building. Seven receptors were determined to be impacted under future build conditions. One impacted receptor (R1001) was isolated from other receptors; thus abatement was not analyzed. Two noise walls were analyzed, Barrier 1A on the East side of Sauk

Trail, and Wall 1B on the West side. Both wall segments were determined to be not feasible according to MDOT policy for several reasons. These included significant constructability issues associated with interference with existing sanitary sewer, utility conflicts (utility poles, overhead lines and gas lines), and conflict with existing sidewalks. A noise wall at this location would also require significant private property acquisition outside of the MDOT right-of-way specifically for the noise wall installation (not otherwise required for the proposed roadway improvements). Therefore, a noise wall at this location is not recommended. These walls are shown in Figure 5-1, and detailed analysis metrics can be found in Tables 5-1 and 5-2.

5.3.2 CNE-1B Noise Abatement Analysis

CNE-1B, north of US-12, contains two commercial buildings with no exterior use areas, an undeveloped wooded area and part of an agriculture field. None of these are no noise sensitive land uses; thus, no noise abatement was analyzed. CNE-1B is shown in Figure 5-1.

5.3.3 CNE-2 Noise Abatement Analysis

CNE-2 contains 58 modeled receiver locations representing a total of 58 individual dwelling units, 29 of which were impacted. Receptors on the East side of the CNE are generally isolated single-family homes, with driveway access directly onto US-12 precluding any feasible barrier designs. A noise barrier was analyzed for the community of multi-family homes along Platt Rd, South of US-12 (Blue Heron Pointe Apartments). A continuous barrier could be placed between the sidewalk and the roadway; however, this would pose safety issues, blocking the view of the sidewalk from the street, or a crash hazard. For this reason, a barrier was analyzed at a location immediately behind the sidewalk, still within the municipal right-of-way, but leaving gaps for existing access sidewalks into the residential community. A 20-ft barrier with small gaps for pedestrian access met MDOT acoustical performance requirements, but existing overhead utility lines and underground sewer lines along the same alignment would preclude constructing a barrier in the area. Thus, noise abatement for CNE-2 for was determined to be not feasible due to constructability issues and utility conflicts. This is shown in Figures 5-2, 5-3, and Table 5-2.

5.3.4 CNE-3 Noise Abatement Analysis

CNE-3 contains 180 modeled receptor locations representing a total of 180 individual dwelling units, 15 of which were impacted. Two of the impacted receptors (3005 and 3006) are isolated single-family homes with direct driveway access to US-12, thus noise abatement was determined to be not feasible for these receptors. A total of 13 receptors were impacted in the multi-family developments generally located between Plum Hollow Dr. and Wellesley Blvd (Arbor Knoll Apartments and Wellesley Garden Condominiums). Noise walls were evaluated on both sides of Plum Hollow Dr, 3A to the West and 3B to the East. Wall 3A failed to meet the design goal of achieving 7 dBA reduction at 50% of benefiting receptors as well as 10 dB reduction at one receptor, resulting in the wall being evaluated as not reasonable.

Wall 3B was analyzed extending NE of Plum Hollow Dr. along the shoulder of the road toward Wellesley Blvd. The noise wall at location 3B was ultimately determined to be Not Feasible in accordance with MDOT noise policy for several reasons. These included significant constructability issues associated with interference with existing drainage features, utility conflicts (existing utility poles and underground water lines), and conflict with existing sidewalks. A noise wall at this location would also require significant private property acquisition outside of the MDOT right-of-way specifically for the noise wall installation (not otherwise required for the proposed roadway improvements. Therefore, a noise wall at this location is not recommended..

Evaluated noise walls 3A and 3B are shown in Figures 5-2 and 5-4 and summarized in Table 5-1 and 5-2. Please note, in Figure 5-4, overlapping receptor symbols indicate upper and lower-level dwelling units, each with an exterior patio or balcony and separate receptor ID (with ID numbers 31XX for first level and 32XX for second level). For the Arbor Knoll Apartments receptors were evaluated at both upper and lower units (balconies and patios) since these are separate dwelling units. The Wellesley Garden Condos were determined to be “townhouse” style dwelling units with a single unit having both upper and lower floors. The units that have upper-level balconies were evaluated for noise impacts and mitigation at the balcony. The units that did not have balconies were evaluated at the outdoor area near the front entrance to the unit.

5.3.5 CNE-4 Noise Abatement Analysis

CNE-4 contained 5 modeled receptor locations representing 5 individual dwelling units, none of which were impacted. As there were no impacts, no abatement was analyzed. CNE 4 is shown in Figure 5-4.

5.3.6 CNE-5 Noise Abatement Analysis

CNE-5 contains no noise sensitive land uses; thus no abatement was analyzed. CNE 5 is shown in Figure 5-4

5.3.7 CNE-6 Noise Abatement Analysis

CNE-6 contained one modeled receptor location representing one dwelling unit, as shown in Figure 5-4, which was impacted. As an isolated receptor, and following a basic assumption that a barrier would need to extend at least 3 times the distance from the barrier to the receiver in each direction and tall enough to block the line of sight to the highway vehicles, a barrier of at least 1100 feet in length and at least 8 feet in height would be needed to provide a minimum of 5 dBA reduction. At $45/square foot, this barrier would cost at least $396,000 per benefited receptor, far exceeding the CPBU. Thus, mitigation is not recommended.

5.3.8 CNE-7 Noise Abatement Analysis

CNE-7 contains 5 modeled receptor locations representing a total of 5 individual dwelling units, 3 of which were impacted.   A noise wall was designed to meet feasibility and design goals, however, the cost per benefitted unit exceeded the MDOT cost allowance. Thus, this wall is not recommended. A summary of this barrier is shown in Tables 5-1 and 5-2.and its location is shown in Figure 5-5

5.3.9 CNE-8 Noise Abatement Analysis

CNE-8 contains three modeled receptor locations representing a total of three individual dwelling units, two of which were impacted.   A noise wall was evaluated to meet feasibility and design goals, however, the cost per benefitted unit exceeded the MDOT allowance. Thus, this wall is not recommended. A summary of this barrier is shown in Tables 5-1 and 5-2, and its location is shown in Figure 5-5.

