Traffic Noise Study

NE 238th Drive Improvement Project:

NE Halsey Street to NE Glisan Street
Gresham, Oregon

July 2018

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EXECUTIVE SUMMARY

Multnomah County requested a noise analysis for planned improvements along NE 238th Drive from the vicinity of NE Arata Road to NE Glisan Street. Currently, this segment of NE 238th Drive is constrained with narrow travel lanes, no bicycle lanes, a narrow sidewalk and tight roadway geometry that prohibits use by trucks over 40 feet in length. The proposed improvements include widening the northbound lane to 15 feet and the southbound climbing and passing lanes to 14 feet and 12 feet, respectively. A 10-foot wide shared-use path would be installed along with other general improvements such as landscaping, drainage and illumination. The project would also include a 36 inch tall traffic safety barrier at the back of the path along the east side of NE 238th Drive, providing some acoustical shielding to the multi-family units at the Treehill condominiums. Construction is anticipated in summer 2019.

Traffic Noise Analysis using Federal Highway Administration (FHWA) and Oregon Department of Transportation (ODOT) regulations are only required if a project meets FHWA Type I requirements and is federally funded or requires FHWA approval. A Type I project is a project that includes construction of a new highway or roadway; an increase in the number of through-traffic lanes; and / or, a substantial realignment (horizontal or vertical) of an existing highway. The proposed NE 238th project would not add any through lanes and the slight realignment is not considered substantial under FHWA policy. Therefore, there is no Federal or State requirement for a traffic noise study for this project. However, the County requested a noise report to gain an understanding of existing traffic noise levels and future traffic noise levels, without (No-Build Alternative) and with (Build Alternative) the proposed improvements.

Land use in the project area includes single-family dwelling units, one park area and commercial uses. On-site noise monitoring and traffic counts were performed and used to verify the noise modeling and assist in establishing the existing noise environment. Noise levels were measured at or near outdoor noise-sensitive land uses. Measured noise levels ranged from 52 to 69 dBA Leq during the monitoring sessions.

For Federal and State projects in Oregon, the level at which traffic noise abatement measures (Noise Abatement Criteria; NAC) should be investigated is 65 dBA Leq for outdoor use at residence and parks. Receivers are also considered impacted when the worst hourly traffic noise is predicted to increase 10 dBA or more between the Existing and Build conditions ("substantial increase"). The noise analysis was performed for the peak traffic hour of the day, which is between 5:00 p.m. to 6:00 pm.

Existing conditions, 2040 No-Build Alternative and 2040 Build Alternative noise levels were predicted for the peak noise hour using the FHWA Traffic Noise Model (TNM version 2.5). The four monitoring sites were used to validate the traffic noise model. Using the validated model, traffic noise levels were modeled for 32 receiver locations, representative of 113 residences and one park within the project corridor.

Existing traffic noise levels at the 32 modeling sites range from 54 to 73 dBA Leq, and there are currently 34 residences where traffic noise levels were predicted to be at or above the 65 dBA NAC. Under the 2040 No-Build Alternative, noise levels would increase by about 1 dB with the expected growth in traffic volumes, ranging from 55 to 74 dBA Leq. Under the No-Build Alternative, there are an additional two residences predicted to have noise levels meeting the NAC, bringing the total affected residences to 36.

Under the 2040 Build Alternative traffic noise levels are predicted to change by -1 dB to +2 dB when compared to the existing noise levels. The increases in traffic noise levels are a result of the expected growth in traffic volumes, the increase in heavy truck traffic usage, and realignment of the roadway. The slight reduction in noise levels at some sites is due to the inclusion of a 36 inch traffic safety barrier and the realignment of the roadway slightly farther away from some residences between NE Shannon and NE Oregon Streets. The number of residences predicted to meet the NAC under the Build Alternative is the same as under the No-Build Alternative, 36, an increase of 2 over existing conditions.

Because the project is not an FHWA Type 1 project, no detailed noise abatement analysis was performed. However, descriptions of typical noise mitigation and noise reducing design options, along with general information on different types of noise mitigation measures available were provided for reference. It is important to note that even if the project did meet the requirements for consideration noise mitigation, providing noise mitigation for this project would be very difficult. The project corridor has several issues that complicate any application of noise mitigation, including topographic conditions, safety and site distances considerations, and openings for driveways, streets and pedestrian access. Details on these issues are provided under Traffic Noise Mitigation Considerations.

Finally, it is important to note that an average person requires at least a 3 dB or more increase in traffic noise levels to perceive an increase in noise levels. The change in traffic noise over the existing conditions of -1 to +2 dB, and -1 to +1 when compared to the No-Build conditions, would not be noticeable to the majority of people. Simply stated, the change in noise levels with, or without the project are not sufficient for the vast majority of people to even notice any difference in the overall traffic noise levels.

A discussion of construction noise and potential construction noise abatement measures is included in Section 9. Supporting documentation used in preparation of this report is in Appendix A.

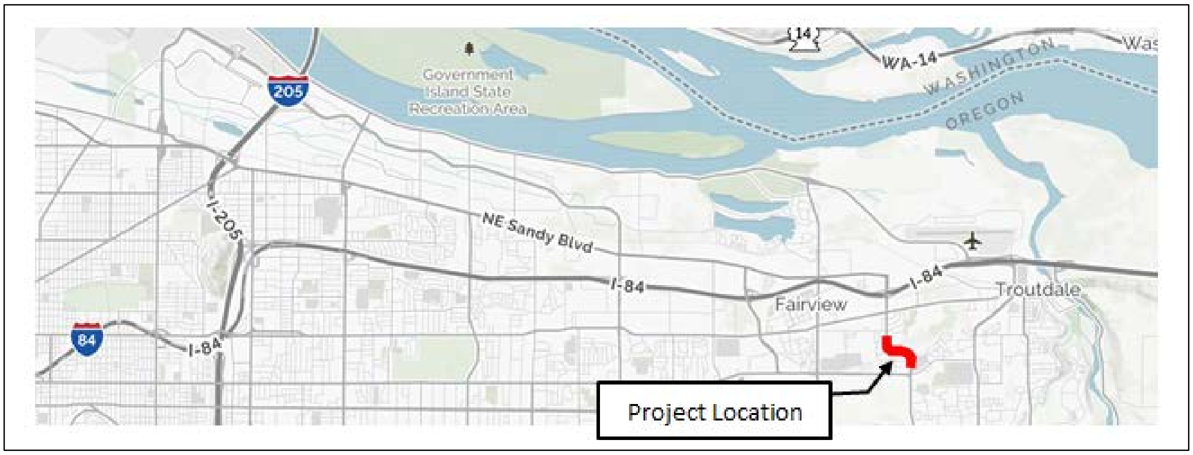
1. INTRODUCTION

This traffic noise study was prepared at the request of Multnomah County. The purpose of this study is to provide an understanding of the existing and future traffic noise levels with and without the proposed project. Supporting documentation used in preparation of this report is in Appendix A.

2. PROJECT DESCRIPTION

The NE 238th Drive Project for Multnomah County completes a link between I-84 and US26 for the East County regional freight network as well as improving bicycle and pedestrian facilities serving the Wood Village community. An overview of the project area is shown in Figure 1.

Figure 1. Project Vicinity Map



This existing segment of NE 238th Drive is a constrained corridor with narrow travel lanes, no bicycle lanes, one narrow sidewalk, steep side slopes, and tight roadway geometry that prohibits use by trucks over 40 feet in length. The current configuration throughout most of the corridor is three lanes, with two lanes southbound and one lane northbound. South of NE Oregon Street, there are two lanes in each direction with left turn lanes at NE Glisan Street.

The proposed improvements include widening the northbound lane to 15 feet and the southbound climbing and passing lanes to 14 feet and 12 feet, respectively; 10-foot wide shared-use paths on both sides of the road; improved drainage and added water quality facilities; retaining walls; landscaping; and illumination. Construction is anticipated to occur in summer 2019.

3. LAND USE

Land use in the project area includes single-family and multi-family dwelling units along with commercial and retail uses. Single-family residential land uses are located along both sides of NE 238th Drive, with several multi-family structures on the west side of the roadway, just south of NE Arata Road. The Treehill Condominiums complex is located on the east side of NE 238th Drive, with several multi-family buildings located below NE 238th Drive as it climbs uphill toward NE Glisan Street. Area land uses are shown with the noise monitoring sites in Figure 6 in Section 5.3.

3.1. Planned Zoning and Land Use

A study of the project area indicated that there are no new residential or commercial developments under way in the vicinity of the project.

3.2. Displacements Due to Project Construction

There are no displacements anticipated as a result of this project.

4. METHODOLOGY

This section provides details on the methods used for the Traffic Noise Analysis. Included is a section describing when a noise study is required under FHWA regulations and a brief introduction to acoustics, with more detailed information on acoustics provided in Appendix B. Also provided is information on the Federal Highway Administration (FHWA) regulations as applicable in Oregon from the Oregon Department of Transportation (ODOT), along with modeling procedures and source data used for the analysis. Finally, local regulations, which are applicable to project construction, are provided for reference.

4.1. Analysis Requirement

A Traffic Noise Analysis is required whenever a Type I project is federally funded or requires FHWA approval. A Type I project is a project that includes one or more of the following elements:

1. The construction of a highway on a new location; or,
2. The physical alteration of an existing highway where there is either:
    a. Substantial Horizontal Alteration. A project that halves the distance between the traffic noise source and the closest receptor from the existing condition to the future build condition;
    b. Substantial Vertical Alteration. A project that removes shielding, therefore, exposing the line-of-sight between the receptor and the traffic noise source. This is done by either altering the vertical alignment of the highway or by altering the topography between the highway traffic noise source and the receptor; or
3. The addition of a through-traffic lane(s). This includes the addition of a through-traffic lane that functions as an HOV lane, High-Occupancy Toll (HOT) lane, bus lane, or truck climbing lane; or,
4. The addition of an auxiliary lane, except for when the auxiliary lane is a turn lane; or,
5. The addition or relocation of interchange lanes or ramps added to a quadrant to complete an existing partial interchange; or,

6. Restriping existing pavement for the purpose of adding a through-traffic lane or an auxiliary lane; or,
7. The addition of a new or substantial alteration of a weigh station, rest stop, ride-share lot or toll plaza.

If a project is determined to be a Type I project under this definition then the entire project area as defined in the environmental document is a Type I.

