

# **Smokey Point Boulevard Project**

**Arlington, Washington**

***Noise Impact Analysis***

**February 2024**

***Prepared for:***

The City of Arlington, Washington

and

Perteet, Inc, Everett, Washington

***Prepared by:***

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## EXECUTIVE SUMMARY

This technical noise analysis for the Smokey Point Boulevard Project in Arlington, Washington was prepared as requested by the city of Arlington and Perteet, Inc. The purpose of the Smokey Point Boulevard Project is to meet current roadway standards and accommodate growth along the Smokey Point Boulevard corridor. The Project includes adding roundabouts at 174th Place NE, 180th Street NE, 183rd Street NE, and 188th Street NE, two drop lanes for protected on-street parking and dedicated bike lanes, a center median, sidewalks, and enhanced bus stops. The purpose of this analysis is to identify all potential traffic noise impacts resulting from the proposed Project and consider noise abatement in accordance with the *Traffic Noise Policy and Procedures*, Washington State Department of Transportation, 2020 (2020 WSDOT Policy).

As part of this study, an on-site inspection and traffic noise monitoring with traffic counts was performed with measured noise levels ranging from 62.4 to 68.3 dBA Leq. The noise monitoring data and traffic counts were used to validate the modeling efforts. Using the *Traffic Noise Model* (TNM) from the Federal Highway Administration (FHWA), and traffic volumes from project traffic engineers, noise levels were modeled at 151 independent locations to determine the potential overall noise effects of the project and identify project impacts. Modeled traffic noise levels for the existing conditions ranged from 52 to 71 dBA Leq during the PM peak hour. Under the No-Build conditions, traffic noise levels ranged from 55 to 72 dBA Leq with variations of 0 to +2 dB when compared to the existing conditions.

Modeled traffic noise levels under the Build alternative range from 55 to 72 dBA Leq, with variations of -1 to +4 dBA Leq over the existing noise levels. The analysis identified 33 residences with noise impacts under the Build alternative.

Noise abatement was considered for all traffic noise impacts; however, noise walls were only recommended at the four locations. The 188th Wall is approximately 157 feet long and 7- to 8-feet tall with a cost of \$57,752 and eliminates all impacts with reductions of 5 to 7 dB. The Smokey Point Wall 1 is 159 feet long and 7-feet tall with a cost of \$57,597 and eliminates all impacts with reductions of 7 dB. The Smokey Point Wall 2 is 155 feet long and 6- to 9-feet tall with a cost of \$65,338 and eliminates all impacts with reductions of 5 to 7 dB. The Smokey Point Wall 3 is 186 feet long and 6- to 9-feet tall with a cost of \$72,615 and eliminates all impacts with reductions of 5 to 7 dB. All four walls are both reasonable and feasible under WSDOT policy. See Section 13 for more information on why noise abatement is not recommended at the other locations where noise impacts were identified.

Noise from construction would be similar to other highway construction projects. Maximum noise levels for construction activities can be expected to range from 70 to 90 dBA as measured at sites 50 feet from the construction activities. Construction activities would be required to meet the city of Arlington noise control ordinance.

# **1. INTRODUCTION AND PROJECT DESCRIPTION**

This technical noise analysis for the Smokey Point Boulevard Project in Arlington, Washington was prepared as requested by the city of Arlington and Perteet, Inc. The purpose of this analysis is to identify traffic noise impacts resulting from the proposed Project and provide future traffic noise levels that can be used for future land use planning. Where traffic noise impacts were identified, noise abatement was considered and analyzed in accordance with the policy and procedures given in the current 2020 WSDOT Policy. Noise abatement that is found to meet WSDOT criteria will be reviewed by WSDOT and could be recommended for inclusion in the Project.

## **2. PROJECT PURPOSE AND DESCRIPTION**

The purpose of the Smokey Point Boulevard Project is to meet current roadway standards and accommodate growth along the Smokey Point Boulevard corridor. Figure 1 provides an overview of the project area.

### **2.1. Project Description**

The City of Arlington proposes to make improvements to Smokey Point Boulevard from 174th Place NE to 200th Street NE to support future growth. The project will make traffic improvements along the corridor, and adding roundabouts at 174th Place NE, 180th Street NE, 183rd Street NE, and 188th Street NE. The project also includes two drop lanes for protected on-street parking and dedicated bike lanes, a center median, sidewalks, and enhanced bus stops. Medians will separate travel lanes and side aisles and multiple pedestrian crossings will be added along the corridor. Utility relocation, potential utility upgrades, lighting, and stormwater facilities will also be installed by this project.