Figure 5-1 Acoustical Analysis for CNE 1A and 1B

Figure 5-2 Acoustical Analysis for CNE 2 and CNE 3

Figure 5-3 Wall 2 Analysis Detail

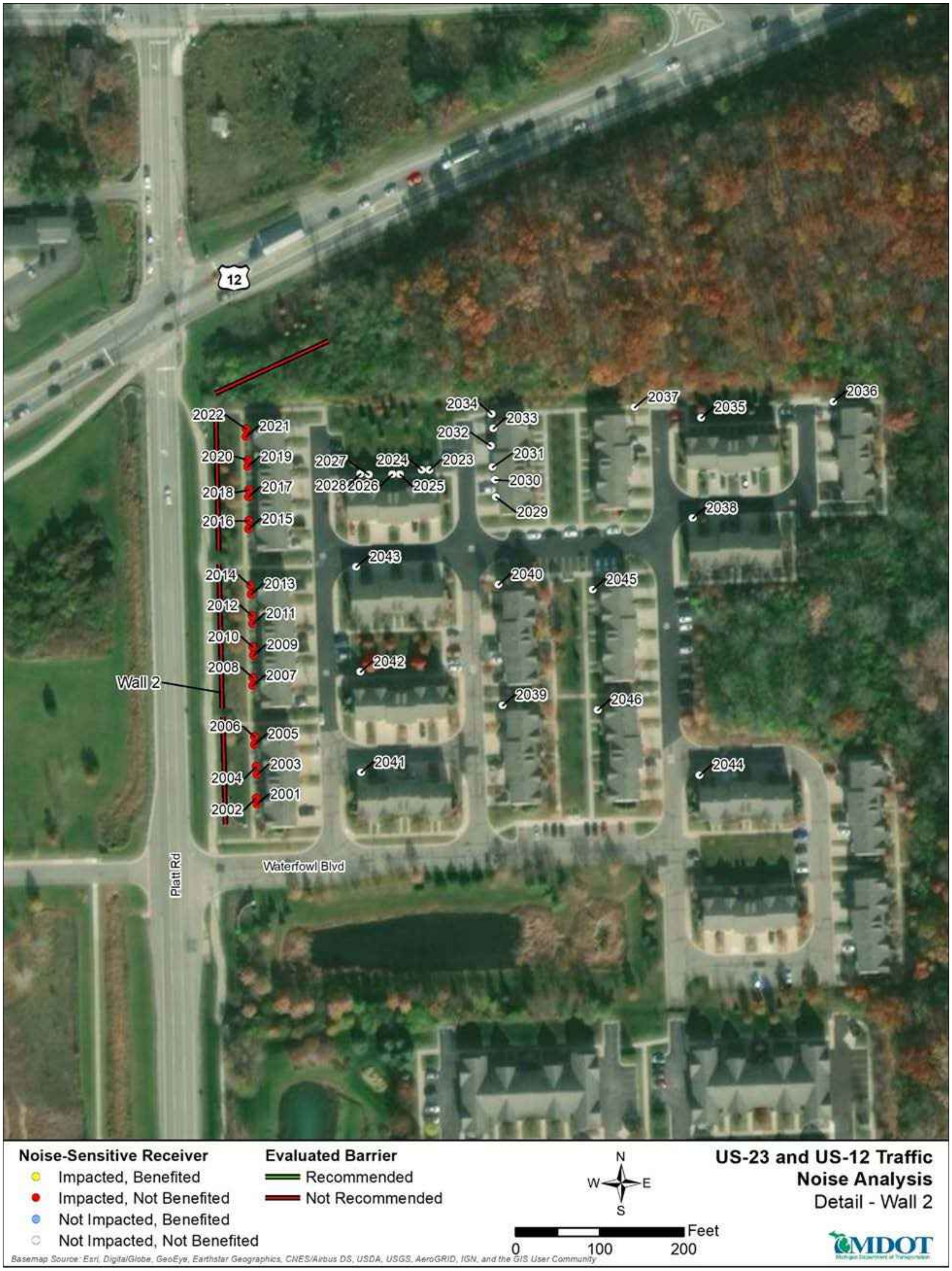


Figure 5-4 Wall 3A and 3B Analysis Detail

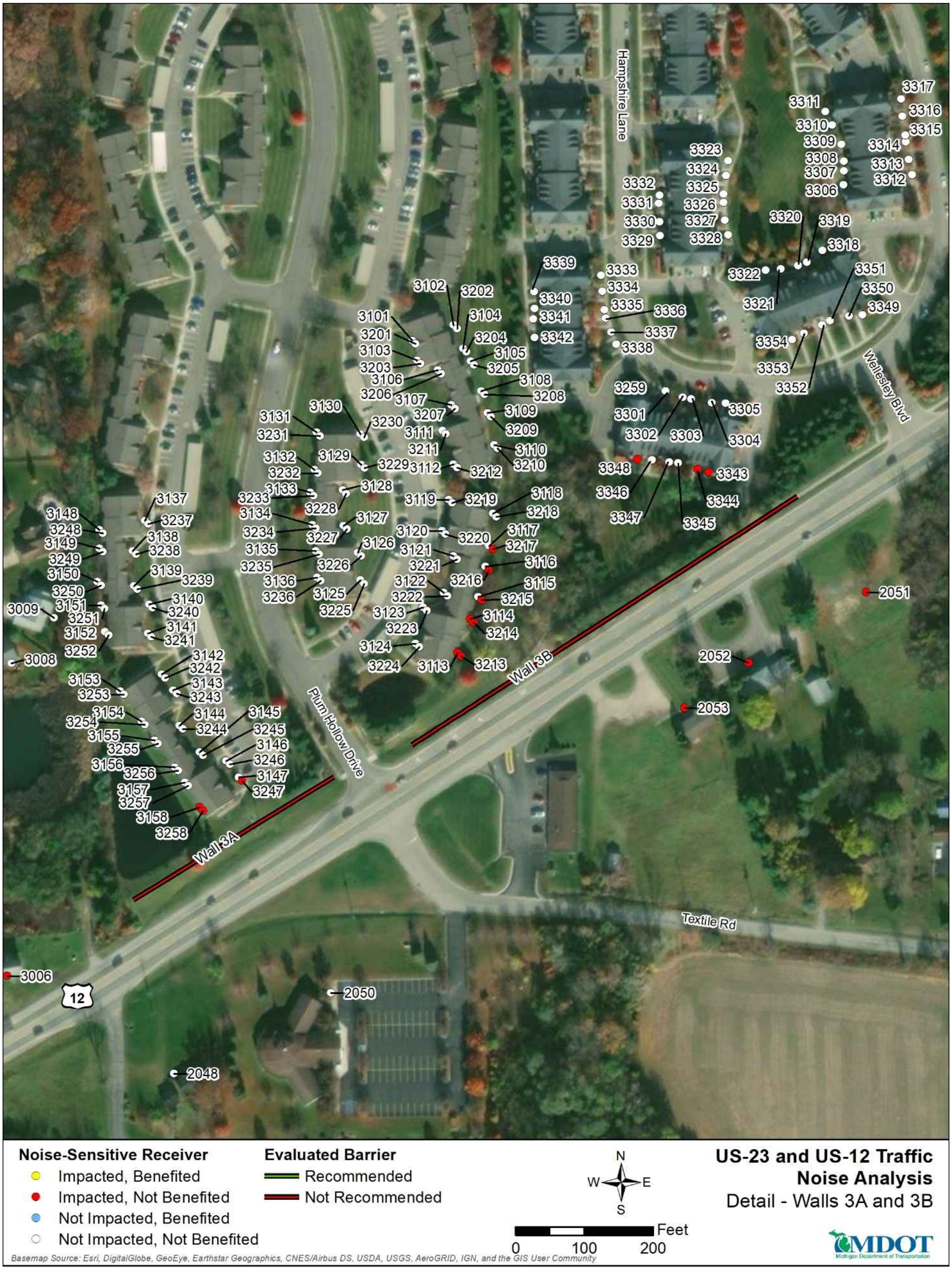


Figure 5-5 Acoustical Analysis for CNE-4, CNE 5, and CNE 6

Figure 5-6 Acoustical Analysis for CNE- 7, and CNE-8

6. Construction Noise Analysis

FHWA policy requires that construction noise be considered in a Type 1 highway noise analysis. This analysis would generally include the following:

1. Identification of land uses that may be affected by construction noise,
2. Determination of the measures needed in the plans and specifications to minimize or eliminate construction noise impacts; and,
3. Incorporate needed abatement into the plans and specifications.

Neither FHWA nor MDOT identify specific construction noise impact criteria. In addition, the detailed information required to predict actual construction noise levels (construction schedules, phasing, equipment lists, laydown areas, etc.) has not yet been determined. However, for this project it is anticipated that pile driving, and some nighttime construction work will be required.

It is recognized that areas adjacent to the highway right of way and other construction areas (such as staging areas and laydown sites) can temporarily be exposed to high levels of noise during peak construction periods. It is reasonable to assume that the same CNEs identified for potential traffic noise impacts could also be exposed to construction noise. The effect of the noise on the local area can be reduced if the hours and days of construction activity are limited to less sensitive time periods. The project construction standard noise specifications help minimize the effects of construction noise.

The following special provisions may be incorporated into the construction contract:

- Inform the local public in advance of construction activities that may generate particularly high noise levels (such as pile drivers) or periods of nighttime construction activity.
- Noise barriers, approved for incorporation into the project, should be constructed as close to the beginning of the project's construction timeline as practical.
- Noise created by truck movement shall not exceed 88 dBA at a distance of 50 feet.
- When working between 7:00 P.M. and 10:00 P.M., use “smart alarms” instead of standard reverse signal alarms or use spotters. When working between 10:00 P.M. and 7:00 A.M. use spotters.
- Have portable noise meters on the job at all times for noise level spot checks on specific operations. Employ an individual trained in the use of noise meters, with working knowledge of sound measurements and their meaning and use as applied to these mitigation/abatement measures.

6.1 Typical Construction Noise Levels

Table 6-1 contains a list of commonly used construction equipment and noise levels associated with using that equipment.

Table 6-1 Typical Construction Equipment Noise Levels

Equivalent Type	Lmax Ref dBA (50 feet)	AUF %
Auger Drill	84	20
Backhoe	78	40
Boring Jack Power Unit	83	50
Chain Saw	84	20
Compactor (ground)	83	20
Compressor (air)	78	40
Concrete Mixer Truck	79	40
Concrete Pump Truck	81	20
Concrete Saw	90	20
Crane	81	16
Dozer	82	40
Drill Rig Truck	79	20
Drum Mixer	80	50
Dump Truck	76	40
Excavator	81	40
Flat Bed Truck	74	40
Front End Loader	79	40
Generator (>25KVA)	81	50
Generator (<25KVA)	73	50
Gradall	83	40
Grader	85	40
Horizontal Boring Jack	82	25
Hoe Ram	90	20
Jackhammer	89	20
Man Lift	75	20
Pavement Scarafier	90	20
Paver	77	50
Pickup Truck	75	40
Pneumatic Tools	85	50
Pumps	81	50
Roller	80	20
Scraper	84	40
Shears (on backhoe)	96	40
Tractor	84	40
Vacuum Excavator	85	40
Vacuum Street Sweeper	82	10
Ventilating Fan	79	100
Vibrating Hopper	87	50
Vibratory Concrete Mixer	80	20
Warning Horn	83	5
Welder/Torch	74	40

Source: RCNM User Guide, Table 1 (actual measured Lmax)

6.2 Construction Noise Abatement Measures

Although MDOT does not identify any specific abatement measures related to construction noise, the following list could be considered best practices for the avoidance of any potential problems related to construction noise impacts:

- No construction shall be performed within 1,000 feet of an occupied dwelling unit on Sundays, legal holidays, or between the hours of 10 p.m. and 6 a.m. on other days without the approval of the MDOT construction project manager.
- All equipment used shall have sound-control devices no less effective than those provided on the original equipment. No equipment shall have unmuffled exhaust.
- All equipment shall comply with pertinent equipment noise standards of the U.S. Environmental Protection Agency.

- No pile driving or blasting operations shall be performed within 3,000 feet of an occupied dwelling unit on Sundays, legal holidays, or between the hours of 8 p.m. and 8 a.m. on other days without the approval of the MDOT construction project manager.
- The noise from rock crushing or screening operations performed within 3,000 feet of any occupied dwelling shall be mitigated by strategic placement of material stockpiles between the operation and the affected dwelling or by other means approved by the MDOT construction project manager.

If a specific noise impact complaint is received during construction of the project, the contractor may be required to implement one or more of the following noise mitigation measures at the contractor's expense, as directed by the construction project manager:

- Locate stationary construction equipment as far from nearby noise-sensitive properties as feasible.
- Shut off idling equipment.
- Reschedule construction operations to avoid periods of noise annoyance identified in the complaint.
- Notify nearby residents whenever extremely noisy work will be occurring.
- Install temporary or portable acoustic barriers around stationary construction noise sources.
- Operate electrically powered equipment using line voltage power or solar power.

7. Information for Local Government Officials

FHWA and MDOT policy specify that local officials should be provided appropriate information to assist with future compatible land use planning, especially about the future planning and development of currently undeveloped lands near the proposed project right-of-way.

Table 7-1 shows noise impact distance for the 66 dB and 71 dB levels (NAC categories B/C and E, respectively) from both highways in the project area. Future developments should not place applicable noise sensitive land uses within the distances listed from Edge of Pavement.

Table 7-1 Noise Impact Distances for Undeveloped Lands

Project Roadway	Distance from the Edge of Pavement	
	71 dB Distance	66 dB Distance
US-23	187 Feet	336 Feet
US-12	45 Feet	114 Feet

8. Conclusions and Recommendations

The noise analysis for the proposed project included a total of eight measurement locations and 165 predicted representative noise levels for 165 dwelling units in the project area. The project was split into eight separate CNEs for noise impact analysis within the study area.

Six of the eight CNEs contained receptors with predicted future noise levels approaching or exceeding the NAC. Noise abatement was considered in six locations. For each of these six locations noise abatement was evaluated but were disqualified for failing to meet some or all feasibility and reasonableness requirement as defined by MDOT noise policy.

9. Statement of Likelihood

Based on the studies thus far accomplished, the Michigan Department of Transportation does not intend to install highway traffic noise abatement in the form of noise walls, as presented in Table 5-1 in this document.

10. References

Federal Highway Administration, 23 CFR 772, Procedures for Abatement of Highway Traffic Noise and Construction Noise, July 2010. https://www.fhwa.dot.gov/legsregs/directives/fapg/cfr0772.htm

Federal Highway Administration (FHWA). 2011. Highway Traffic Noise: Analysis and Abatement Guidance. U.S. Department of Transportation, Federal Highway Administration, Washington, DC. . https://www.fhwa.dot.gov/environment/noise/regulations_and_guidance/analysis_and_abatement_guidance/revguidance.pdf

Michigan Department of Transportation, Highway Noise Analysis and Abatement Handbook. July 13,2011. https://www.michigan.gov/documents/mdot/MDOT_HighwayNoiseAnalysis_and_AbatementHandbook_358156_7.pdf

Pittsfield Zoning Maps. https://www.pittsfield-mi.gov/1031/Current-Projects

Appendix A Noise Measurement Data and Documentation

Appendix A contains the following noise measurement data and documentation:

- Short-term Noise Measurement Summary Table
- Noise Measurement Photo Log
- Noise Measurement Field Data Sheets
- Noise Measurement Equipment Calibration Certificates

Short Term Measurement Summary

ID	*Location*	*Average Leq (dBA)*	*Leq Range (dBA)*	*Start (hh:mm)*	*Stop (hh:mm)*	*Duration (hh:mm)*
ST-1	6227 W Michigan Ave	73.8	70.6-77.4	13:33	13:49	0:16
ST-2	3350 Textile Road	64.4	61.6-66.7	14:08	14:27	0:19
ST-3	5807 Hampshire Ln	63.2	60.4-68.5	14:44	15:02	0:18
ST-4	5495 W Michigan Ave	65.2	62.6-67.4	15:15	15:32	0:17
ST-5	3858 Bestech Dr	75.0	73.8-76.9	11:37	11:55	0:18
ST-6	3667 E Morgan Rd	72.2	70.9-73.9	15:53	16:12	0:19