The proposed project, while widening the roadway to better accommodate truck traffic and adding shared-use paths on both sides of the road, does not meet any of the requirements under the FHWA regulations. The project widening for wider travel lanes was reviewed and did not meet the “halving the distance” requirement under FHWA item 2 above. The shared-use paths and other improvements are also not triggers for an FHWA Type 1 noise study. Therefore, the project does not meet the criteria of a Type 1 project and there is no requirement for a technical noise impacts and abatement analysis.

The main purpose of this study is to provide an understanding of the existing and future noise levels along the corridor and what change in noise levels is predicted as a result of the revised traffic lanes. To aid in this effort, the FHWA Traffic Noise Model was used to provide modeling results of the existing conditions, future No-Build conditions and the future conditions with the proposed project. Details on this effort are provided, along with information to aid in the understanding of acoustics, are provided in the following sections.

4.2. Introduction to Acoustics

Noise is generally defined as unwanted sound. Noise is measured in terms of sound pressure level, and is expressed in decibels (dB), which is a conversion of pressure to a measurement system more applicable to human reaction to noise. Because the human ear is less sensitive to higher and lower frequencies than to mid-range frequencies, noise measurements incorporate a weighing system that filters out higher and lower frequencies in a manner similar to the human ear. This system produces noise measurements that approximate the normal human perception of noise, and are termed "A-weighted" and are specified as "dBA" readings.

In most neighborhoods, nighttime noise levels are noticeably lower than daytime noise levels. In a quiet rural area at night, noise levels from crickets or winds rustling leaves on the trees can range between 32 and 35 dBA. As residents start their day and local traffic increases, the same rural area can have noise levels ranging from 50 to 60 dBA. While noise levels in urban neighborhoods are louder than rural areas, they share the same pattern of lower noise levels at night than during the day. Quiet urban nighttime noise levels range from 40 to 50 dBA. Noise levels during the day in a noisy urban area are frequently as high as 70 to 80 dBA. Table 1 provides a summary of some common noise sources and compares their relative loudness to that of an 80 dBA source, such as a garbage disposal or food blender.

Table 1. Sound Levels and Relative Loudness of Typical Noise Sources			
Noise Source or Activity	**Sound Level (dBA)**	**Subjective Impression**	**Relative Loudness (human judgment of different sound levels)**
Jet aircraft takeoff from carrier (50 feet)	140	Threshold of pain	64 times as loud
50-horse power siren (100 feet)	130		32 times as loud
Loud rock concert near stage, Jet takeoff (200 feet)	120	Uncomfortably loud	16 times as loud
Float plane takeoff (100 feet)	110		8 times as loud
Jet takeoff (2,000 feet)	100	Very loud	4 times as loud
Heavy truck or motorcycle (25 feet)	90		2 times as loud
Garbage disposal, food blender (2 feet), Pneumatic drill (50 feet)	80	Moderately loud	Reference loudness
Vacuum cleaner (10 feet), Passenger car at 65 mph (25 feet)	70		1/2 as loud
Large store air-conditioning unit (20 feet)	60		1/4 as loud
Light auto traffic (100 feet)	50	Quiet	1/8 as loud
Bedroom or quiet living room Bird calls	40		1/16 as loud
Quiet library, soft whisper (15 feet)	30	Very quiet	
High quality recording studio	20		
Acoustic Test Chamber	10	Just audible	
	0	Threshold of hearing	

Sources: Beranek (1988) and U.S. EPA (1971).

Leq: ***The Leq is an energy average noise level, in dBA, for a specific time period, and is also one of the most widely used noise level metrics.***

Noise levels from most sources tend to vary with time. The quietest one second, or minimum noise level during a measurement period, is denoted Lmin. The maximum noise levels (Lmax) is the loudest one second during a measurement period, such as the passing of a heavy truck. To account for the variance in noise levels over time, a common noise measurement is the equivalent sound pressure level, denoted Leq. The Leq is defined as the energy average noise level, in dBA, for a specific time period (typically 1 hour).

Noise levels decrease with distance from a noise source. For traffic noise on a busy roadway or highway, the Leq noise levels typically decrease by 3 dBA for each doubling of distance. Additional attenuation of noise can occur if there are objects between the receiver and the source, and noise transmissions are also affected by the type of ground cover.

Existing structures and topography, including existing hills and other surface features, between the noise source and receiver location can substantially affect noise levels. A row of buildings between the receiver and the source can reduce noise by 5 to 7 dB or more. Dense foliage can affect noise levels. Studies have shown that locations with at least 100 feet of dense evergreen foliage can see noise reductions of 3 to 5 dB from traffic noise. However, under most circumstance, the actual reduction from foliage is less than 3 dB. As noted above, ground cover between the receiver and the noise source can also affect noise transmission. For example, sound will travel very well across reflective surfaces such as water and pavement, but can be attenuated when the ground cover is field grass, lawn, or even loose soil. Atmospheric conditions can also affect the transmission of noise; however they are rarely severe enough to result in noticeable changes in noise levels.

Important facts to remember when reviewing traffic noise levels and changes are:

- A 3 dB change is a barely perceptible increase to most people;
- A 5 dB change is usually perceptible to most everyone;
- A 10 dB change in noise level is judged by most people to be a doubling in the perceived loudness (e.g., an increase from 50 dBA to 60 dBA causes the loudness to double).

4.3. Modeling Procedures

Although this project is not a Type 1 project under FHWA criteria, the methodology for a Type I traffic noise analysis, as defined in the current ODOT 2011 Traffic Noise Manual was used for the study. This methodology is taken from the United States Department of Transportation (USDOT) Federal Highway Traffic Noise Standards (Title 23 of the Code of Federal Regulations (CFR) Part 772, *Procedures for Abatement of Highway Traffic Noise and Construction Noise*).

Projected traffic noise level conditions were calculated using the *FHWA Traffic Noise Model* (TNM version 2.5 - USDOT, 1998 and 2004). Prior to predicting the existing and future noise levels, the traffic noise model was verified using actual traffic counts and measured noise levels. Noise emission levels used in the model were based on nationwide averages for automobiles, medium trucks, and heavy trucks provided by the FHWA and built into the TNM. Model input included traffic volumes, and vehicle type and speed information.

Traffic volumes and vehicle class percentages used for the modeled roadways are taken from traffic projections provided by project traffic engineers for the existing year (2017) and future year (2040). The projections were provided with and without the proposed improvements. As would be expected, there is an increase in truck traffic when the existing conditions are compared to the future conditions.

Traffic counts used to validate the existing condition model are provided in Section 5, and field sheets of the monitoring sessions with traffic counts are provided in Appendix C. Traffic data used in the analysis is provided in Appendix D. The TNM files are provided, when requested, in electronic format as Appendix E. Note that in order to use the TNM files, a copy of the program must be obtained.

4.4. Regulatory Setting and Impact Criteria

The FHWA traffic noise impact criteria, against which the project traffic noise levels are evaluated, are taken from Title 23 of the Code of Federal Regulations (CFR) Part 772, Procedures for Abatement of Highway Traffic Noise and Construction Noise. The FHWA criterion applicable for residences is an exterior hourly equivalent sound level (Leq) that approaches or exceeds 67 dBA. The exterior criterion for places of worship, schools, recreational uses, and similar areas is also 67 dBA Leq. The criterion applicable for hotels, motels, offices, restaurants/bars, and other developed lands is an exterior Leq that approaches or exceeds 72 dBA. There are no FHWA traffic noise impact criteria for retail facilities, industrial uses, warehousing, undeveloped lands that are not permitted at the time of the analysis, or construction noise. No traffic noise analysis is required for those uses for which no criteria exist.

ODOT considers a predicted sound level of 2 dBA below the NAC as sufficient to satisfy the condition of *approaching the NAC*. Therefore, the impact criterion for residences is a noise level of 65 dBA. Receivers are also considered to have a noise impact if future traffic noise levels increase by 10 dBA (“substantial increase”) or more between the Existing and Build conditions. Table 2 summarizes the FHWA and the ODOT traffic noise abatement criteria. Note that these criteria are only applicable to federally funded projects that meet the FHWA definition for a Type 1 project, described in Section 4.2.

Table 2. Noise Abatement Criteria (NAC) by Land Use Category				
Activity Category	**Activity Criteria in hourly Leq (dBA)**		**Evaluation Location**	**Activity Description**
	FHWA NAC	**ODOT NAC**		
A	57	55	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[1]	67	65	Exterior	Residential (single and multi-family units)
C[1]	67	65	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	50	Interior	Auditoriums, day care centers, hospitals, libraries, medical facilities, places of worship, public meeting rooms, public or nonprofit institutional structures, radio studios, recording studios, schools, and television studios
E[1]	72	70	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

Notes:
1. Includes lands that are planned and permitted for this activity category

The primary FHWA category applicable to this analysis is Category B and C, which includes exterior noise levels at residential land uses and one park area at the Treehill Condominiums. There are no Category A, or E land uses located in the project corridor, and Category D is only used when the interior noise levels of a property are critical and is not applicable to this study. There are no noise criteria levels for Categories F and G.

4.4.1. Local Noise Regulations

The project is located along the eastern limits of the city of Wood Village, Oregon, with some commercial uses east of NE 238th Drive inside the city of Troutdale, Oregon. The city of Wood Village Municipal Code, Chapter 9.12 has a noise control ordinance that would apply to project construction. During weekday daytime hours of 7:00 am to 7:00 pm, construction noise is exempt. For construction outside these hours, a noise variance from the Wood Village City Manager would be required.

5. NOISE MONITORING

On-site noise monitoring and traffic counts were performed and used to verify the noise model and assist in establishing the existing noise environment. Noise levels were monitored at four sites. The sites are designated M1, M2, M3 and M4. Figures 2 through 5 include aerial views and photos showing the exact location of the monitoring sites. The monitoring sites and land use types are also identified on an aerial view of the entire project corridor in Figure 6.

Monitoring location M1 was chosen to verify noise levels at the residences near the top of the hillside on the west side of NE 238th Drive. Sites M-2 and M-3 are for the condominiums along the north side of NE 238th Drive, with some hillside shielding. Site M-4 is for single and multi-family residences along the gradual slope in the northern part of the corridor

The sound level meter used for the measurements was a Bruel & Kjaer Type 2238. The sound level meters meet or exceed American National Standards Institute (ANSI) S1.4-1983 for Type I Sound Measurement Devices. All measurement procedures complied with FHWA and ODOT methods for environmental noise measurements. System calibration was performed before and after each measurement session with a Bruel & Kjaer Type 4231 sound level calibrator.