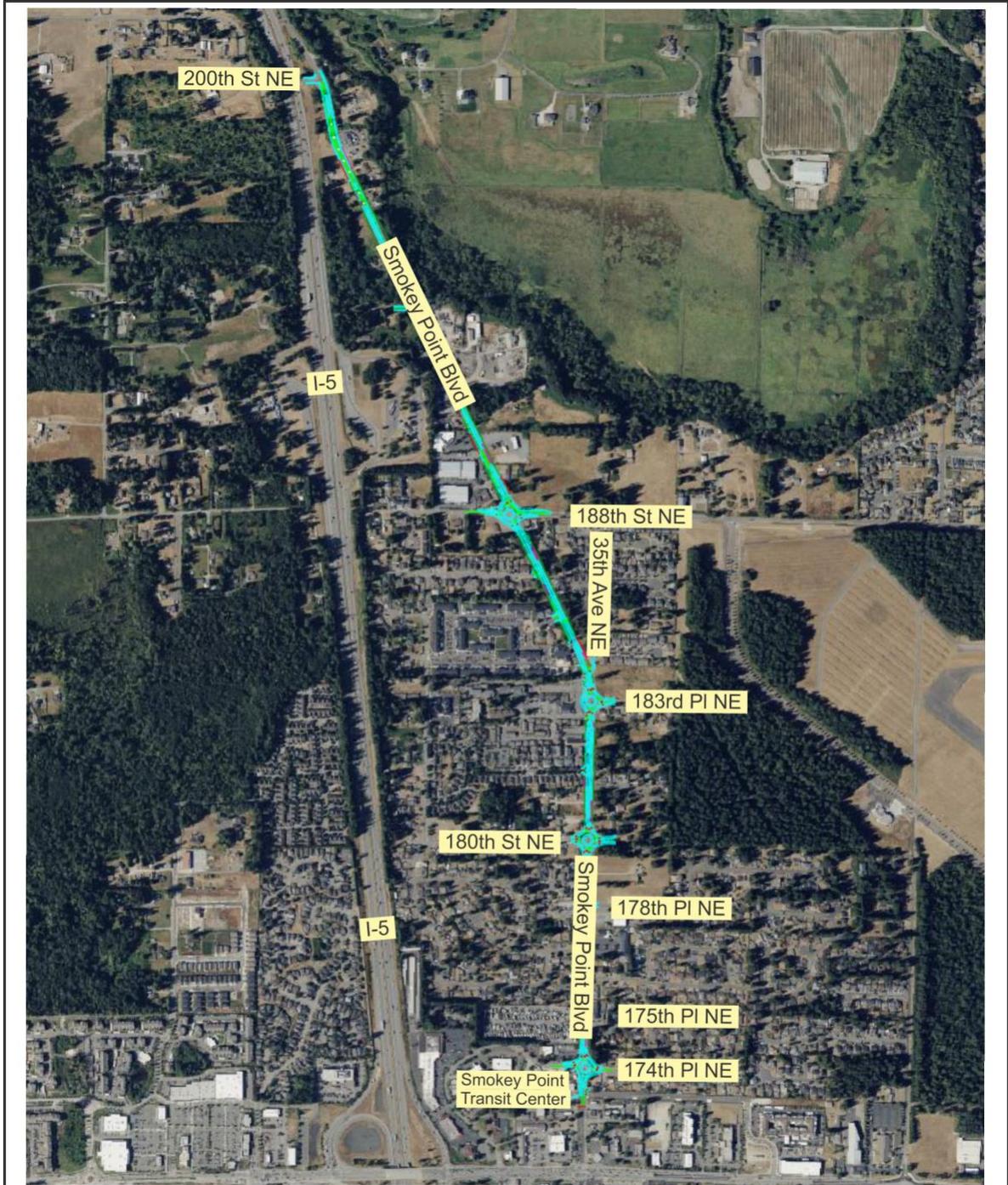


Figure 1. Vicinity Map with Alignment

0 600 1200  
 Approximate Scale  
 in feet

N

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= Roadway Improvements



### 3. 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 construction of a new highway or roadway, an increase in the number of traffic lanes, a substantial realignment (horizontal or vertical) of an existing highway, or significant changes to the existing topography around roadways. The proposed Project would include new roundabouts causing a substantial horizontal realignment along Smokey Point Boulevard and, therefore, meets the requirement for a detailed noise impact and abatement analysis for a Type 1 project.

### 4. INTRODUCTION TO ACOUSTICS

Noise is generally defined as unwanted sound. Noise is measured in terms of sound pressure level. It is expressed in decibels (dB), which are defined as  $10 \text{ Log } P^2/P^2_{\text{ref}}$ , where  $P$  is the root-mean-square (RMS) sound pressure and  $P_{\text{ref}}$  is the reference RMS sound pressure of  $2 \times 10^5$  Newtons per square meter.

The number of fluctuation cycles or pressure waves per second of a particular sound is the frequency of the sound. The human ear is less sensitive to higher and lower frequencies than to mid-range frequencies. Therefore, sound level meters used to measure environmental noise generally 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. Measurements made with this weighing system are termed "A-weighted" and are specified as "dBA" readings.

Several noise descriptors are used that take into account the variability of noise over time. The minimum noise level during a measurement period is denoted as  $L_{\text{min}}$ . The maximum noise levels ( $L_{\text{max}}$ ) that occur during an event, such as the passing of a heavy truck or the flyover of an airplane, can be useful indicators of interference with speech or sleep.

The equivalent sound level ( $L_{\text{eq}}$ ) is the level of a constant sound for a specified period of time that has the same sound energy as an actual fluctuating noise over the same period of time. It is an energy average sound level.

In summary, the noise level descriptors are defined as follows:

<b>Symbol</b>	<b>Description</b>
$L_{\text{eq}}$	The average noise level (energy basis)
$L_{\text{min}}$	The minimum noise level
$L_{\text{max}}$	The maximum noise level

Noise levels decrease with distance from a noise source. For each doubling of the distance from a point source (such as an engine), noise levels decrease by 6 dBA because of the

geometric divergence of the sound waves. Additional noise reduction (attenuation) can be provided by vegetation, terrain, and atmospheric effects that block or absorb noise.

For traffic noise, the level of noise reduction depends on the type of descriptor in use. The Leq noise level from a line source (such as a road) will decrease by 3 dBA for each doubling of distance (3 dB / DD) because of geometric divergence alone. However, the Lmax from individual vehicles on the road will decrease by 6 dBA / DD. In simple terms, the maximum noise levels (Lmax) decrease more rapidly with distance from the road than do the average noise levels (Leq).

It is important to understand how humans perceive noise and changes in noise levels. Subjectively, a 10-dBA change in noise level is judged by most people to be approximately a twofold change in loudness (e.g., an increase from 50 dBA to 60 dBA causes the loudness to double). A 3-dBA increase is a barely perceptible increase. Therefore, if traffic noise levels increase by 1 to 2 dB, the majority of people may not even notice the change in noise levels.

It is also important to understand the compatibility with land use based on area noise levels. For example, noise levels at night in a quiet rural area are typically between 32 and 35 dBA. Quiet urban nighttime noise levels range from 40 to 50 dBA. Daytime noise levels in a noisy urban area are frequently as high as 70 to 80 dBA.