Noise Measurement Photo Log

LT-01 Outside the Pittsfield Police Department

LT-01 Facing North

LT-01 Facing South

LT-02 Outside 3858 Bestech Dr

LT-02 Facing West

LT-02 Facing South

ST-01 6227 W Michigan Ave

ST-01 Facing North

ST-01 Facing South

ST-02 3350 Textile Road

ST-02 Facing North East

ST-02 Facing South

ST-03 5807 Hampshire Ln

ST-03 Facing South

ST-03 Facing North

ST-04 5495 W Michigan Ave

ST-04 Facing West

ST-04 Facing East

ST-05 3858 Bestech Dr

ST-05 Facing West

ST-05 Facing East

ST-06 3667 E Morgan Rd

ST-06 Facing East

ST-06 Facing West

Field Data Sheets

AECOM Acoustics and Noise Control Practice
FIELD NOISE MEASUREMENT DATA FORM

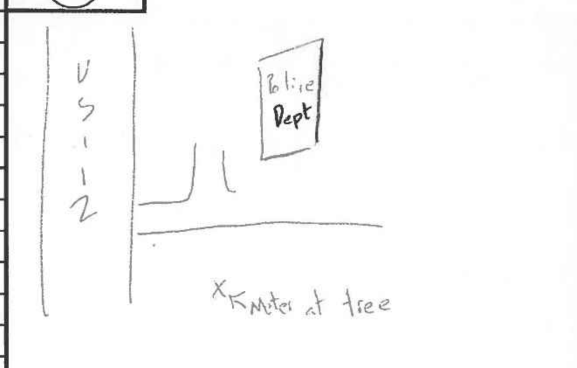
Project Name: MDOT - US 12/23 Project #: Date: 11-16-20 Page of
Measurement Location: LT-1 Analyst: Schad

Sound Level Meter	Field Calibration	Meteorological Data
Model #: LxT1	Model #: Cal200	Model #: K3500 Time Obs/Meas: 10:30
Serial #: 6202	Serial #: 3704	Serial #: 2385189
Weighting: A / C / Flat	Calibration Level (dB): 94 / 114	Precipitation: Yes (explain) / No
Response: Slow / Fast / Impl	Pre-Test 10.08 dBA	Wind: Steady / Gusty / Calm
Windscreen: Yes / No (explain)	Post-Test -0.00 dBA	Avg Wind Speed/Direction: 4 W m/s / MPH
Topo: Flat / Hilly	GPS Coordinates (at SLM location)#	Temp (°F): 49.00 RH (%): 70%
Terrain: Hard / Soft / Mixed / Agg / Snow	42°11'49.8" N 83°42'13.9" W	Bar Psr (Hg): 29.17 Cloud Cover (%): 25%

Loc. ID	Start Time (hh:mm)	Stop Time (hh:mm)	L_{eq}	L_{min}	L_{max}	L_{10}	L_{50}	L_{90}	Notes/Events
	10:18								Start on Monday
		10:21							Stop on Tuesday
									Meter checked at 6PM, 26000 mpA
									+ 2 hand warmers under lunchbox
									Full batt pack in morning

Roadway Name/Dir.				compass
Speed (post/obs*)				N
Number of Lanes				
Width (pave/row)				
1- or 2- way				
Grade				
Bus Stops				
Stoplights				
Motorcycles				
Automobiles				
Medium Trucks				
Heavy Trucks				
Buses				
Count duration				

Site Diagram:



- note coordinate system if other than NAD84 * - Speed estimated by Radar / Driving / Observation

Photos Taken? Yes / No

Additional Notes/Comments: Lots of double-wides on US-12 EB.

Noise Sources (circle all that apply): distant aircraft/roadway traffic/rail ops/landscaping/rustling leaves/children playing/dogs barking/birds vocalizing/insects/mechanical
Additional Notes and Sketches on Reverse or Indicated Separate Sheet(s)

AECOM ANCP, Field Noise Measurement Form, Vers. 1.4 rev010918

AECOM Acoustics and Noise Control Practice

FIELD NOISE MEASUREMENT DATA FORM

Project Name: MDOT US-12/23 Project #: Date: 11/16/20 Page of

Measurement Location: ST-2 Analyst: Schad

Sound Level Meter	Field Calibration	Meteorological Data
Model #: LxT1	Model #: Cal200	Model #: K3500 Time Obs/Meas: 14:18
Serial #: 6200	Serial #: 3704	Serial #: 2385189
Weighting: A / C / Flat	Calibration Level (dB): 94/114	Precipitation: Yes (explain) / No
Response: Slow / Fast / Impl	Pre-Test +0.08 dBA	Wind: Steady / Gusty / Calm
Windscreen: Yes / No (explain)	Post-Test -0.04 dBA	Avg Wind Speed/Direction: 4 W m/s / MPH
Topo: Flat / Hilly	GPS Coordinates (at SLM location)#	Temp (°F): 59° RH (%): 29%
Terrain: Hard / Soft / Mixed / Agg / Snow	42°12'06.1"N 83°41'33.5"W	Bar Psr (Hg): 29.14 Cloud Cover (%): 0%

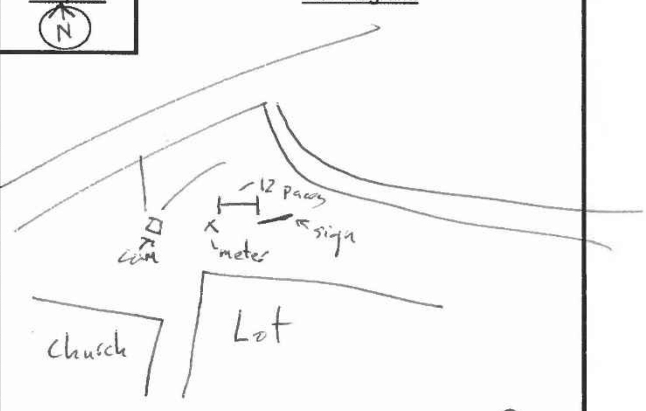
Loc. ID	Start Time (hh:mm)	Stop Time (hh:mm)	L_{eq}	L_{min}	L_{max}	L_{10}	L_{50}	L_{90}	Notes/Events
	14:08								Start at ST-2
		14:27							Stop

Roadway Name/Dir.			
Speed (post/obs*)			
Number of Lanes			
Width (pave/row)			
1- or 2- way			
Grade			
Bus Stops			
Stoplights			
Motorcycles			
Automobiles			
Medium Trucks			
Heavy Trucks			
Buses			
Count duration			

compass

N

Site Diagram:



- note coordinate system if other than NAD84 * - Speed estimated by Radar / Driving / Observation

Photos Taken? Yes / No

Additional Notes/Comments:

Noise Sources (circle all that apply): distant aircraft/roadway traffic/rail ops/landscaping/rustling leaves/children playing/dogs barking/birds vocalizing/insects/mechanical

Additional Notes and Sketches on Reverse or Indicated Separate Sheet(s)

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AECOM Acoustics and Noise Control Practice

FIELD NOISE MEASUREMENT DATA FORM

Project Name: MDOT US-12/23 Project #: Date: 11/16/20 Page of

Measurement Location: ST-1 Analyst: Schad

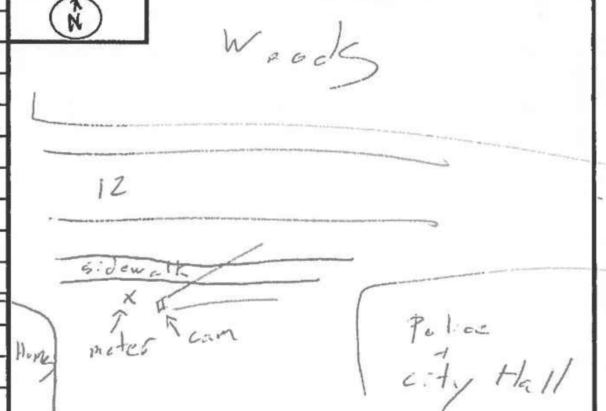
Sound Level Meter	Field Calibration	Meteorological Data
Model #: LxT1	Model #: Cal200	Model #: K3500 Time Obs/Meas: 13:36
Serial #: 6200	Serial #: 5707	Serial #: 2385189
Weighting: A / C / Flat	Calibration Level (dB): 94 / 114	Precipitation: Yes (explain) / No
Response: Slow / Fast / Impl	Pre-Test +0.15 dBA	Wind: Steady / Gusty / Calm
Windscreen: Yes / No (explain)	Post-Test −0.12 dBA	Avg Wind Speed/Direction: 7 W m/s / MPH
Topo: Flat / Hilly	GPS Coordinates (at SLM location)#	Temp (°F): 49 RH (%): 34
Terrain: Hard / Soft / Mixed / Agg / Snow	42°11'49.3"N 83°42'15.4"W	Bar Psr (Hg): 29.16 Cloud Cover (%): 5%

Loc. ID	Start Time (hh:mm)	Stop Time (hh:mm)	L_{eq}	L_{min}	L_{max}	L_{10}	L_{50}	L_{90}	Notes/Events
	13:33								Start, camera adjacent
	13:35								Trailer's home
	13:44								Stop

Roadway Name/Dir.		
Speed (post/obs*)		
Number of Lanes		
Width (pave/row)		
1- or 2- way		
Grade		
Bus Stops		
Stoplights		
Motorcycles		
Automobiles		
Medium Trucks		
Heavy Trucks		
Buses		
Count duration		

compass N

Site Diagram:



- note coordinate system if other than NAD84 * - Speed estimated by Radar / Driving / Observation

Photos Taken? Yes / No

Additional Notes/Comments:

Noise Sources (circle all that apply): distant aircraft/roadway traffic/rail ops/landscaping/rustling leaves/children playing/dogs barking/birds vocalizing/insects/mechanical

Additional Notes and Sketches on Reverse or Indicated Separate Sheet(s)

AECOM ANCP, Field Noise Measurement Form, Vers. 1.4 rev010918

AECOM Acoustics and Noise Control Practice

FIELD NOISE MEASUREMENT DATA FORM

Project Name: MDOT US-12/23 Project #: Date: Nov 16,20 Page of

Measurement Location: LT-2 Analyst: Schad

Sound Level Meter	Field Calibration	Meteorological Data
Model #: LxT1	Model #: Cal 200	Model #: K3500 Time Obs/Meas: 10:57
Serial #: 6201	Serial #: 3704	Serial #: 2385189 Tues
Weighting: A / C / Flat	Calibration Level (dB): 94 / 114	Precipitation: Yes (explain) / No
Response: Slow / Fast / Impl	Pre-Test 0,00 dBA	Wind: Steady / Gusty / Calm
Windscreen: Yes / No (explain)	Post-Test -0.13 dBA	Avg Wind Speed/Direction: 7 W m/s / MPH
Topo: Flat / Hilly	GPS Coordinates (at SLM location)#	Temp (°F): 43 RH (%): 32%
Terrain: Hard / Soft / Mixed / Agg / Snow	42°12'42.9"N 83°41'04.4"W	Bar Psr (Hg): 29.43 Cloud Cover (%): 60%

Loc. ID	Start Time (hh:mm)	Stop Time (hh:mm)	L_{eq}	L_{min}	L_{max}	L_{10}	L_{50}	L_{90}	Notes/Events
	10:48								Start on Mon
		10:59	Tues						Stop on Tues

Roadway Name/Dir.			compass N
Speed (post/obs*)			
Number of Lanes			
Width (pave/row)			
1- or 2- way			
Grade			
Bus Stops			
Stoplights			
Motorcycles			
Automobiles			
Medium Trucks			
Heavy Trucks			
Buses			
Count duration			

Site Diagram:

- note coordinate system if other than NAD84 * - Speed estimated by Radar / Driving / Observation

Photos Taken? Yes / No

Additional Notes/Comments:

Noise Sources (circle all that apply): distant aircraft/roadway traffic/rail ops/landscaping/rustling leaves/children playing/dogs barking/birds vocalizing/insects/mechanical

Additional Notes and Sketches on Reverse or Indicated Separate Sheet(s)

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AECOM Acoustics and Noise Control Practice