Noise measurements and traffic counts were performed for 15 minutes at each of the monitoring locations. The traffic data was normalized to one hour by multiplying the traffic counts by a factor of four (4). Table 3 lists each monitoring location, time of the monitoring period, traffic counts and the measured noise level at that location. Due to lack of sight to the roadway, counts from M-1 were also used for M-2 and counts from M-4 were used for M-3.

Figure 2. Noise Monitoring Location: M1

Figure 3. Noise Monitoring Location: M2

Figure 4. Noise Monitoring Location: M3

Figure 5. Noise Monitoring Location: M4

Figure 6. Corridor Overview with Land Uses and Monitoring Sites

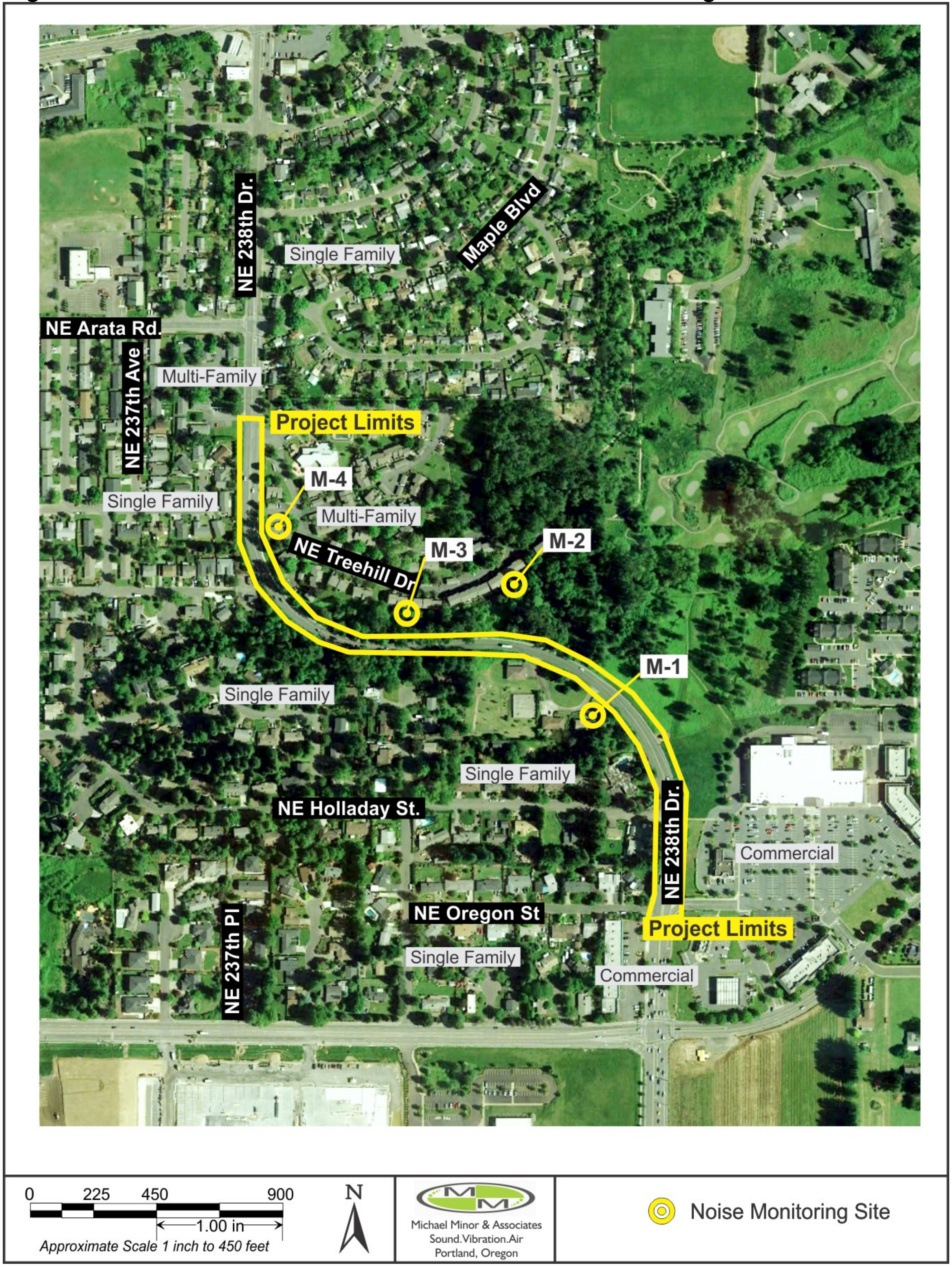


Table 3. Noise Monitoring and Contributing Roadway Traffic Counts							
Site No.	**Monitoring Location**	**Sound Level Measurement Period[1]**	**Traffic Counts Normalized to One (1) Hour[2]**				**Sound Level dBA[3]**
			NE 238th Dr Direction	**Cars**	**MT**	**HT**	
M1	1123 NE 238th Drive	11:46 am – 12:01 pm	Northbound	760	8	12	69.1
			Southbound	708	24	4	
M2	24070 NE Treehill Drive	12:26 pm – 12:41 pm	Northbound	760	8	12	52.1
			Southbound	708	24	4	
M3	24002 NE Treehill Drive	12:50 pm – 13:05 pm	Northbound	768	40	8	58.2
			Southbound	756	20	8	
M4	23804 NE Treehill Drive	1:21 pm – 1:36 pm	Northbound	768	40	8	66.9
			Southbound	756	20	8	

Notes:
1. Noise monitoring was performed on April 9, 2018.
2. Cars = passenger vehicles and light trucks (2 axels & 4 tires); MT = medium trucks (2 axels & 6 tires), such as FedEx delivery trucks; and HT = heavy trucks (3 or more axels), such as tractor trailers and dump trucks with elevated exhaust. There are no long haul trucks over 40 feet currently allowed on NE 238th Drive. There are no bus routes on NE 238th Drive. These are one-hour counts based on 15-minute periods.
3. One-hour Leq in dBA based on 15-minute measurement periods
4. Observed speeds during measurements: ~35 to 45 mph for all vehicles
5. Data sheets are provided in Appendix C

Traffic on NE 238th Drive was the dominant noise source at all locations in the corridor. There were no other notable noise sources besides traffic during the monitoring periods. Field monitoring sheets are provided in Appendix C.

5.1. Model Validation

Prior to performing the traffic noise analysis, the traffic noise levels were modeled to test the agreement of calculated and measured noise levels. Traffic volumes and speeds observed during the noise monitoring were used as input to the model. A comparison of the resulting data for the four (4) monitoring locations is contained in Table 4.

Table 4. Measured Versus Modeled Noise Levels			
Receiver	**Measured (dBA Leq)**	**Modeled (dBA Leq)**	**Difference (in dB)**
M1	69.1	67.9	-1.2
M2	52.1	52.0	-0.1
M3	58.2	59.6	+1.4
M4	66.9	67.0	+0.1

The modeled and measured noise results agree within -1.2 to +1.4 dB for the four monitoring locations. ODOT considers an agreement of +/- 2 dB or less to be acceptable for modeled and measured noise level deviations. The TNM modeling files are provided in Appendix E

5.2. Selection of Receivers

Existing and future noise levels were predicted using the TNM computer model. Figures 7 and 8 are aerial maps of the north and south project segments, and include the proposed project alignment, the 36 inch traffic safety barrier and the noise modeling locations used for this analysis. In total, 32receiver sites were modeled, representing 113 residences and one park space.

Receivers R-1 through R-7 represents single and multi-family residences in the north end of the corridor, between Arata Road and NE Stanley Street/NE Treehill Drive. These 7 modeling locations provide representative noise levels for 22 residential structures. Receivers R-8 through R-17 represents 60 residential units and one park space at the Treehill Condominiums. Finally, receivers R-18 through R-32 represent 30 single family residences on the north and west sides of NE 238th Drive, from NE Stanley Street/NE Treehill Drive to NE Oregon Street. All of the sites, except the park area at the Treehill Condominiums are FHWA Category B. The Treehill Condominiums park space is FHWA Category C.

All of the modeling locations represent a ground floor, typical outdoor use at the property. For residential land use, this is typically in the back yard. No modeling sites were placed at any of the nearby commercial uses because none are considered noise sensitive. Commercial uses, like those north of NE Glisan Street, are FHWA Category F, which has no NAC, or do not have an exterior noise sensitive use at the site.

Figure 7. Noise Modeling Sites: North End

Continued on next page

Figure 8. Noise Modeling Sites: South End

6. EXISTING CONDITIONS

The study area consists of single and multi-family residential uses, one park space and commercial uses. Traffic on NE 238th Drive is the dominate noise source for all modeling locations in the study area. North of the corridor, outside the study area, noise from NE Halsey Street and potentially from Interstate 84 could also be major contributors to the noise environment. South of the corridor, noise from NE Glisan Street and commercial activities are also predicted to affect the noise environment.

6.1. Existing Modeled Noise Levels

This section provides the noise modeling results for the peak-hour traffic noise. Modeling was performed for all 32 representative receiver locations shown on Figures 7 and 8. Table 5 provides a summary of the existing modeled traffic noise levels for the 32 receivers. A discussion of the results follows the table.