Areas with PM peak hour traffic noise levels below 50 dBA Leq are typically found in quiet bedroom communities (rural and suburban) that are far from interstate or state highways, major arterial roadways, and urban areas. PM peak hour traffic noise levels from 50 dBA to 60 dBA Leq are typically found in quiet bedroom communities with arterial roadways nearby and primarily passenger traffic accessing the area (little or no truck traffic). Communities with traffic noise levels of 60 dBA to 67 dBA Leq are typically closer to urban areas and / or major arterial roadways where some truck traffic is present.

A more detailed section about acoustics is provided in Appendix B.

## **5. METHODOLOGY**

This section provides a summary of the methods used for the Traffic Noise Analysis. In general, the methods follow the WSDOT policy and procedures for a traffic noise study as published in the 2020 WSDOT Policy. Reference policies, manuals and guides used for this report are provided in Appendix A.

### **5.1. 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, warehousing, undeveloped lands that are not permitted for development, or construction noise. No traffic noise analysis is required for those uses for which no criteria exist. See Table 1 for the list of categories and impact criteria if one exists.

The FHWA allows each state to define the term “approach”. WSDOT considers a predicted sound level of 1 dBA below the NAC as sufficient to satisfy the condition of “approach,” or approaching the NAC, required by FHWA for all land use categories. For example, where the NAC is 67 dBA for outdoor use at a residence, a noise level of 66 dBA is considered an impact. Receivers are also considered impacted when the worst hourly traffic noise is predicted to increase 10 dBA (“substantial increase”) or more between the Existing and Build conditions. Impacts at places of worship, schools, and recreational areas (Category C properties) also occur at 66 dBA or higher in Washington. Hotel / motel, office building, and restaurant / bar impacts (Category E properties) occur at 71 dBA or higher. Table 1 summarizes the FHWA and the WSDOT traffic noise abatement criteria.

<b>Table 1. Noise Abatement Criteria (NAC) by Land Use Category</b>				
<b>Activity Category</b>	<b>Activity Criteria in hourly Leq (dBA)</b>		<b>Evaluation Location</b>	<b>Activity Description</b>
	<b>FHWA NAC</b>	<b>WSDOT NAC</b>		
A	57	56	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 <sup>1</sup>	67	66	Exterior	Residential (single and multi-family units)
C <sup>1</sup>	67	66	Exterior	Active sport areas, amphitheatres, 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	51	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 <sup>1</sup>	72	71	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 undeveloped lands permitted for this activity category				

The primary FHWA categories applicable to this analysis are FHWA categories applicable to this analysis are FHWA Categories B and C, which include residential land uses (B) and parks and churches (C). Under FHWA policy, the noise impact criteria is applicable to frequently used exterior areas, for example, a back-yard deck or patio at a residence, frequent outdoor uses at parks, or entrances and frequent outdoor uses at churches.

## **5.2. Local Noise Control for Construction**

Project construction would be required to meet the state, county, or local noise control ordinances. The City of Arlington noise control ordinance is found in Section 7.05.040(4)(A) of the city code, where the City of Arlington exempts sounds originating from construction sites and activities between 7:00 a.m. and 10:00 p.m. daily. Construction activities outside the permitted hours must be first approved by the city (City of Arlington Municipal Code Section 7.05.040 – Nuisances – Public nuisances prohibited).

## **5.3. Analysis and Modeling Procedures**

The methodology used for a Type I traffic noise analysis is defined in the 2020 WSDOT Policy. Following this policy, traffic noise levels were calculated using the FHWA Traffic Noise Model (TNM). Noise emission levels used in the model were nationwide averages for automobiles, medium trucks, and heavy trucks provided by the FHWA and built into the TNM. Model inputs included traffic volumes, vehicle type, and speed information. The area was evaluated for noise-reducing effects of sensitive receivers, existing outbuildings, roadway depressions, and topography. Actual roadway width and average pavement type were used for existing and future conditions. The effects of signalized intersections and roundabouts were also included where appropriate.

Traffic volumes and vehicle class percentages used for the modeled roadways were provided by the city of Arlington, Perteet, Inc, and Transpo Group traffic engineers. The traffic data used for the analysis is provided in Appendix C. Vehicle speeds used are the current or proposed posted speeds and are also provided in Appendix C. The PM peak traffic hour on weekdays has the highest total traffic volumes and, therefore, was used throughout the analysis to ensure the worst-case noise levels were predicted. The traffic data is provided by vehicle types, with percentages of passenger vehicles and heavy trucks.

## **5.4. Noise Study Area**

The study area for traffic noise studies must be large enough to identify all potential noise impacts at noise sensitive properties related to the Project. For this Project, the study area includes noise sensitive properties within 300 feet of the project roadway construction between the intersection of Smokey Point Boulevard and 200th Street NE at the north end of the corridor to Smokey Point Boulevard and 173rd Place NE at the south end of the Project corridor. The 300-foot distance is sufficient to make sure all project related noise impacts are identified. In addition to the north-south limits, the study area also includes noise sensitive uses east and west of the Project corridor. Even though not all individual receivers in the study area were modeled, sufficient receivers were modeled to show that all potential impacts were identified. The Project boundary and noise analysis area is found in Figure 2 and Figure 3.

## **6. AFFECTED ENVIRONMENT**

This section provides a summary of the land use in the project area, including planned and permitted developments and project related structure removal.

### **6.1. Existing Land Uses**

Land use in the Project area includes single- and multi-family homes (FHWA Category B), church (FHWA Category C), and a proposed city park (FHWA Category C). Single- and multi-family residences are found throughout the Project corridor. There are two churches in the Project corridor. The Faith Baptist Church is located between Smokey Point Boulevard and 35th Avenue NE. The Smokey Point Community Church is located east of Smokey Point Boulevard between 178th Place NE and 176th Place NE. The remaining land uses in the area are undeveloped lots and commercial uses.