FIELD NOISE MEASUREMENT DATA FORM

Project Name: MDOT US-12/23 Project #: Date: 11/16/20 Page of
Measurement Location: ST-4 Analyst: Schad

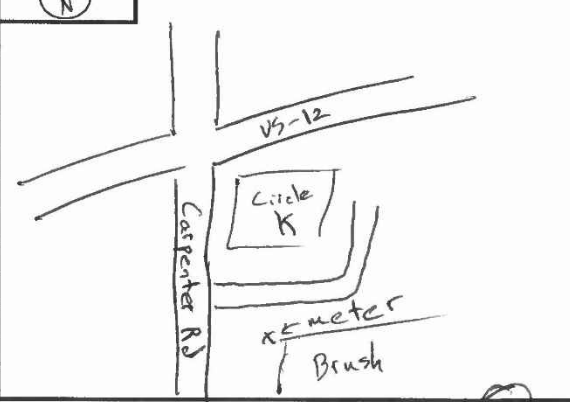
Sound Level Meter	Field Calibration	Meteorological Data
Model #: LxT1	Model #: CAL200	Model #: K3500 Time Obs/Meas: 15:33
Serial #: 6200	Serial #: 3764	Serial #: 2385189
Weighting: A / C / Flat	Calibration Level (dB): 94 / 114	Precipitation: Yes (explain) / No
Response: Slow / Fast / Impl	Pre-Test +0.00 dBA	Wind: Steady / Gusty / Calm
Windscreen: Yes / No (explain)	Post-Test -0.01 dBA	Avg Wind Speed/Direction: 8 W m/s / MPH
Topo: Flat / Hilly	GPS Coordinates (at SLM location)#	Temp (°F): 49 RH (%): 28%
Terrain: Hard / Soft / Mixed / Agg / Snow	42°12'28.2" N 83°40'45.0"W	Bar Psr (Hg): 29.12 Cloud Cover (%): 0%

Loc. ID	Start Time (hh:mm)	Stop Time (hh:mm)	L_{eq}	L_{min}	L_{max}	L_{10}	L_{50}	L_{90}	Notes/Events
	15:15								Start at ST-4
		15:31							Stop

Roadway Name/Dir.		
Speed (post/obs*)		
Number of Lanes		
Width (pave/row)		
1- or 2- way		
Grade		
Bus Stops		
Stoplights		
Motorcycles		
Automobiles		
Medium Trucks		
Heavy Trucks		
Buses		
Count duration		

compass N

Site Diagram:



- note coordinate system if other than NAD84 * - Speed estimated by Radar / Driving / Observation

Photos Taken? Yes / No

Additional Notes/Comments:

Noise Sources (circle all that apply): distant aircraft/roadway traffic/rail ops/landscaping/rustling leaves/children playing/dogs barking/birds vocalizing/insects/mechanical
Additional Notes and Sketches on Reverse or Indicated Separate Sheet(s)

AECOM ANCP, Field Noise Measurement Form, Vers. 1.4 rev010918

Calibration certificates for each SLM used to conduct field measurements.

AECOM Acoustics and Noise Control Practice

FIELD NOISE MEASUREMENT DATA FORM

Project Name: MDOT US-12/23 Project #: Date: 11/16/20 Page of

Measurement Location: ST-3 Analyst: GcL

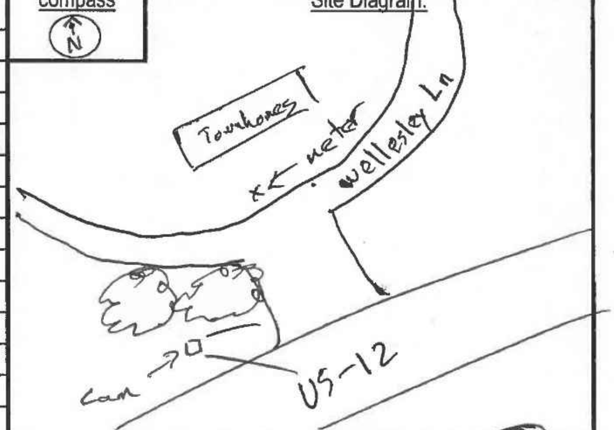
Sound Level Meter	Field Calibration	Meteorological Data
Model #: LxT1	Model #: CAL200	Model #: K3500 Time Obs/Meas: 2:50
Serial #: 6200	Serial #: 3704	Serial #: 2385189
Weighting: A / C / Flat	Calibration Level (dB): 94/114	Precipitation: Yes (explain) / No
Response: Slow / Fast / Impl	Pre-Test -0.01 dBA	Wind: Steady / Gusty / Calm
Windscreen: Yes / No (explain)	Post-Test 0.04 dBA	Avg Wind Speed/Direction: 7 W m/s / MPH
Topo: Flat / Hilly	GPS Coordinates (at SLM location)#	Temp (°F): 58 RH (%): 28%
Terrain: Hard / Soft / Mixed / Agg / Snow	42°12'14.7"N 83°41'24.6"	Bar Psr (Hg): 29.13 Cloud Cover (%): 0%

Loc. ID	Start Time (hh:mm)	Stop Time (hh:mm)	L_{eq}	L_{min}	L_{max}	L_{10}	L_{50}	L_{90}	Notes/Events
	14:44								Start
	14:54								Sirens
		15:02							Stop

Roadway Name/Dir.		
Speed (post/obs*)		
Number of Lanes		
Width (pave/row)		
1- or 2- way		
Grade		
Bus Stops		
Stoplights		
Motorcycles		
Automobiles		
Medium Trucks		
Heavy Trucks		
Buses		
Count duration		

compass

Site Diagram:



- note coordinate system if other than NAD84 * - Speed estimated by Radar / Driving / Observation

Photos Taken? Yes / No

Additional Notes/Comments:

Noise Sources (circle all that apply): distant aircraft/roadway traffic/rail ops/landscaping/rustling leaves/children playing/dogs barking/birds vocalizing/insects/mechanical

Additional Notes and Sketches on Reverse or Indicated Separate Sheet(s)

AECOM ANCP, Field Noise Measurement Form, Vers. 1.4 rev010918

AECOM Acoustics and Noise Control Practice

FIELD NOISE MEASUREMENT DATA FORM

Project Name: MDOT US-12/23 Project #: ______ Date: 11-16-20 Page ___ of ___

Measurement Location: ST-5 Analyst: Schad

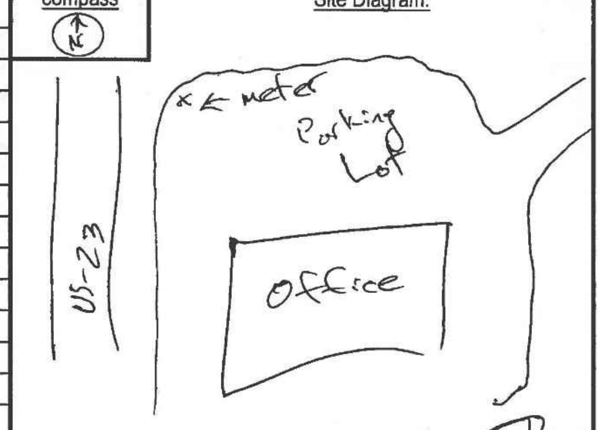
Sound Level Meter	Field Calibration	Meteorological Data
Model #: LxT1	Model #: Cal200	Model #: K3500 Time Obs/Meas: 11:40
Serial #: 6200	Serial #: 3704	Serial #: 2385189
Weighting: A / C / Flat	Calibration Level (dB): 94 / 114	Precipitation: Yes (explain) / No
Response: Slow / Fast / Impl	Pre-Test -0.02 dBA	Wind: Steady / Gusty / Calm
Windscreen: Yes / No (explain)	Post-Test +0.07 dBA	Avg Wind Speed/Direction: 6 m/s / MPH
Topo: Flat / Hilly	GPS Coordinates (at SLM location)#	Temp (°F): 46 RH (%): 30%
Terrain: Hard / Soft / Mixed / Agg / Snow	42°12'43.4N 83°41'04.2W	Bar Psr (Hg): 29.42 Cloud Cover (%): 50%

Loc. ID	Start Time (hh:mm)	Stop Time (hh:mm)	L_{eq}	L_{min}	L_{max}	L_{10}	L_{50}	L_{90}	Notes/Events
	11:37								Start
		11:55							Stop

Roadway Name/Dir.		
Speed (post/obs*)		
Number of Lanes		
Width (pave/row)		
1- or 2- way		
Grade		
Bus Stops		
Stoplights		
Motorcycles		
Automobiles		
Medium Trucks		
Heavy Trucks		
Buses		
Count duration		

compass

Site Diagram:



- note coordinate system if other than NAD84 * - Speed estimated by Radar / Driving / Observation

Photos Taken? Yes / No

Additional Notes/Comments:

Noise Sources (circle all that apply): distant aircraft/roadway traffic/rail ops/landscaping/rustling leaves/children playing/dogs barking/birds vocalizing/insects/mechanical

Additional Notes and Sketches on Reverse or Indicated Separate Sheet(s)

AECOM ANCP, Field Noise Measurement Form, Vers. 1.4 rev010918

AECOM Acoustics and Noise Control Practice

FIELD NOISE MEASUREMENT DATA FORM

Project Name: MDOT US-12/23 Project #: ______ Date: 11-16-20 Page ___ of ___

Measurement Location: ST-6 Analyst: Schad

Sound Level Meter	Field Calibration	Meteorological Data
Model #: LxT	Model #: CAL200	Model #: K3500 — Time Obs/Meas: 16.07
Serial #: 6200	Serial #: 3804	Serial #: 2385189
Weighting: A / C / Flat	Calibration Level (dB): 94 / 114	Precipitation: Yes (explain) / No
Response: Slow / Fast / Impl	Pre-Test +0.06 dBA	Wind: Steady / Gusty / Calm
Windscreen: Yes / No (explain)	Post-Test -0.02 dBA	Avg Wind Speed/Direction: 6 W m/s / MPH
Topo: Flat / Hilly	GPS Coordinates (at SLM location)[#]	Temp (°F): 57° RH (%): 27%
Terrain: Hard / Soft / Mixed / Agg / Snow	42° 12'56.9N 83° 41'09.4"W	Bar Psr (Hg): 29.12 Cloud Cover (%):

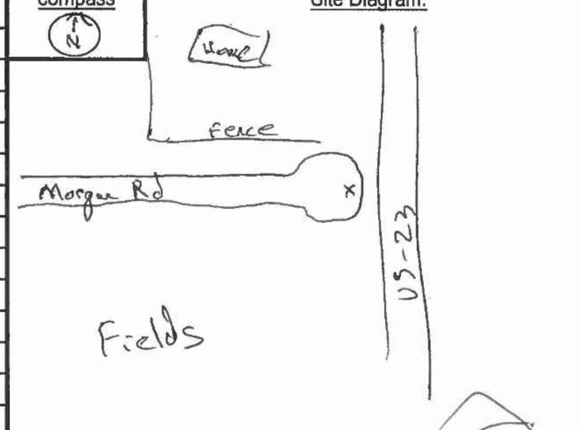
Loc. ID	Start Time (hh:mm)	Stop Time (hh:mm)	L_{eq}	L_{min}	L_{max}	L_{10}	L_{50}	L_{90}	Notes/Events
	15:54								Start
	16:00								Rumble Strip
	16:12								Stop

Roadway Name/Dir.		
Speed (post/obs*)		
Number of Lanes		
Width (pave/row)		
1- or 2- way		
Grade		
Bus Stops		
Stoplights		
Motorcycles		
Automobiles		
Medium Trucks		
Heavy Trucks		
Buses		
Count duration		

compass

N

Site Diagram:



- note coordinate system if other than NAD84 * - Speed estimated by Radar / Driving / Observation

Photos Taken? Yes / No

Additional Notes/Comments:

Noise Sources (circle all that apply): distant aircraft/roadway traffic/rail ops/landscaping/rustling leaves/children playing/dogs barking/birds vocalizing/insects/mechanical

Additional Notes and Sketches on Reverse or Indicated Separate Sheet(s)

AECOM ANCP, Field Noise Measurement Form, Vers. 1.4 rev010918

Equipment Calibration Certificates

Calibration Certificate

Certificate Number 2020007216

Customer:

AECOM
Suite 1200
401 West A Street
San Diego, CA 92101, United States

Model Number	LxT1	*Procedure Number*	D0001.8384		
Serial Number	0006201	*Technician*	Kyle Holm		
Test Results	Pass	*Calibration Date*	29 Jun 2020		
Initial Condition	As Manufactured	*Calibration Due*			
		Temperature	23.64	°C	± 0.25 °C
Description	SoundTrack LxT Class 1 Class 1 Sound Level Meter Firmware Revision: 2.403	*Humidity*	52.4	%RH	± 2.0 %RH
		Static Pressure	85.77	kPa	± 0.13 kPa

Evaluation Method — *Tested with:* — *Data reported in dB re 20 μPa.*

Larson Davis PRMLxT1L, S/N 069962
PCB 377B02, S/N 322051
Larson Davis CAL200, S/N 9079
Larson Davis CAL291, S/N 0108

Compliance Standards — Compliant to Manufacturer Specifications and the following standards when combined with Calibration Certificate from procedure D0001.8378:

IEC 60651:2001 Type 1	ANSI S1.4-2014 Class 1
IEC 60804:2000 Type 1	ANSI S1.4 (R2006) Type 1
IEC 61252:2002	ANSI S1.11 (R2009) Class 1
IEC 61260:2001 Class 1	ANSI S1.25 (R2007)
IEC 61672:2013 Class 1	ANSI S1.43 (R2007) Type 1

Issuing lab certifies that the instrument described above meets or exceeds all specifications as stated in the referenced procedure (unless otherwise noted). It has been calibrated using measurement standards traceable to the International System of Units (SI) through the National Institute of Standards and Technology (NIST), or other national measurement institutes, and meets the requirements of ISO/IEC 17025:2005.
Test points marked with a ‡ in the uncertainties column do not fall within this laboratory's scope of accreditation.

The quality system is registered to ISO 9001:2015.

This calibration is a direct comparison of the unit under test to the listed reference standards and did not involve any sampling plans to complete. No allowance has been made for the instability of the test device due to use, time, etc. Such allowances would be made by the customer as needed.

The uncertainties were computed in accordance with the ISO Guide to the Expression of Uncertainty in Measurement (GUM). A coverage factor of approximately 2 sigma (k=2) has been applied to the standard uncertainty to express the expanded uncertainty at approximately 95% confidence level.

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Correction data from Larson Davis LxT Manual for SoundTrack LxT & SoundExpert Lxt, I770.01 Rev J Supporting Firmware Version 2.301, 2015-04-30

LARSON DAVIS - A PCB PIEZOTRONICS DIV.
1681 West 820 North
Provo, UT 84601, United States
716-684-0001

ilac-MRA ACCREDITED Cert. #3622.01

LARSON DAVIS
A PCB PIEZOTRONICS DIV.

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Calibration Certificate

Certificate Number 2020007219

Customer:

AECOM
Suite 1200
401 West A Street
San Diego, CA 92101, United States

Model Number	LxT1	*Procedure Number*	D0001.8384
Serial Number	0006202	*Technician*	Kyle Holm
Test Results	Pass	*Calibration Date*	29 Jun 2020
Initial Condition	As Manufactured	*Calibration Due*	
		Temperature	23.64 °C ± 0.25 °C
Description	SoundTrack LxT Class 1 Class 1 Sound Level Meter Firmware Revision: 2.403	*Humidity*	52.1 %RH ± 2.0 %RH
		Static Pressure	85.78 kPa ± 0.13 kPa

Evaluation Method — *Tested with:*
Larson Davis PRMLxT1L. S/N 069963
PCB 377B02. S/N 322055
Larson Davis CAL200, S/N 9079
Larson Davis CAL291, S/N 0108

Data reported in dB re 20 μPa.

Compliance Standards — Compliant to Manufacturer Specifications and the following standards when combined with Calibration Certificate from procedure D0001.8378:

IEC 60651:2001 Type 1	ANSI S1.4-2014 Class 1
IEC 60804:2000 Type 1	ANSI S1.4 (R2006) Type 1
IEC 61252:2002	ANSI S1.11 (R2009) Class 1
IEC 61260:2001 Class 1	ANSI S1.25 (R2007)
IEC 61672:2013 Class 1	ANSI S1.43 (R2007) Type 1

Issuing lab certifies that the instrument described above meets or exceeds all specifications as stated in the referenced procedure (unless otherwise noted). It has been calibrated using measurement standards traceable to the International System of Units (SI) through the National Institute of Standards and Technology (NIST), or other national measurement institutes, and meets the requirements of ISO/IEC 17025:2005.
Test points marked with a ‡ in the uncertainties column do not fall within this laboratory's scope of accreditation.

The quality system is registered to ISO 9001:2015.

This calibration is a direct comparison of the unit under test to the listed reference standards and did not involve any sampling plans to complete. No allowance has been made for the instability of the test device due to use, time, etc. Such allowances would be made by the customer as needed.

The uncertainties were computed in accordance with the ISO Guide to the Expression of Uncertainty in Measurement (GUM). A coverage factor of approximately 2 sigma (k=2) has been applied to the standard uncertainty to express the expanded uncertainty at approximately 95% confidence level.

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Correction data from Larson Davis LxT Manual for SoundTrack LxT & SoundExpert Lxt, I770.01 Rev J Supporting Firmware Version 2.301, 2015-04-30

LARSON DAVIS - A PCB PIEZOTRONICS DIV.
1681 West 820 North
Provo, UT 84601, United States
716-684-0001

ACCREDITED
Cert #3622.01

LARSON DAVIS
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Calibration Certificate

Certificate Number 2020007201

Customer:

AECOM
Suite 1200
401 West A Street
San Diego, CA 92101, United States

Model Number	LxT1	*Procedure Number*	D0001.8384
Serial Number	0006200	*Technician*	Kyle Holm
Test Results	Pass	*Calibration Date*	29 Jun 2020
		Calibration Due	
Initial Condition	As Manufactured	*Temperature*	23.62 °C ± 0.25 °C
Description	SoundTrack LxT Class 1 Class 1 Sound Level Meter Firmware Revision: 2.403	*Humidity*	53.3 %RH ± 2.0 %RH
		Static Pressure	85.72 kPa ± 0.13 kPa

Evaluation Method — *Tested with:* — *Data reported in dB re 20 μPa.*

Larson Davis PRMLxT1L. S/N 069961
PCB 377B02. S/N 322050
Larson Davis CAL200, S/N 9079
Larson Davis CAL291, S/N 0108

Compliance Standards — Compliant to Manufacturer Specifications and the following standards when combined with Calibration Certificate from procedure D0001.8378:

IEC 60651:2001 Type 1	ANSI S1.4-2014 Class 1
IEC 60804:2000 Type 1	ANSI S1.4 (R2006) Type 1
IEC 61252:2002	ANSI S1.11 (R2009) Class 1
IEC 61260:2001 Class 1	ANSI S1.25 (R2007)
IEC 61672:2013 Class 1	ANSI S1.43 (R2007) Type 1

Issuing lab certifies that the instrument described above meets or exceeds all specifications as stated in the referenced procedure (unless otherwise noted). It has been calibrated using measurement standards traceable to the International System of Units (SI) through the National Institute of Standards and Technology (NIST), or other national measurement institutes, and meets the requirements of ISO/IEC 17025:2005.

Test points marked with a ‡ in the uncertainties column do not fall within this laboratory's scope of accreditation.

The quality system is registered to ISO 9001:2015.

This calibration is a direct comparison of the unit under test to the listed reference standards and did not involve any sampling plans to complete. No allowance has been made for the instability of the test device due to use, time, etc. Such allowances would be made by the customer as needed.

The uncertainties were computed in accordance with the ISO Guide to the Expression of Uncertainty in Measurement (GUM). A coverage factor of approximately 2 sigma (k=2) has been applied to the standard uncertainty to express the expanded uncertainty at approximately 95% confidence level.

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Correction data from Larson Davis LxT Manual for SoundTrack LxT & SoundExpert Lxt, I770.01 Rev J Supporting Firmware Version 2.301, 2015-04-30

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1681 West 820 North
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716-684-0001

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A PCB PIEZOTRONICS DIV.

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Odin Metrology, Inc.
Calibration of Sound & Vibration Instruments

Certificate Number: **25883-3**

Certificate of Calibration for Larson Davis Calibrator

This calibration is performed by comparison with measurement reference standard microphone:

Type No.	4134
Serial No.	1315901
Calibrated by	HL
Cal Date	25 MAR 2020
Due Date	25 MAR 2021

a) Estimated uncertainty of comparison: ± 0.05 dB
b) Estimated uncertainty of calibration service for standard pistonphone: ± 0.06 dB
c) Total uncertainty: $\sqrt{a^2+b^2}$ = ± 0.08 dB
d) Expanded uncertainty (coverage factor k = 2 for 95% confidence level): = ± 0.16 dB

This acoustic calibrator has been calibrated using standards with values traceable to the National Institute of Standards and Technology. This calibration is traceable to NIST Test Number **683/289533-17.**

Condition of Test		
Ambient Pressure	**989.21**	hPa
Temperature	**23**	°C
Relative Humidity	**42**	%
Date of Calibration	**11 OCT 2020**	
Re-calibration due on	**11 OCT 2021**	

The calibration of this acoustic calibrator was performed using a test system conforming to the requirements of ANSI/NCSLZ540-1, 1994, ISO 17025, and ISO 9001:2015, Certification NQA No. 11252.

Calibration procedure: **OM-P-1001-Acoustic_Calibrator, Rev. 1.0 20130522.**

Calibration performed by Harold Lynch

Harold Lynch, Service Manager

Calibrator type **CAL200**
Serial no. **3704**
Submitted by **AECOM**
San Diego, CA 92101
Purchase order no. **Credit Card**
Asset no. **N/A**

This calibrator has been found to perform **within** the specifications listed below at the normalized conditions stated.

SPL produced in coupler terminated by a loading volume of a ½" microphone	94.0 ± 0.2 dB 114 ± 0.2 dB
Frequency	1,000 Hz ± 1%
Distortion	< 2%
At 1,013 hPa, 23°C, and 65% relative humidity	

Performance as Received		
Frequency	**1000.3**	Hz
SPL (94 dB)	**93.97**	dB
SPL (114 dB)	**113.97**	dB
Distortion (at 94 dB)	**0.3**	%
Battery Voltage	**9.4**	V

Was adjustment performed? **No**
Were batteries replaced? **No**

Final Performance		
Frequency	**1000.3**	Hz
SPL (94 dB)	**93.97**	dB
SPL (114 dB)	**113.97**	dB
Distortion (at 94 dB)	**0.3**	%

Note: This calibrator was **within** manufacturer's specifications as received.