Table 5. Existing Modeled Traffic Noise Levels

Receiver[1]	Uses Rep[2]	Land Use Activity Category[3]	Land Use[4]	Sound Level in Leq(dBA)		Properties with Noise Levels => 65dBA[7]
				Criteria[5]	Existing[6]	
R-1	2	B	Res	65	**73**	2
R-2	2	B	Res	65	**68**	2
R-3	3	B	Res	65	62	0
R-4	4	B	Res	65	62	0
R-5	2	B	Res	65	**65**	2
R-6	3	B	Res	65	**69**	3
R-7	6	B	Res	65	60	0
R-8	4	B	Res	65	**68**	4
R-9	3	B/C	Res/PK	65	61	0
R-10	4	B	Res	65	**69**	4
R-11	2	B	Res	65	60	0
R-12	8	B	Res	65	**66**	8
R-13	8	B	Res	65	62	0
R-14	8	B	Res	65	60	0
R-15	8	B	Res	65	60	0
R-16	8	B	Res	65	56	0
R-17	8	B	Res	65	54	0
R-18	2	B	Res	65	**67**	2
R-19	4	B	Res	65	62	0
R-20	1	B	Res	65	57	0
R-21	1	B	Res	65	63	0
R-22	2	B	Res	65	60	0
R-23	3	B	Res	65	61	0
R-24	3	B	Res	65	**65**	3
R-25	3	B	Res	65	59	0

Table 5. Existing Modeled Traffic Noise Levels						
Receiver[1]	Uses Rep[2]	Land Use Activity Category[3]	Land Use[4]	Sound Level in Leq(dBA)		Properties with Noise Levels => 65dBA[7]
				Criteria[5]	Existing[6]	
R-26	2	B	Res	65	64	0
R-27	1	B	Res	65	**68**	1
R-28	1	B	Res	65	63	0
R-29	1	B	Res	65	**66**	1
R-30	2	B	Res	65	60	0
R-31	2	B	Res	65	61	0
R-32	2	B	Res	65	**67**	2

Notes:
1. All receivers are shown in Figures 7 and 8
2. Number of dwellings (or other uses) represented by each receiver
3. FHWA land use activity category designation
4. Land use: Res = Residential | PK = Park Area
5. ODOT traffic noise abatement criteria
6. Calculated peak-hour traffic noise levels in dBA Leq from FHWA TNM version 2.5, with noise levels that meet or exceed the NAC in **Bold-Red** typeface
7. The number of uses with noise levels that meet or exceed the NAC

The existing modeled noise levels in the project area range from 54 to 73 dBA Leq during the peak-hour traffic noise. Out of the 113 residences, 34 currently experience noise levels at or above 65 dBA Leq during peak hours. Nine receivers with levels at or above the NAC are located in the north section, between Arata Road and NE Stanley Street/NE Treehill Drive, where noise levels ranged from 60 to 73 dBA Leq.

In the Treehill Condominiums, there are an estimated 16 units with noise levels at or above the criteria, with levels ranging from 54 to 69 dBA Leq. Noise levels at the park are below the criteria. In the southern end of the corridor, south of NE Stanley Street/NE Treehill Drive, there are 9 residences with noise levels meeting the NAC, with noise levels of 57 to 68 dBA Leq.

7. FUTURE ENVIRONMENT

This section discusses the TNM analyses for the future year 2040 No-Build and Build Alternatives. The TNM inputs include Year 2040 traffic volumes and speeds prepared for this project.

7.1. Future No-Build Analysis

The same 32 noise modeling locations shown in Figures 7 and 8 that were used to model the existing conditions were used to model for the No-Build Alternative peak-hour traffic conditions. This section provides the noise modeling results for the No-Build conditions using traffic volumes projected for the Year 2040 with no changes to any of the roadways in the project corridor. Table 6 summarizes the future 2040 No-Build traffic noise levels for these 32 receivers. A discussion of the results follows the table.

Table 6. Future No-Build Modeled Traffic Noise Levels						
Receiver[1]	Uses Rep[2]	Land Use Activity Category[3]	Land Use[4]	Sound Level in Leq(dBA)		Properties with Noise Levels => 65dBA[7]
				Criteria[5]	No-Build[6]	
R-1	2	B	Res	65	**74**	2
R-2	2	B	Res	65	**69**	2
R-3	3	B	Res	65	63	0
R-4	4	B	Res	65	63	0
R-5	2	B	Res	65	**66**	2
R-6	3	B	Res	65	**70**	3
R-7	6	B	Res	65	61	0
R-8	4	B	Res	65	**69**	4
R-9	3	B/C	Res/PK	65	62	0
R-10	4	B	Res	65	**70**	4
R-11	2	B	Res	65	61	0
R-12	8	B	Res	65	**67**	8
R-13	8	B	Res	65	62	0
R-14	8	B	Res	65	61	0
R-15	8	B	Res	65	61	0
R-16	8	B	Res	65	57	0
R-17	8	B	Res	65	55	0
R-18	2	B	Res	65	**68**	2
R-19	4	B	Res	65	63	0
R-20	1	B	Res	65	58	0
R-21	1	B	Res	65	64	0
R-22	2	B	Res	65	61	0
R-23	3	B	Res	65	62	0
R-24	3	B	Res	65	**66**	3
R-25	3	B	Res	65	60	0
R-26	2	B	Res	65	**65**	2
R-27	1	B	Res	65	**68**	1
R-28	1	B	Res	65	64	0
R-29	1	B	Res	65	**67**	1
R-30	2	B	Res	65	60	0
R-31	2	B	Res	65	62	0
R-32	2	B	Res	65	**67**	2

Notes:

1. All receivers are shown in Figures 7 and 8.
2. Number of dwellings (or other uses) represented by each receiver
3. FHWA land use activity category designation
4. Land use: Res = Residential | PK = Park Area
5. ODOT traffic noise abatement criteria
6. Calculated peak noise hour levels in dBA Leq from FHWA TNM version 2.5, with noise levels that meet or exceed the NAC in **Bold-Red** typeface
7. The number of uses with noise levels that meet or exceed the NAC.

Under the 2040 No-Build Alternative, traffic noise levels are predicted to increase by 1 dBA above existing peak-hour traffic conditions in most locations due to projected growth in traffic volumes. The No-Build modeled noise levels would range from 55 to 74 dBA Leq. The number of residential units with noise levels at or above the NAC increased by 2, from 34 units under existing conditions to 36 units under the future No-Build conditions. The two new locations with levels above the criteria are represented by receiver R-26, where noise levels increased by 1 dB, from 64 dBA Leq to 65 dBA Leq.

7.2. Future Build Analysis

This section provides the noise modeling results for the Build Alternative. The same 32 receiver locations shown in Figures 7 and 8 that were used to model the existing conditions and No-Build Alternative were modeled for the Build Alternative peak-hour traffic conditions. The TNM inputs included the proposed roadway improvements and the projected Build Alternative Year 2040 traffic volumes and speeds.

As part of the project the roadway widening a 36 inch tall traffic safety barrier (TSB) would be installed along the east side of NE 238th Drive from just south of the entrance to Treehill Condos (between R-16 and R-18), ending just north of the commercial area (between R-34 and R-35). The barrier is identified on Figures 7 and 8. To show the benefit of the traffic barrier on the transmission of noise toward receivers in the Treehill condominiums, modeling was performed without and with the TSB.

Table 7 summarizes the future 2040 Build Alternative traffic noise levels without the TSB. Table 8 provides the levels with the TSB and also includes a comparison of the benefit the barrier provides. A discussion of the results follows the tables.

Table 7. Future Build Alternative Modeled Traffic Noise Levels
Modeled Noise Levels without the Traffic Safety Barrier

Receiver[1]	Uses Rep[2]	Land Use Activity Category[3]	Land Use[4]	Sound Level in Leq(dBA)		Properties with Noise Levels => 65dBA[7]
				Criteria[5]	Build[6]	
R-1	2	B	Res	65	**74**	2
R-2	2	B	Res	65	**69**	2
R-3	3	B	Res	65	64	0
R-4	4	B	Res	65	63	0
R-5	2	B	Res	65	**67**	2
R-6	3	B	Res	65	**71**	3
R-7	6	B	Res	65	62	0
R-8	4	B	Res	65	**69**	4
R-9	3	B/C	Res/PK	65	62	0
R-10	4	B	Res	65	**70**	4
R-11	2	B	Res	65	61	0
R-12	8	B	Res	65	**68**	8
R-13	8	B	Res	65	63	0
R-14	8	B	Res	65	62	0

Table 7. Future Build Alternative Modeled Traffic Noise Levels *Modeled Noise Levels without the Traffic Safety Barrier*						
Receiver[1]	**Uses Rep[2]**	**Land Use Activity Category[3]**	**Land Use[4]**	**Sound Level in Leq(dBA)**		**Properties with Noise Levels => 65dBA[7]**
				Criteria[5]	**Build[6]**	
R-15	8	B	Res	65	62	0
R-16	8	B	Res	65	57	0
R-17	8	B	Res	65	55	0
R-18	2	B	Res	65	**69**	2
R-19	4	B	Res	65	63	0
R-20	1	B	Res	65	58	0
R-21	1	B	Res	65	63	0
R-22	2	B	Res	65	61	0
R-23	3	B	Res	65	62	0
R-24	3	B	Res	65	**65**	3
R-25	3	B	Res	65	60	0
R-26	2	B	Res	65	**65**	2
R-27	1	B	Res	65	**67**	1
R-28	1	B	Res	65	63	0
R-29	1	B	Res	65	**67**	1
R-30	2	B	Res	65	60	0
R-31	2	B	Res	65	62	0
R-32	2	B	Res	65	**68**	2

Notes:
1. All receivers are shown in Figures 7 and 8
2. Number of dwellings (or other uses) represented by each receiver
3. FHWA land use activity category designation
4. Land use: Res = Residential | PK = Park Area
5. ODOT traffic noise abatement criteria
6. Calculated peak-hour noise levels in dBA Leq from FHWA TNM version 2.5, with noise levels that meet or exceed the NAC in **Bold-Red** typeface
7. The number of uses with noise levels that meet or exceed the NAC

Table 7. Future Build Alternative Modeled Traffic Noise Levels *Modeled Noise Levels with the Traffic Safety Barrier*						
Receiver[1]	**Uses Rep[2]**	**Criteria[5]**	**Sound Level in Leq(dBA)**		**TSB Reduction**	**Properties with Noise Levels => 65dBA[7]**
			Without TSB	**With TSB**		
R-1	2	65	**74**	**74**	0	2
R-2	2	65	**69**	**69**	0	2
R-3	3	65	64	64	0	0
R-4	4	65	63	63	0	0
R-5	2	65	**67**	**67**	0	2

Table 7. Future Build Alternative Modeled Traffic Noise Levels *Modeled Noise Levels with the Traffic Safety Barrier*						
Receiver[1]	**Uses Rep[2]**	**Criteria[5]**	**Sound Level in Leq(dBA)**		**TSB Reduction**	**Properties with Noise Levels => 65dBA[7]**
			Without TSB	**With TSB**		
R-6	3	65	**71**	**71**	0	3
R-7	6	65	62	62	0	0
R-8	4	65	**69**	**69**	0	4
R-9	3	65	62	62	0	0
R-10	4	65	**70**	**70**	0	4
R-11	2	65	61	60	-1	0
R-12	8	65	**68**	**66**	-2	8
R-13	8	65	63	61	-2	0
R-14	8	65	62	60	-2	0
R-15	8	65	62	59	-3	0
R-16	8	65	57	55	-2	0
R-17	8	65	55	53	-2	0
R-18	2	65	**69**	**69**	0	2
R-19	4	65	63	63	0	0
R-20	1	65	58	58	0	0
R-21	1	65	63	63	0	0
R-22	2	65	61	61	0	0
R-23	3	65	62	62	0	0
R-24	3	65	**65**	**65**	0	3
R-25	3	65	60	60	0	0
R-26	2	65	**65**	**65**	0	2
R-27	1	65	**67**	**67**	0	1
R-28	1	65	63	63	0	0
R-29	1	65	**67**	**67**	0	1
R-30	2	65	60	60	0	0
R-31	2	65	62	62	0	0
R-32	2	65	**68**	**68**	0	2

Notes:
1. All receivers are shown in Figures 7 and 8
2. Number of dwellings (or other uses) represented by each receiver
3. FHWA land use activity category designation
4. Land use: Res = Residential | PK = Park Area
5. ODOT traffic noise abatement criteria
6. Calculated peak-hour noise levels in dBA Leq from FHWA TNM version 2.5, with noise levels that meet or exceed the NAC in **Bold-Red** typeface
7. The number of uses with noise levels that meet or exceed the NAC

The 2040 Build Alternative modeled noise levels would range from 55 to 74 dBA Leq without the TSB, and 53 to 74 dBA with the TSB. The same 36 receivers that would have noise levels meeting or exceeding the NAC under the No-Build Alternative would be affected under the Build Alternative. The TSB has no effect on the number of units with levels at or above the NAC.