Project area land uses, and noise monitoring sites, are shown in Figure 2 and Figure 3. Land use not identified in the figures are either FHWA Category E with no exterior noise sensitive use or Category F or G and is therefore not noise sensitive.

### **6.2. Zoning and Comprehensive Land Use Plan Design**

A study of the Project area indicated that the area is a mix of high density to medium density residential and commercial lands. There are no planned or approved land use changes that would affect this noise study.

### **6.3. Planned and Permitted Projects**

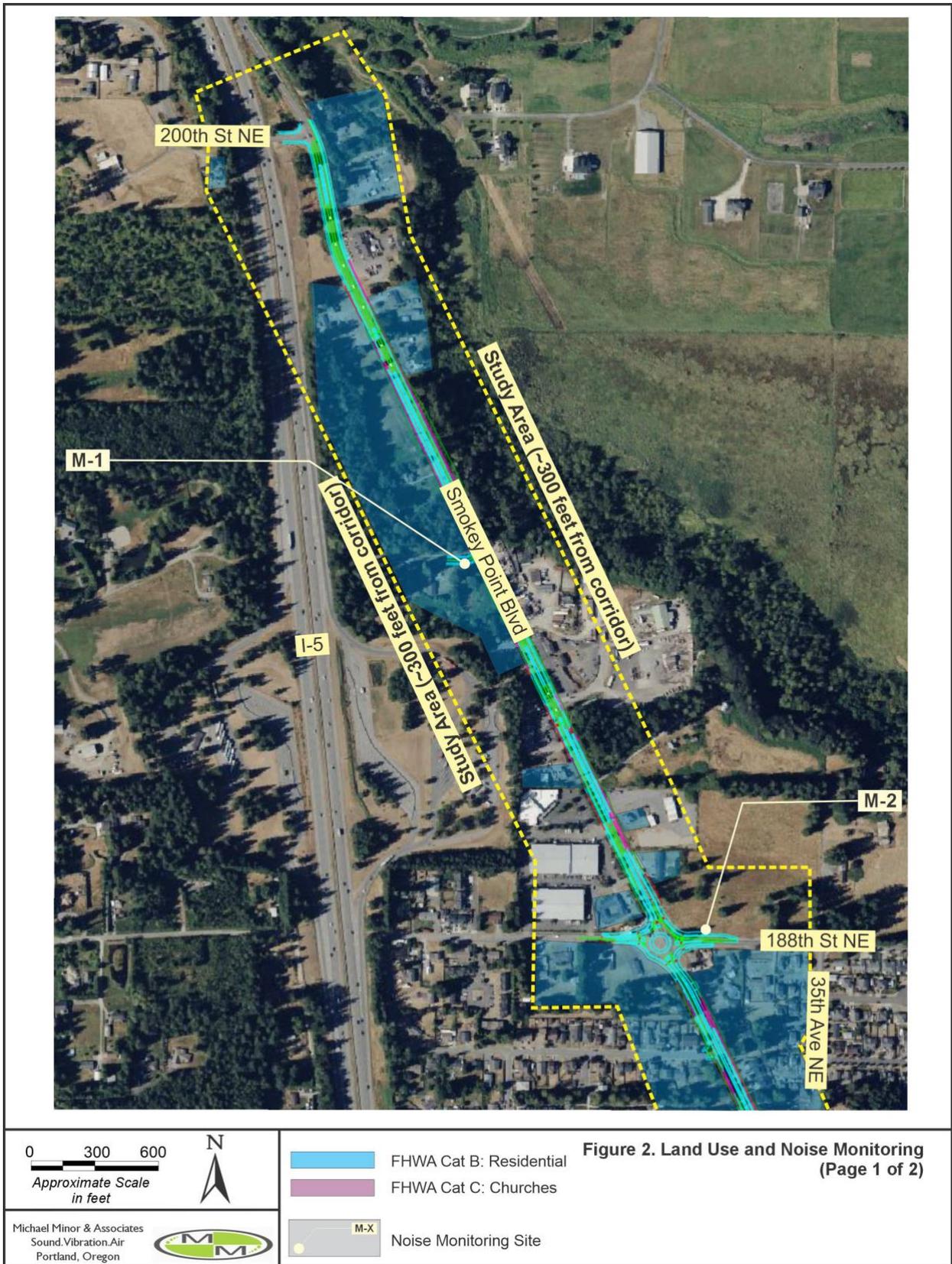
There is currently only one planned or permitted project that would affect this noise study. There is future planning for new developments along the east side of Smokey Point Boulevard, however, at the time of this report no projects have received permits from the City of Arlington.