Odin Metrology, Inc.
3533 Old Conejo Road, Suite 125
Thousand Oaks, CA 91320
Phone: (805) 375-0830; Fax: (805) 375-0405

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Doc. Rev. 18 Jun 2020

Appendix B Sample TNM Input/Output Files

Sample TNM output tables are provided for CNE 3 Abatement analysis. Additional input and output files are available upon request.

CNE 3 TNM Sound Level Prediction Output Table

Sound Levels : CNE3-Wall3B:4

AECOM
Andrew Schad

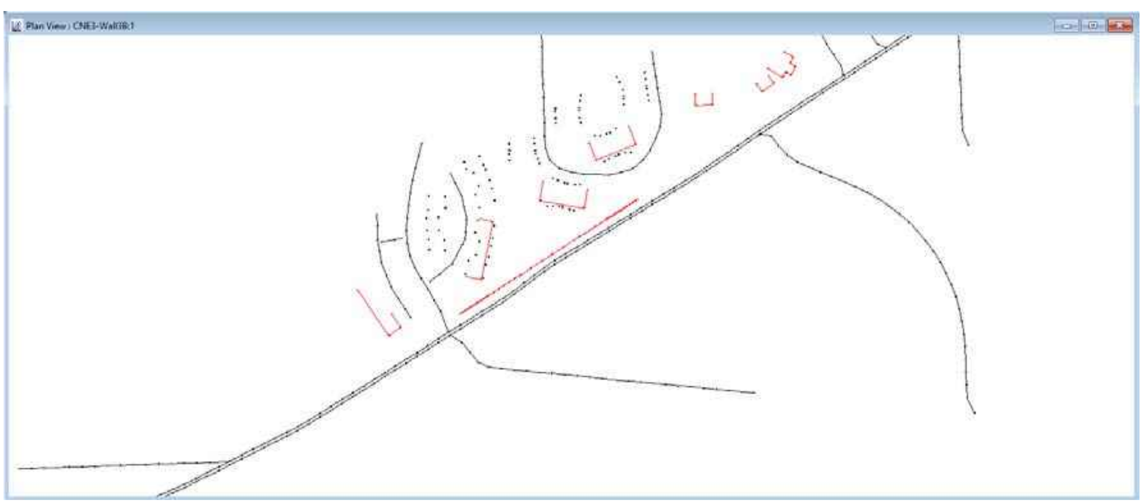
17 September 2021
TNM 2.5
Calculated with TNM 2.5

RESULTS: SOUND LEVELS
PROJECT/CONTRACT: MDOT US-12 23
RUN: US-12 23 CNE 3 Abatement (A)
BARRIER DESIGN: 3B (balconies)
ATMOSPHERICS: 68 deg F, 50% RH

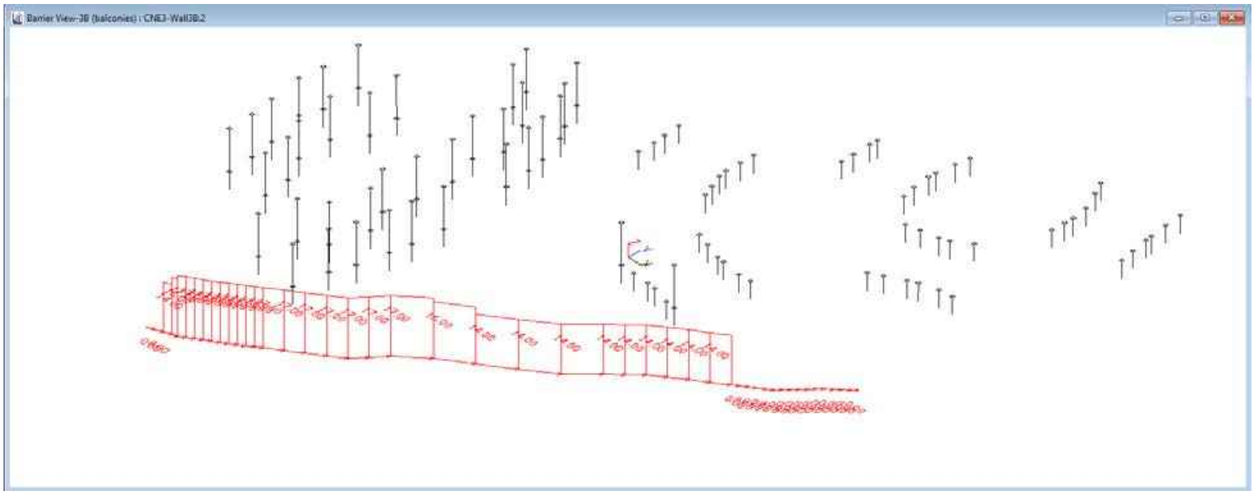
Average pavement type shall be used u
a State highway agency substantiates tl
of a different type with approval of FHW

Receiver Name	No.	#DUs	Existing LAeq1h	No Barrier LAeq1h Calculated	No Barrier LAeq1h Crit'n	Increase over existing Calculated	Increase over existing Crit'n Sub'l Inc	Type Impact	With Barrier Calculated LAeq1h	Noise Reduction Calculated	Goal
			dBA	dBA	dBA	dB	dB		dBA	dB	dB
3101	182	1	0.0	54.4	66	54.4	10	—	52.6	1.8	
3102	183	1	0.0	54.8	66	54.8	10	—	52.9	1.9	
3103	184	1	0.0	54.8	66	54.8	10	—	52.9	1.9	
3104	185	1	0.0	55.3	66	55.3	10	—	53.1	2.2	
3105	186	1	0.0	55.6	66	55.6	10	—	53.1	2.5	
3106	197	1	0.0	55.2	66	55.2	10	—	53.0	2.2	
3107	203	1	0.0	56.3	66	56.3	10	—	53.6	2.7	
3108	204	1	0.0	56.3	66	56.3	10	—	52.9	3.4	
3109	205	1	0.0	56.7	66	56.7	10	—	52.4	4.3	
3110	206	1	0.0	57.8	66	57.8	10	—	52.1	5.7	
3111	207	1	0.0	55.4	66	55.4	10	—	52.2	3.2	
3112	208	1	0.0	56.2	66	56.2	10	—	53.4	2.8	

Plan View



Barrier Analysis Screenshot



Barrier Description Table

Barrier Descriptions Table : CNE3-Wall3B:5

AECOM — 17 September 2021
Andrew Schad — TNM 2.5

RESULTS: BARRIER DESCRIPTIONS
PROJECT/CONTRACT: MDOT US-12 23
RUN: US-12 23 CNE 3 Abatement (A)
BARRIER DESIGN: 3B (balconies)

Barriers

Name	Type	Heights along Barrier			Length	If Wall	If Berm			Cost
		Min	Avg	Max		Area	Volume	Top Width	Run:Rise	
		ft	ft	ft	ft	sq ft	cu yd	ft	ft:ft	$
Wall 3B	W	14.00	15.52	17.00	666	10343				465449
									Total Cost:	465449

Appendix C Predicted Noise Levels and Impacts

Table C-1 Loudest Hour Noise Levels, Leq(1h), dBA

Receptor Number	Land Use	Activity Category	Units	FHWA/MDOT NAC	Existing	Build	Change
CNE 1							
1001	Public Building	C	1	67	65	**67**	+2
1002	Residential	B	1	67	53	53	+0
1003	Residential	B	1	67	54	54	+0
1004	Residential	B	1	67	56	56	0
1005	Residential	B	1	67	57	57	0
1006	Residential	B	1	67	53	53	0
1007	Residential	B	1	67	54	54	0
1008	Residential	B	1	67	54	53	0
1009	Residential	B	1	67	56	56	0
1010	Residential	B	1	67	62	62	+0
1011	Residential	B	1	67	**67**	**67**	+0
1012	Residential	B	1	67	**70**	**70**	+0
1013	Residential	B	1	67	**66**	**66**	0
1014	Residential	B	1	67	60	60	0
1015	Residential	B	1	67	62	61	0
1016	Residential	B	1	67	64	64	0
1017	Residential	B	1	67	65	**66**	+0
1020	Residential	B	1	67	**66**	**66**	0
1021	Residential	B	1	67	**66**	**66**	0
1022	Residential	B	1	67	65	65	0
1023	Residential	B	1	67	65	65	0
1024	Residential	B	1	67	63	63	0
1025	Residential	B	1	67	62	62	0
1026	Residential	B	1	67	59	59	0
CNE 2							
2001	Residential	B	1	67	64	**68**	+4
2002	Residential	B	1	67	64	**68**	+4
2003	Residential	B	1	67	64	**67**	+3
2004	Residential	B	1	67	64	**68**	+4
2005	Residential	B	1	67	64	**68**	+4
2006	Residential	B	1	67	64	**68**	+4
2007	Residential	B	1	67	64	**68**	+4
2008	Residential	B	1	67	64	**68**	+4
2009	Residential	B	1	67	64	**68**	+4
2010	Residential	B	1	67	64	**68**	+4
2011	Residential	B	1	67	65	**68**	+3
2012	Residential	B	1	67	65	**68**	+3
2013	Residential	B	1	67	65	**68**	+3
2014	Residential	B	1	67	65	**68**	+3
2015	Residential	B	1	67	**66**	**69**	+3
2016	Residential	B	1	67	**66**	**69**	+3
2017	Residential	B	1	67	**66**	**69**	+3
2018	Residential	B	1	67	**66**	**69**	+3
2019	Residential	B	1	67	**67**	**70**	+3
2020	Residential	B	1	67	**67**	**70**	+3
2021	Residential	B	1	67	**68**	**70**	+2
2022	Residential	B	1	67	**69**	**71**	+2
2023	Residential	B	1	67	60	61	+1
2024	Residential	B	1	67	60	61	+1
2025	Residential	B	1	67	61	62	+1
2026	Residential	B	1	67	61	62	+1
2027	Residential	B	1	67	61	62	+1
2028	Residential	B	1	67	61	62	+1

Receptor Number	Land Use	Activity Category	Units	FHWA/MDOT NAC	Existing	Build	Change
2029	Residential	B	1	67	57	58	+1
2030	Residential	B	1	67	58	59	+1
2031	Residential	B	1	67	58	59	+1
2032	Residential	B	1	67	59	60	+1
2033	Residential	B	1	67	59	60	+1
2034	Residential	B	1	67	60	62	+2
2035	Residential	B	1	67	57	58	+1
2036	Residential	B	1	67	56	57	+1
2037	Residential	B	1	67	56	57	+1
2038	Residential	B	1	67	50	50	+0
2039	Residential	B	1	67	47	48	+1
2040	Residential	B	1	67	51	52	+1
2041	Residential	B	1	67	48	49	+1
2042	Residential	B	1	67	52	54	+2
2043	Residential	B	1	67	55	57	+2
2044	Residential	B	1	67	49	50	+1
2045	Residential	B	1	67	49	50	+1
2046	Residential	B	1	67	45	46	+1
2047	Commercial	E	1	71	58	58	+0
2048	Residential	B	1	67	64	65	+1
2049	Residential	B	1	67	**72**	**72**	+0
2050	Church	C	1	67	62	63	+1
2051	Residential	B	1	67	**68**	**68**	+0
2052	Residential	B	1	67	**68**	**69**	+1
2053	Residential	B	1	67	**67**	**68**	+1
2054	Residential	B	1	67	59	59	+0
2055	Residential	B	1	67	58	59	+1
2056	Residential	B	1	67	**72**	**72**	+0
2057	Residential	B	1	67	**72**	**72**	+0
2058	Residential	B	1	67	65	**66**	+1
CNE 3							
3001	Residential	B	1	67	60	61	+1
3002	Residential	B	1	67	61	62	+1
3003	Residential	B	1	67	60	60	+0
3004	Residential	B	1	67	61	62	+1
3005	Residential	B	1	67	**70**	**71**	+1
3006	Residential	B	1	67	**71**	**72**	+1
3007	Residential	B	1	67	54	54	+0
3008	Residential	B	1	67	55	55	+0
3009	Residential	B	1	67	55	55	+0
3101	Residential	B	1	67	54	55	+1
3102	Residential	B	1	67	55	55	+0
3103	Residential	B	1	67	55	55	+0
3104	Residential	B	1	67	55	55	+0
3105	Residential	B	1	67	55	56	+1
3106	Residential	B	1	67	55	55	+0
3107	Residential	B	1	67	56	56	+0
3108	Residential	B	1	67	56	56	+0
3109	Residential	B	1	67	57	57	+0
3110	Residential	B	1	67	58	58	+0
3111	Residential	B	1	67	55	56	+1
3112	Residential	B	1	67	56	56	+0
3113	Residential	B	1	67	**69**	**69**	+0
3114	Residential	B	1	67	**66**	**66**	+0
3115	Residential	B	1	67	65	65	+0
3116	Residential	B	1	67	63	63	+0
3117	Residential	B	1	67	62	62	+0
3118	Residential	B	1	67	60	61	+1
3119	Residential	B	1	67	53	54	+1
3120	Residential	B	1	67	54	54	+0