Under the 2040 Build Alternative (with the TSB), traffic noise levels are predicted to increase by up to 2 dBA when compared to the existing noise levels. Due to the TSB and the realignment of the roadway to the north and east, some receivers have a slight reduction in noise levels of -1 dB over existing and -2 dB over the No-Build alternative. In general, the traffic noise levels would increase with expected growth in traffic volumes and the increase in heavy truck traffic. Currently, heavy trucks with lengths of over 40 feet are prohibited south of NE Halsey and north of NE Glisan Street.

Noise levels at receivers in the north end of the study area (R-1 to R-7) have increases of 1 to 2 dB over existing, with nine residences experiencing noise levels above the 65 dBA Leq criteria. These same nine receivers currently experience noise levels at or above the criteria.

In the Treehill Condominiums, 16 units currently meet or exceed the criteria, and with the proposed project, no change in this number is predicted (see R-8 to R-17). Noise levels in the Treehill condominiums are predicted to change by -1 to +1 dB over existing noise levels and 0 to -2 dB over the No-Build conditions. The noise reduction of up to 2 dB is due to the shieling effect of the TSB.

In the south-east section of the corridor, represented by receivers R-18 through R-32, there is very little change predicted in the overall traffic noise levels. Compared to the existing and No-Build conditions, noise levels are predicted to change by -1 to +1 dB at all receivers except R-18. Future Build noise levels at R-18 increase by 2 dB over existing levels. Receivers R-21, R-24, R-27 and R-28 are predicted to have Build conditions noise levels that are 1 dB lower than the No-Build conditions due to the roadway realignment. The same 11 residences expected to have noise levels at or above the NAC under the No-Build Alternative are expected to have noise levels at or above the NAC under the Build Alternative.

7.3. Noise Levels Summary

Table 8 provides a full summary of existing, 2040 No-Build Alternative, and 2040 Build Alternative with the TSB noise levels for all 32 receivers. It is important to remember that it typically takes a 3 dB change in traffic noise levels for an average person to discern a difference. The largest increase in future noise levels are predicted to range from 1 to 2 dB, and therefore would not be noticeable to the average person. Although the corridor will now accept trucks over 40 feet in length, the overall increase in traffic volumes and the number of heavy trucks results in only a very slight increase in the overall noise levels.

Table 8. Summary and Comparison of Traffic Noise Levels											
Rec Num[1]	Uses[2]	NAC[3]	Existing Conditions		No-Build Alternative			Build Alternative with TSB			
			Level[4]	=> 65dBA[5]	Level[4]	=> 65dBA[5]	Chg vs. Ext[6]	Level[4]	=> 65dBA[5]	Chg vs. Ext[7]	Chg vs. No-Bld[8]
R-1	2	65	**73**	2	**74**	2	1	**74**	2	1	0
R-2	2	65	**68**	2	**69**	2	1	**69**	2	1	0
R-3	3	65	62	0	63	0	1	64	0	2	1
R-4	4	65	62	0	63	0	1	63	0	1	0
R-5	2	65	**65**	2	**66**	2	1	**67**	2	2	1
R-6	3	65	**69**	3	**70**	3	1	**71**	3	2	1
R-7	6	65	60	0	61	0	1	62	0	2	1
R-8	4	65	**68**	4	**69**	4	1	**69**	4	1	0
R-9	3	65	61	0	62	0	1	62	0	1	0
R-10	4	65	**69**	4	**70**	4	1	**70**	4	1	0
R-11	2	65	60	0	61	0	1	60	0	0	-1
R-12	8	65	**66**	8	**67**	8	1	**66**	8	0	-1
R-13	8	65	62	0	62	0	0	61	0	-1	-1
R-14	8	65	60	0	61	0	1	60	0	0	-1
R-15	8	65	60	0	61	0	1	59	0	-1	-2
R-16	8	65	56	0	57	0	1	55	0	-1	-2
R-17	8	65	54	0	55	0	1	53	0	-1	-2
R-18	2	65	**67**	2	**68**	2	1	**69**	2	2	1
R-19	4	65	62	0	63	0	1	63	0	1	0
R-20	1	65	57	0	58	0	1	58	0	1	0
R-21	1	65	63	0	64	0	1	63	0	0	-1
R-22	2	65	60	0	61	0	1	61	0	1	0
R-23	3	65	61	0	62	0	1	62	0	1	0
R-24	3	65	**65**	3	**66**	3	1	**65**	3	0	-1
R-25	3	65	59	0	60	0	1	60	0	1	0
R-26	2	65	64	0	**65**	2	1	**65**	2	1	0
R-27	1	65	**68**	1	**68**	1	0	**67**	1	-1	-1
R-28	1	65	63	0	64	0	1	63	0	0	-1
R-29	1	65	**66**	1	**67**	1	1	**67**	1	1	0

Table 8. Summary and Comparison of Traffic Noise Levels

Rec Num[1]	Uses[2]	NAC[3]	Existing Conditions		No-Build Alternative			Build Alternative with TSB			
			Level[4]	=> 65dBA[5]	Level[4]	=> 65dBA[5]	Chg vs. Ext[6]	Level[4]	=> 65dBA[5]	Chg vs. Ext[7]	Chg vs. No-Bld[8]
R-30	2	65	60	0	60	0	0	60	0	0	0
R-31	2	65	61	0	62	0	1	62	0	1	0
R-32	2	65	**67**	2	**67**	2	0	**68**	2	1	1
Overall Minimum			**54**		**55**		**0**	**53**		**-1**	**-1**
Overall Maximum			**73**		**74**		**1**	**74**		**2**	**1**
Number Meeting NAC				**34**		**36**			**36**		

Notes:

1. All receivers are shown in Figures 7 and 8
2. Number of residential, commercial, or other uses represented by each receiver
3. ODOT traffic noise abatement criteria
4. Calculated peak-hour noise levels in dBA Leq from TNM version 2.5 with **Bold-Red** typeface used to indicate noise levels that are equal to or greater than the NAC of 65 dBA Leq. Future Build includes the proposed 36 inch TSB.
5. Number of uses predicted to meet or exceed the ODOT traffic noise criteria
6. Change in noise: No-Build compared to existing conditions
7. Change in noise: Build compared to existing conditions
8. Change in noise: Build compared to No-Build

8. TRAFFIC NOISE MITIGATION

For projects that meet the requirements described under the FHWA Type 1 descriptions in Section 4, Methodology, traffic noise mitigation is normally considered. As described the NE 238th Drive Project fails to meet any of the FHWA Type 1 requirements and therefore, noise mitigation was not considered. However, even if the project did meet those requirements, providing noise mitigation for this project would be difficult due to topographic conditions, safety and site distances, and openings for driveways, streets and pedestrian access.

This section provides a general discussion of traffic noise mitigation commonly used for major transportation projects. In addition to descriptions of the mitigation options, general information on the level of noise reduction from different types of noise mitigation measure and ODOT requirements for noise reduction and cost limitations are provided.

8.1. Noise Mitigation

For projects where a detailed mitigation analysis is required, the primary form of noise mitigation evaluated for traffic noise are barriers, including noise walls and earth-berms. Construction of noise barriers between roadways and affected receivers reduce noise levels by physically blocking the transmission of traffic-generated noise. Barriers can be constructed as walls or earth berms. Earth berms require more right-of-way than walls and are usually constructed with a 3 to 1 slope. Due to limited right-of-way and topographical conditions, construction of noise berms is not a feasible form of mitigation and therefore is not discussed further in relation to this project.

There are several aspects of noise barrier design that must be considered to make sure the mitigation measure meets the DOT requirements. For example, noise barriers must do more than break the line-of-sight between the noise source and the receiver. The barrier must also be long enough to prevent significant flanking of noise around the ends of the walls. Openings in a noise barrier for driveways and pedestrian access will significantly reduce the barrier effectiveness at reducing noise. Other items that can impact the overall effectiveness of noise barriers include the horizontal placement, topography between the receiver and the project corridor, and the elevation relationship between the receiver, noise barrier, and roadway.

In general, noise barriers are most effective if placed close to the noise source, or close to the receiver location. In addition, if the sensitive receivers are located above the roadway grade, as is the case in the southern end of the corridor, the overall effectiveness of the noise barrier is significantly reduced unless it is placed at the same elevation as the receptor. Noise barriers are normally most effective for receivers located close to the project corridor. Finally, noise barriers are only recommended for construction if they can be shown to meet ODOT requirements for reasonable and feasibly mitigation as further discussed in the next section.

8.2. ODOT Policy and Procedures for Noise Abatement

Any specific mitigation measures that are recommended as part of any FHWA Type 1 project must be considered *feasible and reasonable* by FHWA and ODOT policies and procedures for traffic noise mitigation. Feasibility has to do with constructability and noise reduction while reasonability has to do with cost.

Other factors that are considered in the feasibility assessment of the noise abatement include maintaining a recovery for disabled vehicles, adequate sight distance, and fire/emergency vehicle access. The consideration of the abatement should also include potential environmental impacts to wetlands, historic properties, parklands, property access, and utility placement. For example, it is not possible to construct a noise barrier under power lines, and moving power lines is often cost prohibitive and could make barrier construction to costly.