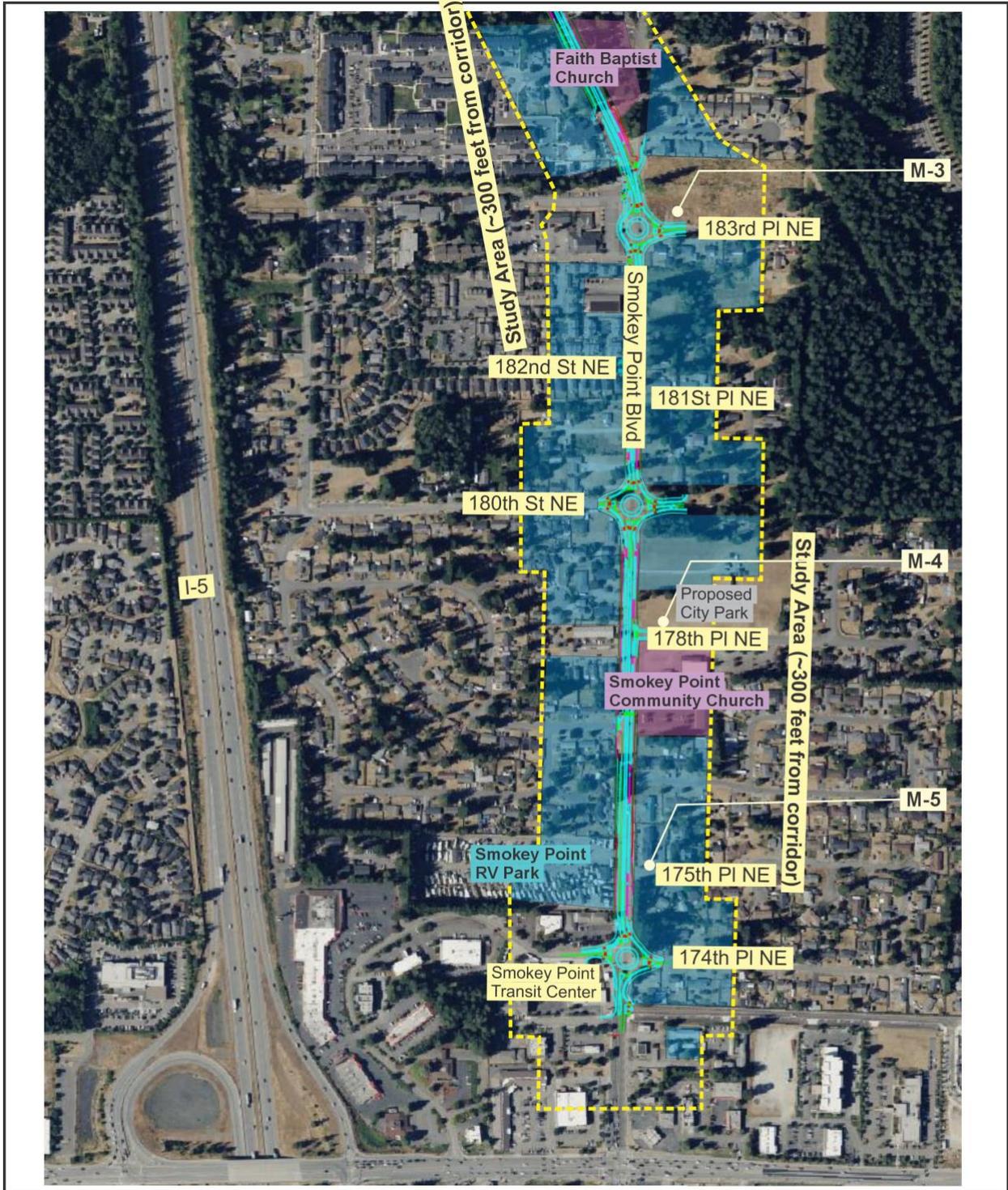
In addition, there is a city owned parcel located north of 178th Place NE that is under review for a new city park. Although the park is not yet planned or permitted, the parcel will most likely be converted to a park and therefore was included for noise planning purposes.

### **6.4. Structure Removal Due to Project Construction**

There is one displacement of a residence located east of 180th Street NE along Smokey Point Boulevard. The Longhorn Saloon Bar and Restaurant is located at 18802 Smokey Point Boulevard and will be displaced to allow for construction of the roundabout at Smokey Point Boulevard and Bjon Road.

There are no other displacements planned that would affect the transmission of noise, noise impacts, or noise abatement measures.





0 300 600  
 Approximate Scale  
 in feet

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FHWA Cat B: Residential  
 FHWA Cat C: Churches  
 M-X Noise Monitoring Site

**Figure 3. Land Use and Noise Monitoring**  
 (Page 2 of 2)

## 7. NOISE MONITORING

On-site noise monitoring and traffic counts were performed at 5 locations within the Project corridor. These sites were selected to provide noise modeling validation and to aid in the understanding of existing noise levels along the corridor. Figure 2 and Figure 3 provide an overview of the monitoring locations denoted M-1 through M-5, and detailed monitoring slides are provided in Appendix D. The noise monitoring was performed on November 17, 2023.

Noise measurements were taken in accordance with methods provided in the 2020 WSDOT Policy and in accordance with the American National Standards Institute (ANSI) procedures for community noise measurements (ANSI/ANA S12.9-2013/Part1). Traffic noise monitoring is typically collected as 15-minute Leq measurements and represent the sound-level environments in the study area, per the FHWA and WSDOT policy. The number of cars during the 15-minute window is then multiplied by four and the total is used in the TNM model to validate noise measurements. The equipment used for noise monitoring were Bruel & Kjaer Type 2238 Sound Level Meters. All meters were calibrated prior to and after the measurement period using a Bruel & Kjaer Type 4231 Sound Level Calibrator. Calibration varied by less than 0.1 dB during the measurement period. Complete system calibration is performed on an annual basis by an accredited instrument calibration laboratory. System calibration is traceable to the National Institute of Standards and Testing (NIST). The system meets or exceeds the requirements for an ANSI Type 1 noise measurement system.

### 7.1. Measurement Results

Noise Monitoring sites were located within the public right-of-way, with clear line of sight to the roadway in order to take concurrent traffic counts with the noise measurements. Noise levels ranged from 62.4 to 68.3 dBA Leq. Traffic on local roads was the primary noise source at most of the monitoring locations. Secondary noise sources included typical neighborhood activities such as dogs barking and, in some cases, small plane flyovers. The highest traffic noise measurement of 68.3 dBA Leq occurred at M-1, located along the west side of Smokey Point Boulevard between 200th Street NE and 188th Street NE. The lowest noise measurement of 62.4 dBA Leq was recorded at M-4, located along the northeast corner of Smokey Point Boulevard and 175th Place NE. Table 2 provides a summary of the measured noise levels.

<b>Site<sup>1</sup></b>	<b>Description or Address<sup>1</sup></b>	<b>Noise Level<sup>2</sup></b>
M-1	Smokey Point Boulevard between 200th Street NE and 188th Street NE	68.3
M-2	Northeast corner of Smokey Point Boulevard and 188th Street NE	65.6
M-3	Northeast corner of Smokey Point Boulevard and 183rd Place NE	62.7
M-4	Northeast corner of Smokey Point Boulevard and 178th Place NE	62.4
M-5	Northeast corner of Smokey Point Boulevard and 175th Place NE	68.0
Notes:		
1. Monitoring sites are shown in Figure 2 and Figure 3.		
2. All data is presented as an hourly Leq.		