Receptor Number	Land Use	Activity Category	Units	FHWA/MDOT NAC	Existing	Build	Change
3121	Residential	B	1	67	54	54	+0
3122	Residential	B	1	67	55	55	+0
3123	Residential	B	1	67	57	57	+0
3124	Residential	B	1	67	60	60	+0
3125	Residential	B	1	67	58	58	+0
3126	Residential	B	1	67	56	56	+0
3127	Residential	B	1	67	55	56	+1
3128	Residential	B	1	67	55	55	+0
3129	Residential	B	1	67	54	55	+1
3130	Residential	B	1	67	54	54	+0
3131	Residential	B	1	67	54	54	+0
3132	Residential	B	1	67	54	55	+1
3133	Residential	B	1	67	55	55	+0
3134	Residential	B	1	67	55	55	+0
3135	Residential	B	1	67	56	56	+0
3136	Residential	B	1	67	57	57	+0
3137	Residential	B	1	67	54	54	+0
3138	Residential	B	1	67	55	55	+0
3139	Residential	B	1	67	56	56	+0
3140	Residential	B	1	67	56	56	+0
3141	Residential	B	1	67	56	56	+0
3142	Residential	B	1	67	57	57	+0
3143	Residential	B	1	67	57	57	+0
3144	Residential	B	1	67	57	57	+0
3145	Residential	B	1	67	56	56	+0
3146	Residential	B	1	67	62	62	+0
3147	Residential	B	1	67	65	65	+0
3148	Residential	B	1	67	54	54	+0
3149	Residential	B	1	67	54	55	+1
3150	Residential	B	1	67	55	55	+0
3151	Residential	B	1	67	56	56	+0
3152	Residential	B	1	67	56	56	+0
3153	Residential	B	1	67	55	56	+1
3154	Residential	B	1	67	57	57	+0
3155	Residential	B	1	67	58	58	+0
3156	Residential	B	1	67	60	60	+0
3157	Residential	B	1	67	62	62	+0
3158	Residential	B	1	67	**66**	**66**	+0
3201	Residential	B	1	67	57	58	+1
3202	Residential	B	1	67	58	58	+0
3203	Residential	B	1	67	58	58	+0
3204	Residential	B	1	67	59	59	+0
3205	Residential	B	1	67	59	59	+0
3206	Residential	B	1	67	58	59	+1
3207	Residential	B	1	67	60	60	+0
3208	Residential	B	1	67	60	60	+0
3209	Residential	B	1	67	61	61	+0
3210	Residential	B	1	67	62	62	+0
3211	Residential	B	1	67	59	60	+1
3212	Residential	B	1	67	60	61	+1
3213	Residential	B	1	67	**70**	**70**	+0
3214	Residential	B	1	67	**68**	**68**	+0
3215	Residential	B	1	67	**67**	**67**	+0
3216	Residential	B	1	67	**66**	**66**	+0
3217	Residential	B	1	67	**66**	**66**	+0
3218	Residential	B	1	67	65	65	+0
3219	Residential	B	1	67	57	57	+0
3220	Residential	B	1	67	58	58	+0
3221	Residential	B	1	67	58	58	+0
3222	Residential	B	1	67	59	59	+0

Receptor Number	Land Use	Activity Category	Units	FHWA/MDOT NAC	Existing	Build	Change
3223	Residential	B	1	67	61	61	+0
3224	Residential	B	1	67	63	63	+0
3225	Residential	B	1	67	62	62	+0
3226	Residential	B	1	67	61	61	+0
3227	Residential	B	1	67	59	59	+0
3228	Residential	B	1	67	58	58	+0
3229	Residential	B	1	67	58	58	+0
3230	Residential	B	1	67	58	58	+0
3231	Residential	B	1	67	57	57	+0
3232	Residential	B	1	67	58	58	+0
3233	Residential	B	1	67	58	58	+0
3234	Residential	B	1	67	59	59	+0
3235	Residential	B	1	67	60	60	+0
3236	Residential	B	1	67	62	62	+0
3237	Residential	B	1	67	56	57	+1
3238	Residential	B	1	67	57	58	+1
3239	Residential	B	1	67	58	58	+0
3240	Residential	B	1	67	59	59	+0
3241	Residential	B	1	67	59	59	+0
3242	Residential	B	1	67	60	61	+1
3243	Residential	B	1	67	61	61	+0
3244	Residential	B	1	67	61	61	+0
3245	Residential	B	1	67	59	59	+0
3246	Residential	B	1	67	65	65	+0
3247	Residential	B	1	67	**67**	**67**	+0
3248	Residential	B	1	67	57	57	+0
3249	Residential	B	1	67	57	57	+0
3250	Residential	B	1	67	58	58	+0
3251	Residential	B	1	67	59	59	+0
3252	Residential	B	1	67	59	60	+1
3253	Residential	B	1	67	61	61	+0
3254	Residential	B	1	67	62	62	+0
3255	Residential	B	1	67	62	63	+1
3256	Residential	B	1	67	64	64	+0
3257	Residential	B	1	67	65	65	+0
3258	Residential	B	1	67	**67**	**68**	+1
3259	Residential	B	1	67	55	56	+1
3301	Residential	B	1	67	56	56	+0
3302	Residential	B	1	67	56	56	+0
3303	Residential	B	1	67	57	57	+0
3304	Residential	B	1	67	57	58	+1
3305	Residential	B	1	67	59	59	+0
3306	Residential	B	1	67	58	58	+0
3307	Residential	B	1	67	58	58	+0
3308	Residential	B	1	67	57	58	+1
3309	Residential	B	1	67	57	58	+1
3310	Residential	B	1	67	57	57	+0
3311	Residential	B	1	67	57	57	+0
3312	Residential	B	1	67	60	60	+0
3313	Residential	B	1	67	59	59	+0
3314	Residential	B	1	67	59	59	+0
3315	Residential	B	1	67	59	59	+0
3316	Residential	B	1	67	57	58	+1
3317	Residential	B	1	67	56	57	+1
3318	Residential	B	1	67	53	53	+0
3319	Residential	B	1	67	51	52	+1
3320	Residential	B	1	67	51	52	+1
3321	Residential	B	1	67	51	52	+1
3322	Residential	B	1	67	51	52	+1
3323	Residential	B	1	67	55	55	+0

Receptor Number	Land Use	Activity Category	Units	FHWA/MDOT NAC	Existing	Build	Change
3324	Residential	B	1	67	55	55	+0
3325	Residential	B	1	67	55	55	+0
3326	Residential	B	1	67	55	55	+0
3327	Residential	B	1	67	54	55	+1
3328	Residential	B	1	67	54	54	+0
3329	Residential	B	1	67	54	54	+0
3330	Residential	B	1	67	54	54	+0
3331	Residential	B	1	67	54	54	+0
3332	Residential	B	1	67	54	54	+0
3333	Residential	B	1	67	54	55	+1
3334	Residential	B	1	67	55	55	+0
3335	Residential	B	1	67	55	55	+0
3336	Residential	B	1	67	55	55	+0
3337	Residential	B	1	67	55	56	+1
3338	Residential	B	1	67	56	56	+0
3339	Residential	B	1	67	55	55	+0
3340	Residential	B	1	67	55	55	+0
3341	Residential	B	1	67	55	55	+0
3342	Residential	B	1	67	55	56	+1
3343	Residential	B	1	67	**69**	**69**	+0
3344	Residential	B	1	67	**66**	**66**	+0
3345	Residential	B	1	67	65	65	+0
3346	Residential	B	1	67	63	63	+0
3347	Residential	B	1	67	64	64	+0
3348	Residential	B	1	67	**66**	**66**	+0
3349	Residential	B	1	67	63	64	+1
3350	Residential	B	1	67	63	63	+0
3351	Residential	B	1	67	62	63	+1
3352	Residential	B	1	67	62	63	+1
3353	Residential	B	1	67	62	62	+0
3354	Residential	B	1	67	62	62	+0
CNE 4							
4001	Residential	B	1	67	58	58	0
4002	Residential	B	1	67	58	58	0
4003	Residential	B	1	67	59	59	0
4004	Residential	B	1	67	60	60	0
4005	Residential	B	1	67	61	61	0

Receptor Number	Land Use	Activity Category	Units	FHWA/MDOT NAC	Existing	Build	Change
CNE 6							
6001	Residential	B	1	67	**68**	**68**	0
CNE 7							
7001	Residential	B	1	67	**67**	**68**	0
7002	Residential	B	1	67	64	65	0
7003	Residential	B	1	67	64	64	0
7004	Residential	B	1	67	**68**	**69**	0
7005	Residential	B	1	67	**75**	**75**	0
CNE 8							
8001	Residential	B	1	67	**67**	**68**	0
8002	Residential	B	1	67	64	65	0
8003	Residential	B	1	67	**71**	**71**	0

Note: Bolded values represent noise impacts.