If mitigation is found to be feasibly constructible, than the reasonability of mitigation measures are considered. For mitigation to be reasonable the mitigation must meet the ODOT policies for cost. For example, construction of a noise barrier for a single home is not normally considered a reasonable expense. In most cases, reasonable mitigation will provide a benefit for several homes, for example, a barrier placed along the backyard of several residences located along a busy highway.

8.2.1. ODOT Feasibility and Reasonability Criteria

ODOT requires a noise abatement measure to obtain a substantial noise reduction of at least 5 dB at a majority of impacted receptors to be considered feasible. ODOT also requires that the noise reduction design goal of at least one benefited property achieving a 7 dB reduction be met. Finally, ODOT also considers engineering factors such as barrier height, safety, topography, drainage, utilities, and access issues when determining feasibility.

For residential areas, all benefited residences must be considered in determining a noise barrier cost per residence. A benefited residence is any residence that receives a reduction of 5 dB or more from the noise abatement. A reasonable cost for noise abatement will be a typical maximum of $25,000 per benefited residence using a cost of $20.00 per square foot for noise barrier construction.

For example, if 10 residences are benefited by a noise wall, and the cost of the wall is $200,000, the cost per residence would be $20,000. This wall would be recommended as long as at least one of the residences achieved a 7 dB reduction.

8.3. Noise Mitigation Considerations for the NE 238th Drive Project

As previously described, providing noise mitigation for this project would be difficult due to topographic conditions, safety and site distances, and openings for driveways, streets and pedestrian access. Information on noise mitigation consideration for traffic noise along the NE 238th Drive project is provided in below.

8.3.1. Northern Section: Receivers R-1 through R-7

Receivers in the northern section of the corridor, represented by receivers R-1 through R-7 have future Build noise levels ranging from 62 to 74 dBA, with increase of 1 to 2 dB over the existing conditions and 1 dB over the No-Build. Most of these receivers have some requirement for access to NE 238th Drive, either for driveways and/or for pedestrian access. Based on this fact, these receivers would not achieve the required average of 5 dB, with one achieving a 7 dB reduction. Based on this, it is unlikely that any reasonable and feasible noise mitigation measures exist and no noise mitigation would be recommended.

Although it is unlikely that noise mitigation would be recommended, it is important to note that an average person requires at least a 3 dB or more increase in traffic noise levels to perceive a change in noise levels. The increases over the existing conditions of 1 to 2 dB would not be noticeable to the majority of people. Also, when compared to the future No-Build conditions, with increases of only 1 dB, the change is not predicted to be perceptible.

8.3.2. Treehill Condominiums: Receivers R-8 through R-17

Receivers in this multi-family complex have future noise levels of 50 to 70 dBA Leq. This amounts to a change of zero to -2 dB over the future No-Build. Simply stated, noise levels will not increase, and at some receivers future noise levels are lower than would occur if the project was not constructed. The reduction in traffic noise levels is due to the addition of the traffic safety barrier, which is capable of blocking noise from the tire-roadway interface, reducing overall noise transmission. For the remaining receivers, a noise barrier would complicate the line-of-sight view from the intersection of NE 238th Drive and NE Treehill Drive, and would likely be rejected due to safety issues. Any wall that would block noise from NE 238th Drive from reaching the receivers with noise impacts (R-8, R-10 and R-12) would also block the line of sight for traffic leaving the complex and traveling onto NE 238th Drive, resulting in a safety issue and preventing the wall from being constructed.

Furthermore, the overall noise levels at most receivers are actually lower than under the No-Build alternative. Receivers that did not have a noise reduction are not predicted to have any noticeable increase in the overall noise from the proposed project when compared to the No-Build or existing conditions.

8.3.3. Southern Segment: Receivers R-18 through R-32

Receives in the southern segment (R-18 through R-32) are predicted to have noise levels change by -1 dB to +1 dB when compared to the No-Build alternative, with future Build levels of 58 to 69 dBA Leq. The minimal change is due to the majority of the widening being to the north and east, away from most of these residences. Providing additional noise mitigation for these residences would be complicate for several reasons. First, most of these homes are located above the grade of the roadway, and as previously described, noise wall in this topographical configuration are not as effective unless the walls are place up on the hill side, near the residences. In order to locate noise walls up on the hill side, the County would be required to purchase the land and install the barriers along the hill side. This would also require clearing trees and shrubby from the hillside and the possible installation of a retaining wall to support the hillside one the foliage is removed. Furthermore, there are a limited number of residences that would be expected to benefit from the walls, and the combined low number of receivers and added cost of land purchase, clearing and potential retaining wall would very likely prevent these walls from meeting the ODOT cost criteria.

However, as with the other locations, the future Build noise levels are essentially the same, or lower than the No-Build alternative, and the slight change in noise levels would not be discernible to the nearby residences.

9. CONSTRUCTION NOISE ANALYSIS

Construction noise levels for the proposed project improvements would result from normal construction activities. Noise levels for construction activities can be expected to range from 70 to 95 dBA at sites 50 feet from the activities. Table 9 lists equipment typically used for constructing this type of project, the activities for which the equipment would be used, and the corresponding maximum noise levels under normal use measured at 50 feet.

Table 9. Construction Equipment List, Use, and Reference Maximum Noise Levels

Equipment	Typical Expected Project Use	Lmax[a]	Source[b]
Air Compressor	Used for pneumatic tools and general maintenance—all phases	70–76	1, 2, 3
Backhoe	General construction and yard work	78–82	2, 3
Concrete Pump	Pumping concrete	78–82	2, 3
Concrete Saw	Concrete removal, utilities access	75–80	2, 3
Crane	Materials handling, removal, and replacement	78–84	2, 3
Excavator	General construction and materials handling	82–88	2, 3
Haul Truck	Materials handling, general hauling	86	2, 3
Jackhammer	Pavement removal	74–82	2, 3
Loader	General construction and materials handling	86	2, 3
Paver	Roadway paving	88	2
Power Plant	General construction use, nighttime work	72	2, 3
Pump	General construction use, water removal	62	2, 3
Pneumatic Tools	Miscellaneous construction work	78–86	3
Service Truck	Repair and maintenance of equipment	72	2, 3
Tractor Trailer	Material removal and delivery	86	3
Utility Truck	General project work	72	2
Vibratory Equipment	Shore up hillsides, preventing slides, soil compacting	82–88	2, 3
Welder	General project work	76	2, 3

a Maximum noise level measured at a distance of 50 feet under normal operation.

b Sources of noise levels presented:

1 Portland, Oregon light rail, I-5 preservation, and Hawthorne Bridge construction projects.

2 Measured data from other projects in the Portland, Oregon area.

3 USDOT or other construction noise source.

These noise levels, although temporary in nature, can be annoying. The following is a list of potential construction noise mitigation measures that could be included in the contract specifications:

- Require all engine-powered equipment to have mufflers that were installed according to the manufacturer’s specifications.
- Require all equipment to comply with pertinent EPA equipment noise standards.
- Limit jackhammers, concrete breakers, saws, and other forms of demolition to daytime hours of 7:00 a.m. to 7:00 p.m. on weekdays, with more stringent restrictions on weekends.
- Minimize noise by regular inspection and replacement of defective mufflers and parts that do not meet the manufacturer’s specifications.
- Install temporary or portable acoustic barriers around stationary construction noise sources and along the sides of the temporary bridge structures, where feasible.
- Locate stationary construction equipment as far from nearby noise-sensitive properties as possible.
- Shut off idling equipment.
- Reschedule construction operations to avoid periods of noise annoyance identified in complaints.
- Notify nearby residents whenever extremely noisy work would be occurring.
- Use non-pure tone back-up alarms or restrict the use of back-up beepers during evening and nighttime hours and use spotters. In all areas, Occupational Safety and Health Administration (OSHA) will require back-up warning devices and spotters for haul vehicles.
- Use pile driving noise shroud and/or employ auguring techniques where possible to limit effects of pile driving.
- Additional noise mitigation measures might be implemented as more details on the actual construction processes are identified.

Appendix A:

Supporting Documents

Oregon Department of Transportation. Traffic Noise Manual, July 2011.

U.S. Department of Transportation. *FHWA Highway Traffic Noise Model User's Guide, Report No. FHWA-PD-96-009.* Federal Highway Administration, Washington, D.C. January 1998.

U.S. Department of Transportation. *FHWA Highway Traffic Noise Model User's Guide, (Version 2.5 Addendum) Final Report.* Federal Highway Administration, Washington, D.C. April 2004.

Appendix B:

Introduction to Acoustics

Sound is defined as any pressure variation that the human ear can detect, from barely perceptible sounds to sound levels that can cause hearing damage. The magnitude of the variations of the air pressure from the static air pressure is a measure of the sound level. The number of cyclic pressure variations per second is the frequency of sound. When sounds are unpleasant, unwanted, or disturbingly loud, we tend to classify them as noise.

Compared with the static air pressure, the audible sound pressure variations range from the threshold of hearing, a very small 20 μPa (20 x 10^{-6} Pascal), to 100 Pa, a level so loud it is referred to as the threshold of pain. Because the ratio between these numbers is more than a million to one, using Pascal to describe sound levels can be awkward. The "dB" measurement is a logarithmic conversion of air pressure level variations from Pascal to a unit of measure with a more convenient numbering system. This conversion not only allows for a more convenient scale, but is also a more accurate representation of how the human ear reacts to variations in air pressure. Measurements made using the decibel scale will be denoted dB.

The smallest noise level change that can be detected by the human ear is approximately 3 dB. A doubling in the static air pressure amounts to a change of 6 dB, and an increase of 10 dB is roughly equivalent to a doubling in the perceived sound level. Under free-field conditions, where there are no reflections or additional attenuation, sound is known to decrease at a rate of 6 dB for each doubling of distance. This is commonly known as the inverse square law. For example, a sound level of 70 dB at a distance of 100 feet would decrease to 64 dB at 200 feet, or 58 dB at 400 feet. The mathematical definition of sound pressure level in dB is listed below.

- **L_p (sound pressure level).** The sound pressure in dB is 20 times the log of the ratio of the measured pressure, p, to the static pressure, p_o, where p_o is 20 μPa.

$$L_{pa} = 20Log_{10}\left(\frac{p}{p_o}\right)dB \quad (re\ 20\mu Pa)$$

In acoustic measurements where the primary concern is the effect on humans, the sound readings are sometimes compensated by an "A"-weighted filter. The A-weighted filter accounts for people's limited hearing response in the upper and lower frequency bands. Sound pressure level measurements made using the A-weighted filter are denoted dBA. For short-term and impulsive noises, such as surface blasting, a C-weighted filter is normally used. The C-weighted filter helps to account for the short time period and frequency of impulsive noises.