## 8. NOISE MODELING VALIDATION AND RECEIVERS

As previously described, the noise levels used for describing the existing and future conditions are taken from the FHWA TNM. This section describes the noise model validation results and selection of receivers used for modeling noise levels related to the Smokey Point Boulevard Project.

### 8.1. Noise Model Validation

Traffic noise levels were modeled to test the agreement of calculated and measured noise levels. For model verification, the actual traffic counts and speeds as observed during the noise monitoring were used as input to the model. All five monitoring sites are in areas where traffic noise was the dominating noise source and, thereby, could be used to validate the traffic noise model. TNM was used to predict the traffic noise levels based on the traffic counts and a comparison of the measured and modeled noise levels are provided in Table 3.

<b>Receiver</b>	<b>Measured</b>	<b>Modeled</b>	<b>Difference</b>
M-1	68.3	67.0	-1.3
M-2	65.6	66.2	0.6
M-3	62.7	62.2	-0.5
M-4	62.4	61.4	-1.0
M-5	68.0	66.7	-1.3

The modeled and measured noise results agree within +/- 2dBA at both locations. Because a 2 dBA change in noise levels is barely perceptible to a person with average hearing, an agreement of +/- 2 dBA or less is considered acceptable deviation for modeled and measured

noise levels. It is important to remember that TNM only predicts noise for traffic on roadways that are included in the model, while other noise sources (most side street traffic, residential activities, maintenance, and aircraft), which will be included in the onsite monitoring data, would not be included in the traffic noise model.

## **8.2. Selection of Receivers**

Noise modeling sites were selected to represent noise-sensitive areas within the Project area, where traffic noise impacts are most likely to occur. More specifically, the receiver locations were located in areas of frequent outdoor human use such as back yards and balconies, church entrances, and parks. Because it is likely that this area will continue to grow, with several long range plans for residential developments in the near future, care was taken to make sure this analysis provided a comprehensive summary of noise levels along both sides of Smokey Point Boulevard. Therefore, in addition to receiver locations immediately adjacent to the Project roadways, modeled receiver locations were also extended beyond the distance where impacts can be modeled to verify that the full impacted area is captured. This resulted in 151 noise modeling sites that provided representative traffic noise levels for 238 residences, two churches, and one park.

## **8.3. Modeling Location Descriptions**

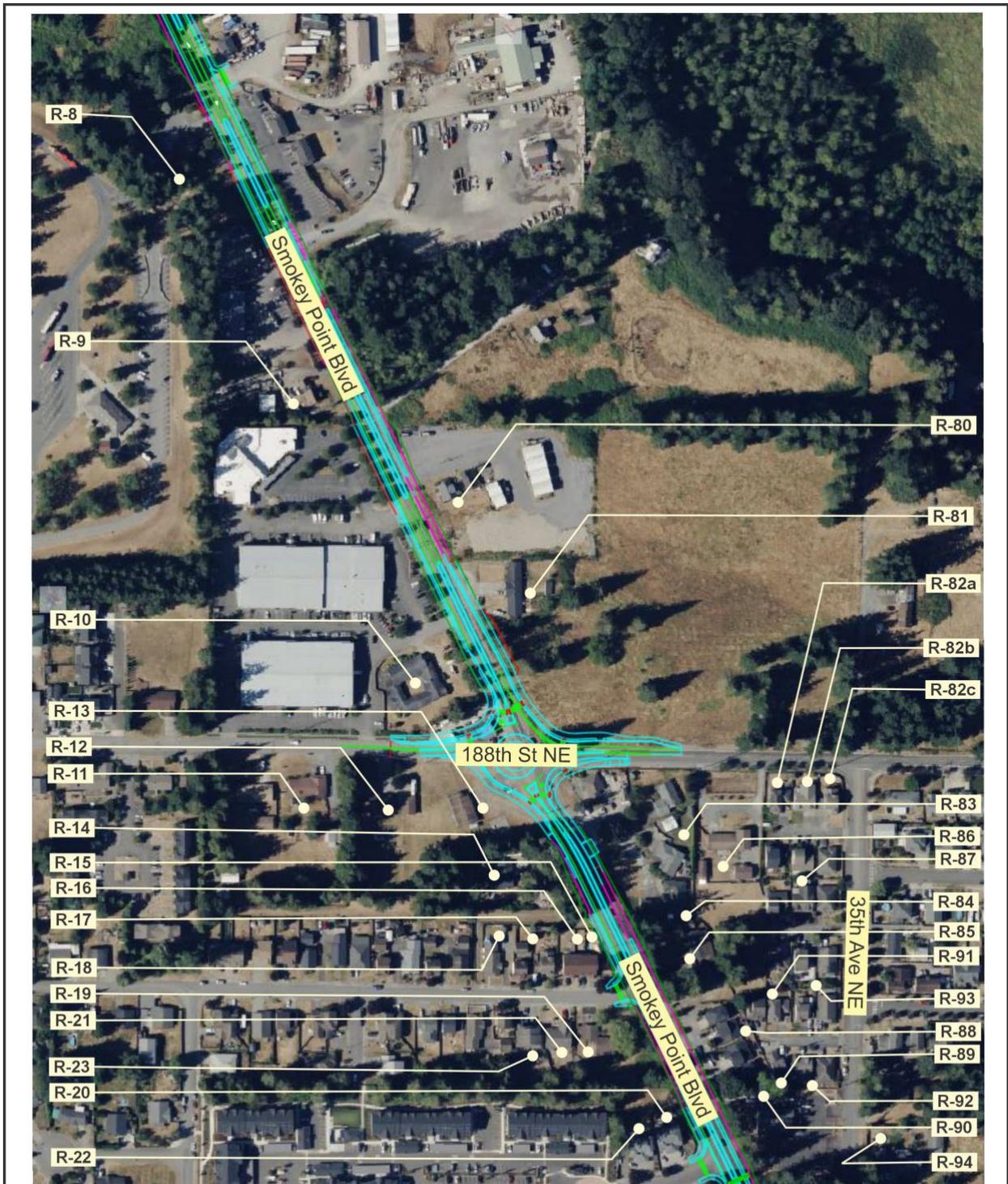
Traffic noise modeling was performed using the FHWA TNM. Existing and future traffic noise levels were predicted throughout the Project corridor at 151 locations representing 242 sensitive uses, denoted as R-1 through R-137b. In several instances, one receiver location is used to represent a group of two or more neighboring residences expected to experience similar sound levels for both existing and future conditions and have comparable noise reductions if a noise barrier was constructed. Receivers denoted as R-Xa, b, or c represent multistory apartments with outdoor use balconies or single-family residences where noise mitigation was modeled. Figures 4 through 7 provide an aerial view of all Project noise modeling locations.