Appendix D Noise Barrier Analysis Detail

Table D-1 Noise Barrier Analysis, Receiver Level Detail

Receptor Number	Land Use	Category	Units	FHWA/MDOT NAC	Build	Noise Level w/Barr	Noise Reduction	Benefit?
Wall 1A								
1006	Residential	B	1	67	53	52	1	
1007	Residential	B	1	67	54	52	2	
1008	Residential	B	1	67	53	52	2	
1009	Residential	B	1	67	56	55	1	
1010	Residential	B	1	67	62	60	2	
1011	Residential	B	1	67	**67**	61	**7**	Y
1012	Residential	B	1	67	**70**	60	**10**	Y
1013	Residential	B	1	67	**66**	57	**9**	Y
1014	Residential	B	1	67	60	55	**6**	Y
1015	Residential	B	1	67	61	55	**7**	Y
1016	Residential	B	1	67	64	58	**6**	Y
1017	Residential	B	1	67	**66**	61	**5**	Y
Wall 1B								
1020	Residential	B	1	67	**66**	61	**5**	Y
1021	Residential	B	1	67	**66**	59	**7**	Y
1022	Residential	B	1	67	65	58	**7**	Y
1023	Residential	B	1	67	65	60	**5**	Y
1024	Residential	B	1	67	63	61	2	
1025	Residential	B	1	67	62	61	1	
1026	Residential	B	1	67	60	59	1	
Wall 2								
2001	Residential	B	1	67	**68**	63	**5**	Y
2002	Residential	B	1	67	**68**	62	**5**	Y
2003	Residential	B	1	67	**67**	61	**7**	Y
2004	Residential	B	1	67	**68**	60	**7**	Y
2005	Residential	B	1	67	**68**	60	**8**	Y
2006	Residential	B	1	67	**68**	60	**8**	Y
2007	Residential	B	1	67	**68**	59	**9**	Y
2008	Residential	B	1	67	**68**	59	**9**	Y
2009	Residential	B	1	67	**68**	58	**10**	Y
2010	Residential	B	1	67	**68**	58	**10**	Y
2011	Residential	B	1	67	**68**	58	**10**	Y
2012	Residential	B	1	67	**68**	59	**10**	Y
2013	Residential	B	1	67	**68**	60	**9**	Y
2014	Residential	B	1	67	**68**	60	**8**	Y
2015	Residential	B	1	67	**69**	60	**8**	Y
2016	Residential	B	1	67	**69**	60	**9**	Y
2017	Residential	B	1	67	**69**	59	**10**	Y
2018	Residential	B	1	67	**69**	59	**10**	Y
2019	Residential	B	1	67	**70**	60	**10**	Y
2020	Residential	B	1	67	**70**	61	**9**	Y
2021	Residential	B	1	67	**70**	62	**8**	Y
2022	Residential	B	1	67	**71**	63	**8**	Y
2023	Residential	B	1	67	61	59	2	
2024	Residential	B	1	67	61	59	3	

Receptor Number	Land Use	Category	Units	FHWA/MDOT NAC	Build	Noise Level w/Barr	Noise Reduction	Benefit?
2025	Residential	B	1	67	62	59	3	
2026	Residential	B	1	67	62	59	3	
2027	Residential	B	1	67	62	58	4	
2028	Residential	B	1	67	62	58	4	
2029	Residential	B	1	67	58	57	1	
2030	Residential	B	1	67	59	58	1	
2031	Residential	B	1	67	59	58	1	
2032	Residential	B	1	67	60	59	1	
2033	Residential	B	1	67	60	60	0	
2034	Residential	B	1	67	62	61	1	
2035	Residential	B	1	67	58	58	0	
2036	Residential	B	1	67	57	57	1	
2037	Residential	B	1	67	57	59	0	
2038	Residential	B	1	67	50	56	0	
2039	Residential	B	1	67	48	51	0	
2040	Residential	B	1	67	52	54	0	
2041	Residential	B	1	67	49	48	1	
2042	Residential	B	1	67	54	52	1	
2043	Residential	B	1	67	57	54	3	
2044	Residential	B	1	67	50	52	0	
2045	Residential	B	1	67	50	54	0	
2046	Residential	B	1	67	46	52	0	
Wall 3A								
3142	Residential	B	1	67	57	55	2	
3143	Residential	B	1	67	57	55	2	
3144	Residential	B	1	67	57	56	2	
3145	Residential	B	1	67	56	55	1	
3146	Residential	B	1	67	62	58	**5**	Y
3147	Residential	B	1	67	65	59	**6**	Y
3153	Residential	B	1	67	56	53	2	
3154	Residential	B	1	67	57	54	3	
3155	Residential	B	1	67	58	55	4	
3156	Residential	B	1	67	60	56	**5**	Y
3157	Residential	B	1	67	62	56	**6**	Y
3158	Residential	B	1	67	**66**	57	**9**	Y
3242	Residential	B	1	67	61	58	2	
3243	Residential	B	1	67	61	59	2	
3244	Residential	B	1	67	61	59	2	
3245	Residential	B	1	67	59	59	1	
3246	Residential	B	1	67	65	61	4	
3247	Residential	B	1	67	**67**	61	**6**	Y
3253	Residential	B	1	67	61	59	2	
3254	Residential	B	1	67	62	59	3	
3255	Residential	B	1	67	63	60	3	
3256	Residential	B	1	67	64	60	4	
3257	Residential	B	1	67	65	60	**5**	Y
3258	Residential	B	1	67	**68**	60	**8**	Y
Wall 3B								
3101	Residential	B	1	67	55	53	2	
3102	Residential	B	1	67	55	53	2	

Receptor Number	Land Use	Category	Units	FHWA/MDOT NAC	Build	Noise Level w/Barr	Noise Reduction	Benefit?
3103	Residential	B	1	67	55	53	2	
3104	Residential	B	1	67	55	53	2	
3105	Residential	B	1	67	56	53	3	
3106	Residential	B	1	67	55	53	2	
3107	Residential	B	1	67	56	54	3	
3108	Residential	B	1	67	56	53	3	
3109	Residential	B	1	67	57	52	4	
3110	Residential	B	1	67	58	52	**6**	Y
3111	Residential	B	1	67	56	52	3	
3112	Residential	B	1	67	56	53	3	
3113	Residential	B	1	67	**69**	60	**9**	Y
3114	Residential	B	1	67	**66**	56	**10**	Y
3115	Residential	B	1	67	65	55	**9**	Y
3116	Residential	B	1	67	63	55	**8**	Y
3117	Residential	B	1	67	62	54	**8**	Y
3118	Residential	B	1	67	61	54	**7**	Y
3119	Residential	B	1	67	54	52	2	
3120	Residential	B	1	67	54	53	2	
3121	Residential	B	1	67	54	53	2	
3122	Residential	B	1	67	55	53	2	
3123	Residential	B	1	67	57	56	1	
3124	Residential	B	1	67	60	59	1	
3125	Residential	B	1	67	58	56	2	
3126	Residential	B	1	67	56	55	2	
3127	Residential	B	1	67	56	54	2	
3128	Residential	B	1	67	55	53	2	
3129	Residential	B	1	67	55	53	2	
3130	Residential	B	1	67	54	53	2	
3131	Residential	B	1	67	54	52	2	
3132	Residential	B	1	67	55	53	2	
3133	Residential	B	1	67	55	53	1	
3134	Residential	B	1	67	55	54	2	
3135	Residential	B	1	67	56	55	2	
3136	Residential	B	1	67	57	56	2	
3201	Residential	B	1	67	58	55	3	
3202	Residential	B	1	67	58	56	3	
3203	Residential	B	1	67	58	55	3	
3204	Residential	B	1	67	59	56	3	
3205	Residential	B	1	67	59	56	4	
3206	Residential	B	1	67	59	55	3	
3207	Residential	B	1	67	60	56	4	
3208	Residential	B	1	67	60	56	**5**	Y
3209	Residential	B	1	67	61	56	**6**	Y
3210	Residential	B	1	67	62	55	**8**	Y
3211	Residential	B	1	67	60	55	4	
3212	Residential	B	1	67	61	57	4	
3213	Residential	B	1	67	**70**	62	**8**	Y
3214	Residential	B	1	67	**68**	59	**9**	Y
3215	Residential	B	1	67	**67**	59	**9**	Y
3216	Residential	B	1	67	**66**	58	**9**	Y

Receptor Number	Land Use	Category	Units	FHWA/MDOT NAC	Build	Noise Level w/Barr	Noise Reduction	Benefit?
3217	Residential	B	1	67	**66**	57	**8**	Y
3218	Residential	B	1	67	65	56	**8**	Y
3219	Residential	B	1	67	57	56	1	
3220	Residential	B	1	67	58	57	1	
3221	Residential	B	1	67	58	57	1	
3222	Residential	B	1	67	59	58	1	
3223	Residential	B	1	67	61	60	1	
3224	Residential	B	1	67	63	62	1	
3225	Residential	B	1	67	62	60	2	
3226	Residential	B	1	67	61	59	2	
3227	Residential	B	1	67	59	58	2	
3228	Residential	B	1	67	58	57	1	
3229	Residential	B	1	67	58	56	2	
3230	Residential	B	1	67	58	56	2	
3231	Residential	B	1	67	57	56	2	
3232	Residential	B	1	67	58	56	2	
3233	Residential	B	1	67	58	57	1	
3234	Residential	B	1	67	59	57	2	
3235	Residential	B	1	67	60	59	2	
3236	Residential	B	1	67	62	60	2	
3259	Residential	B	1	67	56	55	0	
3301	Residential	B	1	67	56	56	0	
3302	Residential	B	1	67	56	56	0	
3303	Residential	B	1	67	57	56	0	
3304	Residential	B	1	67	58	57	0	
3305	Residential	B	1	67	59	59	0	
3306	Residential	B	1	67	58	58	0	
3307	Residential	B	1	67	58	58	0	
3308	Residential	B	1	67	58	58	0	
3309	Residential	B	1	67	58	57	0	
3310	Residential	B	1	67	57	57	0	
3311	Residential	B	1	67	57	57	0	
3312	Residential	B	1	67	60	60	0	
3313	Residential	B	1	67	59	59	0	
3314	Residential	B	1	67	59	59	0	
3315	Residential	B	1	67	59	59	0	
3316	Residential	B	1	67	58	58	0	
3317	Residential	B	1	67	57	57	0	
3318	Residential	B	1	67	53	53	0	
3319	Residential	B	1	67	52	52	0	
3320	Residential	B	1	67	52	52	0	
3321	Residential	B	1	67	52	52	0	
3322	Residential	B	1	67	52	52	0	
3323	Residential	B	1	67	55	55	0	
3324	Residential	B	1	67	55	55	0	
3325	Residential	B	1	67	55	55	1	
3326	Residential	B	1	67	55	54	1	
3327	Residential	B	1	67	55	54	1	
3328	Residential	B	1	67	54	54	1	
3329	Residential	B	1	67	54	53	1	

Receptor Number	Land Use	Category	Units	FHWA/MDOT NAC	Build	Noise Level w/Barr	Noise Reduction	Benefit?
3330	Residential	B	1	67	54	54	1	
3331	Residential	B	1	67	54	54	1	
3332	Residential	B	1	67	54	54	1	
3333	Residential	B	1	67	55	53	1	
3334	Residential	B	1	67	55	53	2	
3335	Residential	B	1	67	55	54	2	
3336	Residential	B	1	67	55	54	2	
3337	Residential	B	1	67	56	54	2	
3338	Residential	B	1	67	56	54	2	
3339	Residential	B	1	67	55	53	2	
3340	Residential	B	1	67	55	53	2	
3341	Residential	B	1	67	55	53	2	
3342	Residential	B	1	67	56	53	3	
3343	Residential	B	1	67	**69**	64	**5**	Y
3344	Residential	B	1	67	**66**	60	**7**	Y
3345	Residential	B	1	67	65	58	**7**	Y
3346	Residential	B	1	67	63	56	**7**	Y
3347	Residential	B	1	67	64	57	**7**	Y
3348	Residential	B	1	67	**66**	59	**7**	Y
3349	Residential	B	1	67	64	63	0	
3350	Residential	B	1	67	63	63	0	
3351	Residential	B	1	67	63	62	0	
3352	Residential	B	1	67	63	62	1	
3353	Residential	B	1	67	62	62	1	
3354	Residential	B	1	67	62	62	1	
Wall 7								
7001	Residential	B	1	67	**68**	61	**7**	Y
7002	Residential	B	1	67	65	58	**7**	Y
7003	Residential	B	1	67	64	60	4	
7004	Residential	B	1	67	**69**	62	**7**	Y
7005	Residential	B	1	67	**75**	62	**13**	Y
Wall 8								
8001	Residential	B	1	67	**68**	60	**8**	Y
8002	Residential	B	1	67	65	58	**7**	Y
8003	Residential	B	1	67	**71**	61	**10**	Y