General Measurement Descriptors

- **Leq (equivalent continuous sound level).** The constant sound level in dBA that, lasting for a time "T," would have produced the same energy in the same time period "T" as an actual A-weighted noise event.

$$L_{eq} = 20Log_{10}\frac{1}{T}\int_{T}^{0}\left(\frac{p(t)}{p_o}\right)^2 dt$$

- **MaxPeak (maximum A-weighted sound level).** The greatest continuous sound level, in dBA, measured during the preset measurement period.
- **L_{max} (maximum A-weighted RMS sound level).** The greatest RMS (root-mean square) sound level, in dBA, measured during the preset measurement period.
- **L_{min} (minimum A-weighted RMS sound level).** The lowest RMS (root-mean square) sound level, in dBA, measured during the preset measurement period.

Community Noise Level Descriptors

The following sound level descriptors are commonly used in community noise measurements:

- **L_{dn} (day-night average sound level).** A 24-hour equivalent continuous level in dBA where 10 dB is added to nighttime noise levels from the hours of 10:00 p.m. to 7:00 a.m.
- **CNEL (community noise equivalent level)**. A 24-hour equivalent continuous level in dBA where 5 dBA is added to evening noise levels from 7:00 p.m. to 10:00 p.m. and 10 dBA is added to nighttime noise levels from 10:00 p.m. to 7:00 a.m.
- **SEL (sound exposure level)**. That constant level in dBA that, lasting for one second, has the same amount of acoustic energy as a given A-weighted noise event lasting for a period of time T. This measurement is most commonly used for airport noise.

Statistical Noise Level Descriptors

Public response to sound depends greatly upon the range that the sound varies in a given environment. For example, people generally find a moderately high, constant sound level more tolerable than a quiet background level interrupted by high-level noise intrusions. In light of this subjective response, it is often useful to look at a statistical distribution of sound levels over a given time period. Such distributions identify the sound level exceeded and the percentage of time exceeded. Therefore, it allows for a more complete description of the range of sound levels during the given measurement period.

The sound level descriptor L_{xx} is defined as the sound level exceeded XX percent of the time. Some of the more common versions of this descriptor and their corresponding definitions are listed below:

- L_{01} The sound level is exceeded 1 percent of the time. This is a measure of the loudest sound levels during the measurement period. Example: During a 1-hour measurement, an L_{01} of 95 dBA means the sound level was at or above 95 dBA for 36 seconds.

- L_{10} The sound level is exceeded 10 percent of the time. This is a measure of the louder sound levels during the measurement period. Example: During a 1-hour measurement, an L_{10} of 85 dBA means the sound level was at or above 85 dBA for 6 minutes.

- L_{50} The sound level is exceeded 50 percent of the time. This level corresponds to the median sound level. Example: During a 1-hour measurement, an L_{50} of 67 dBA means the sound level was at or above 67 dBA for 30 minutes.

- L_{90} The sound level is exceeded 90 percent of the time. This is a measure of the nominal background level. Example: During a 1-hour measurement, an L_{90} of 50 dBA means the sound level was at or above 50 dBA for 54 minutes.

- L_{99} The sound level is exceeded 99 percent of the time. This is the quietest or minimum level during the measurement period. Example: During a 1-hour measurement, an L_{99} of 42 dBA means the sound level was at or above 42 dBA for 59 minutes and 24 seconds.

Other commonly used L_{XX} values include $L_{2.5}$, $L_{8.3}$, and L_{25}. These correspond to the 5-, 10-, and 15-minute time levels for a 1-hour measurement period, respectively.

Sound Propagation Characteristics

Several factors determine how sound levels reduce over distance. Under ideal conditions, a point noise source in free space will attenuate at a rate of 6 dB each time the distance from the source doubles (using the inverse square law). An ideal line source (such as constant flowing traffic on a busy highway) reduces at a rate of approximately 3 dB each time the distance doubles. Under real-life conditions however, interactions of the sound waves with the ground often results in attenuation that is slightly higher than the *ideal* reduction factors given above. Other factors that affect the attenuation of sound with distance include existing structures, topography, foliage, ground cover, and atmospheric conditions such as wind, temperature, and relative humidity. The following list provides some general information on the potential affects each of these factors may have on sound propagation.

- **Existing Structures.** Existing structures can have a substantial effect on noise levels in any given area. Structures can reduce noise by physically blocking the sound transmission and, under special circumstances, may cause an increase in noise levels if the sound is reflected off the structure and transmitted to a nearby receiver location. Measurements have shown that a single story house has the potential, through shielding, to reduce noise levels by as much as 10 dB or greater. The actual noise reduction will depend greatly on the geometry of the noise source, receiver, and location of the structure. Increases in noise caused by reflection are normally 3 dB or less, which is the minimum change in noise levels that can be noticed by the human ear.

- **Topography**. Topography includes existing hills, berms, and other surface features between the noise source and receiver location. As with structures, topography has the potential to reduce or increase sound depending on the geometry of the area. Hills and berms when placed between the noise source and receiver can have a significant effect on noise levels. In many situations, berms are used as noise abatement by physically blocking the noise source from the receiver location. In some locations, however, the topography can result in an overall increase in sound levels by either reflecting or channeling the noise towards a sensitive receiver location.

- **Foliage.** Foliage, if dense, can provide slight reductions in noise levels. FHWA provides for up to a 5 dBA reduction in traffic noise for locations with at least 30 feet of dense evergreen foliage. Because foliage varies in the project area, no reduction for foliage will be used in the analysis.

- **Ground Cover.** The ground cover between the receiver and the noise source can have a significant effect on noise transmission. For example, sound will travel very well across reflective surfaces such as water and pavement, but can be attenuated when the ground cover is field grass, lawns, or even loose soil. During the environmental impact statement (EIS) phase of the project, detailed information related to sound transmission in the project area will be compiled through a combination of on-site monitoring, noise modeling, and published information. This information will be used during the final noise modeling to account for the varying ground conditions in the project area.

- **Atmospheric Conditions**. Atmospheric conditions that can have an effect on the transmission of noise include wind, temperature, humidity, and precipitation. Wind can increase sound levels if it is blowing from the noise source to the receiver. Conversely, it can reduce noise levels if blowing in the opposite direction. Noise propagation can also be significantly affected when the temperature gradient is such that an inversion is formed. Other atmospheric conditions, such as humidity and precipitation, are rarely severe enough to result in significant changes in noise level propagation.

Appendix C:

Noise Monitoring Data Sheets

Traffic Noise Monitoring Information Sheet

Project Name: NE 238TH DRIVE **Date:** 4-9-18 **Site Number:** 1

Monitoring Location: 238TH **Meter:** BLUE

Time (12 hr):__________ **Meter Start Time:** 11:30 **End Time:** 11:43 71.4 **Leq:** [redacted] FILE 3

11:46:00 12:01:03 69.1 [redacted] Leq

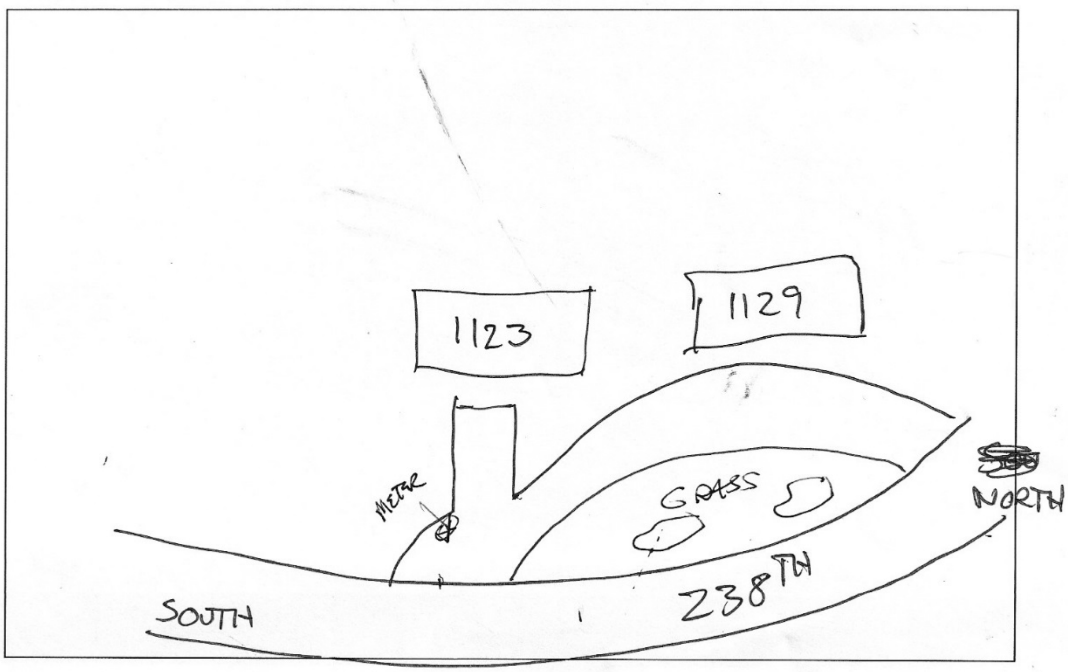
Weather Conditions: CLEAR/CRISP

Traffic Counts:

Roadway Name	Cars	MedTrucks	HvyTrucks	Speeds
238TH N	190	2	3	35 POSTED
238TH S	177	6	1	35 POSTED

Area Observations: TRAFFIC SLOWED N/B MOMENTARILY -

Site Sketch



Traffic Noise Monitoring Information Sheet

Project Name: NE 238TH DRIVE **Date:** 4-9-18 **Site Number:** 2 FILE 4

Monitoring Location: END OF COMPLEX TREEHILL RD **Meter:** BLUE

Time (12 hr): ______ **Meter Start Time:** 12:26:40 **End Time:** 12:41:41 **L_{eq}:** [redacted] 52.1

Weather Conditions: CLEAR/CRISP

Traffic Counts:

Roadway Name: ______ **Cars** ___ **MedTrucks** ___ **HvyTrucks** ___ **Speeds:** ___