**Figure 4. Modeling Locations**  
(Page 1 of 4)

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0 100 300  
 Approximate Scale  
 in feet

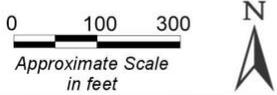
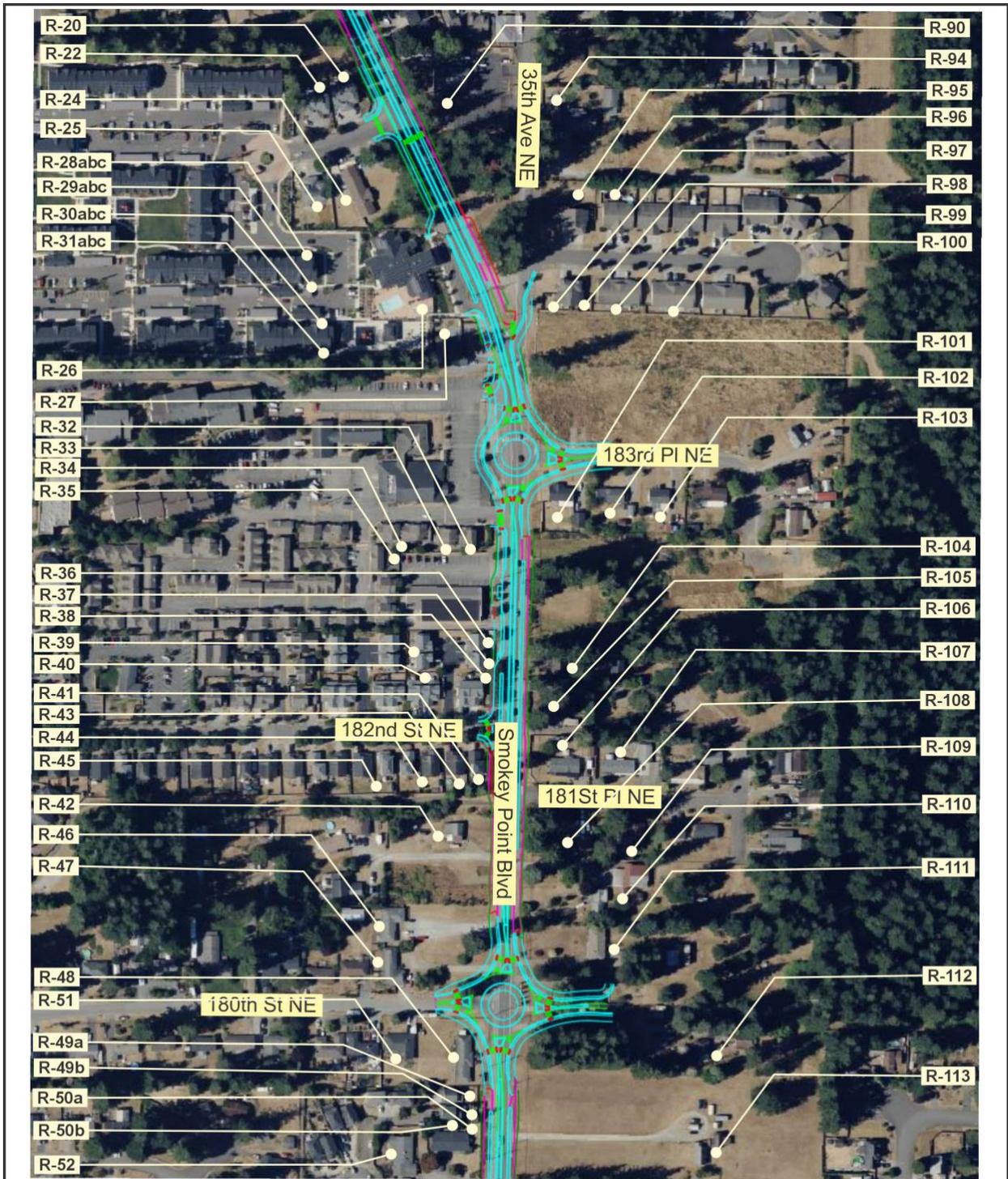
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 Sound, Vibration, Air  
 Portland, Oregon

R-X = Noise Monitoring Location

= Roadway Improvements

Figure 5. Modeling Locations  
 (Page 2 of 4)



Michael Minor & Associates  
 Sound, Vibration, Air  
 Portland, Oregon



-  = Noise Monitoring Location
-  = Roadway Improvements

**Figure 6. Modeling Locations**  
 (Page 3 of 4)



0 100 300  
Approximate Scale  
in feet

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R-X = Noise Monitoring Location

= Roadway Improvements

Figure 7. Modeling Locations  
(Page 4 of 4)

## 9. EXISTING ENVIRONMENT

Modeling was performed for 151 representative receiver locations shown in Figures 4 through 7 for the Existing conditions (year 2020) PM peak traffic hour. Inputs to the TNM model include Existing roadway conditions. Overall, noise levels ranged from 52 to 71 dBA Leq, and 16 receivers that would meet the WSDOT NAC but are not considered impacts under the Existing conditions. Receivers meeting the NAC are located along Smokey Point Boulevard and nearest to I-5 (R-1 through R-3), closest to Smokey Point Boulevard (R-62, R-67 through R-71, R-122, R-125, R-127, and R-132) or closest to 188th Street NE (R-82a through R-82b).