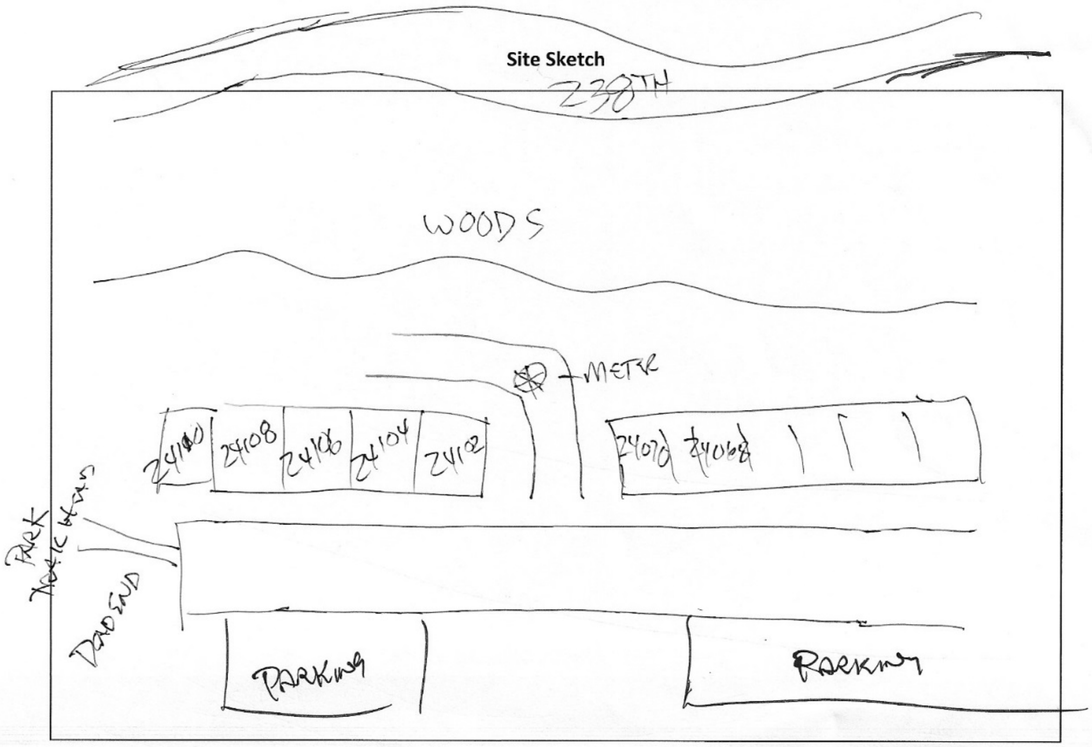
Roadway Name: ______ **Cars** ___ **MedTrucks** ___ **HvyTrucks** ___ **Speeds:** ___

Roadway Name: ______ **Cars** ___ **MedTrucks** ___ **HvyTrucks** ___ **Speeds:** ___

Roadway Name: ______ **Cars** ___ **MedTrucks** ___ **HvyTrucks** ___ **Speeds:** ___

Area Observations: METER BELOW 238TH SURFACE
NO VIEW OF ROAD

Site Sketch



Traffic Noise Monitoring Information Sheet

Project Name: NE 238TH DRIVE **Date:** 4-9-18 **Site Number:** 3 FILE (5)

Monitoring Location: TREE HILL RD **Meter:** BLUE

Time (12 hr): ____________ **Meter Start Time:** 12:30:45 **End Time:** 13:05:37 **L_{eq}:** ~~54.5~~ 58.2

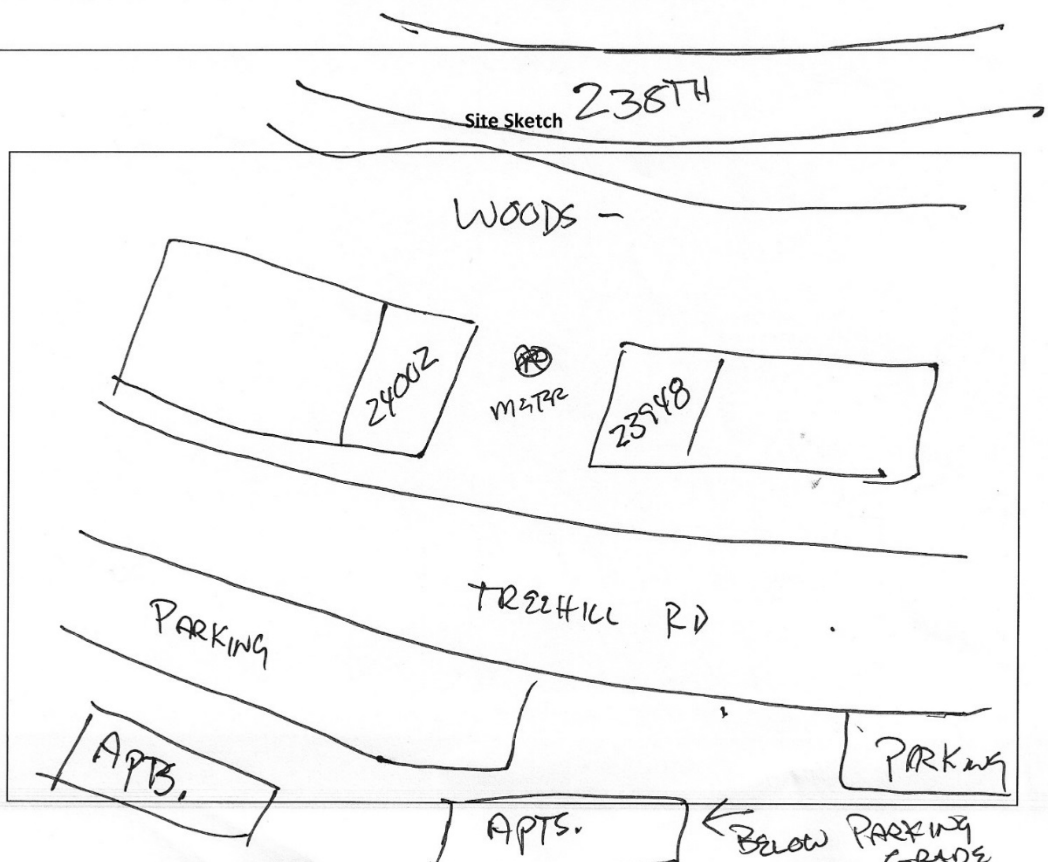
Weather Conditions: CLEAR / MILD

Traffic Counts:

Roadway Name	Cars	MedTrucks	HvyTrucks	Speeds

Area Observations: METRE BELOW 238TH - NO VIEW TO TRAFFIC

Site Sketch



Traffic Noise Monitoring Information Sheet

Project Name: NE 238TH DRIVE **Date:** 4-9-18 **Site Number:** 4 FILE 6

Monitoring Location: TREE HILL RD **Meter:** BLUE

Time (12 hr): ____ **Meter Start Time:** 1:21:15 **End Time:** 1:36:18 **L_{eq}:** ~~64.9~~ 66.9

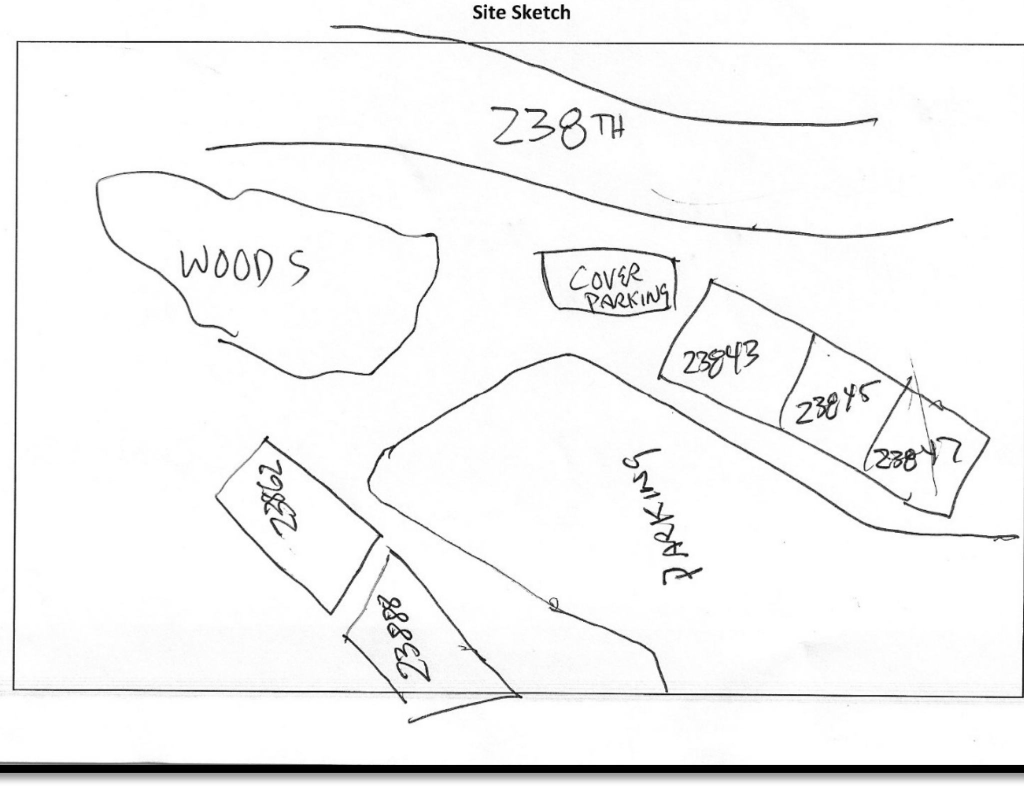
Weather Conditions: CLEAR / MILD

Traffic Counts:

Roadway Name	Cars	MedTrucks	HvyTrucks	Speeds
238 S	192	10	2	35 POSTED
238 N	189	5	2	

Area Observations: SOUTH BOUND TRAFFIC - CARS DOWNSHIFT FOR HILL

Site Sketch



Appendix D:

Traffic Data

2017 PM Peak Hour			
	Passenger Cars	Medium Trucks	Heavy Trucks
NB	671	45	8
SB	837	68	17
Total	1508	113	25

2040 PM Peak Hour			
Total	Passenger Cars	Medium Trucks	Heavy Trucks
NB	825	55	10
SB	1030	84	21
Total	1855	139	31

Appendix E:

TNM Modeling Files

(Available on request, request FHWA Traffic Noise Model version 2.5 or newer)