Table 4 provides a summary of the existing modeled traffic noise levels.

## 10. FUTURE NO-BUILD ENVIRONMENT

Noise modeling was also performed for the No-Build condition using traffic volumes projected for the year 2040. The same modeling locations used for the existing conditions were used for the No-Build conditions.

Based on the future projected traffic data for the year 2040 without the proposed Project, increased traffic volumes have resulted in increased traffic noise levels when compared to the existing conditions. Overall, noise levels ranged from 55 to 72 dBA Leq. Changes in noise levels range from 0 to +2 dB over the Existing conditions. There are 24 residences with noise levels meeting the WSDOT NAC but are not considered impacts under the future No-Build conditions. In addition to the same receivers meeting the NAC under the Existing conditions, new receivers are located along Smokey Point Boulevard and nearest to I-5 (R-7) and closest to Smokey Point Boulevard (R-36, R-37, R-120, and R-121).

Table 4 provides a summary of the No-Build modeled traffic noise levels.

## 11. FUTURE BUILD ANALYSIS

The same 151 noise modeling locations used to model the existing conditions were modeled for the Build Alternative with year 2040 PM peak hour traffic conditions. The TNM inputs include the proposed realignment of Smokey Point Boulevard and roundabouts at 188th Street NE, 183rd Place NE, 180th Street NE, and 174th Place NE and year 2040 traffic volumes and speeds prepared for the Project. The traffic noise levels for the Build Alternative are the worst-case noise levels for the year 2040.

Future Build Alternative traffic noise levels are predicted to range from 55 to 72 dBA Leq during the PM peak hour, with changes ranging from -1 to +4 dB over the Existing conditions. There are 33 residences with noise levels that meet the WSDOT NAC of 66 dBA Leq and are considered impacts under the future Build Alternative. The same residents meeting the NAC under the No-Build conditions include R-1 through R-3, R-7, R-36, R-37, R-62, R-67 through R-70, R-82a through R-82c, R-120 through R-122, R-125, R-127, and R-

132. New impacts include R-15, R-38, R-41, R-49a, R-49b, R-50a, and R-60 through R-61, where the proposed realignment moves the roadway closer to the residence and increased traffic volumes contribute to higher noise levels.

Table 4 provides a summary of the build modeled traffic noise levels. Note that this table comprises a full summary of the Existing, No-Build and Build traffic noise levels, change in noise levels and a summary of potential traffic noise impacts.

**Table 4. Traffic Noise Level Summary**

Receiver <sup>1</sup>	Land Use <sup>2</sup>	Units <sup>3</sup>	Criteria (dBA Leq) <sup>4</sup>	Existing Conditions	No-Build Conditions		Build Alternative			
				Level (Leq dBA) <sup>5</sup>	Level (Leq dBA) <sup>5</sup>	Vs. Exist (in dB) <sup>6</sup>	Level (Leq dBA) <sup>5</sup>	Vs. Exist (in dB) <sup>7</sup>	No. of Impacts <sup>8</sup>	Vs. No-Build (in dB) <sup>9</sup>
R-1	B	1	66	71	72	1	72	1	1	0
R-2	B	1	66	68	70	2	70	2	1	0
R-3	B	1	66	67	69	2	69	2	1	0
R-4	B	1	66	62	64	2	65	3	0	1
R-5	B	1	66	60	62	2	63	3	0	1
R-6	B	1	66	63	65	2	65	2	0	0
R-7	B	2	66	64	66	2	66	2	2	0
R-8	B	1	66	59	61	2	62	3	0	1
R-9	B	1	66	59	60	1	62	3	0	2
R-10	B	1	66	59	60	1	62	3	0	2
R-11	B	1	66	57	58	1	59	2	0	1
R-12	B	1	66	57	59	2	60	3	0	1
R-13	B	1	66	61	62	1	62	1	0	0
R-14	B	1	66	59	60	1	61	2	0	1
R-15	B	1	66	64	65	1	67	3	1	2
R-16	B	2	66	61	62	1	64	3	0	2
R-17	B	2	66	58	59	1	60	2	0	1
R-18	B	1	66	56	58	2	59	3	0	1
R-19	B	1	66	59	60	1	61	2	0	1
R-20	B	2	66	62	63	1	63	1	0	0
R-21	B	2	66	56	57	1	58	2	0	1
R-22	B	1	66	58	59	1	60	2	0	1
R-23	B	1	66	55	56	1	57	2	0	1
R-24	B	1	66	57	58	1	59	2	0	1
R-25	B	2	66	55	57	2	57	2	0	0
R-26	B	1	66	58	59	1	60	2	0	1
R-27	B	1	66	61	61	0	62	1	0	1

Table 4. Traffic Noise Level Summary										
Receiver <sup>1</sup>	Land Use <sup>2</sup>	Units <sup>3</sup>	Criteria (dBA Leq) <sup>4</sup>	Existing Conditions	No-Build Conditions		Build Alternative			
				Level (Leq dBA) <sup>5</sup>	Level (Leq dBA) <sup>5</sup>	Vs. Exist (in dB) <sup>6</sup>	Level (Leq dBA) <sup>5</sup>	Vs. Exist (in dB) <sup>7</sup>	No. of Impacts <sup>8</sup>	Vs. No-Build (in dB) <sup>9</sup>
R-28a <sup>10</sup>	B	2	66	54	56	2	56	2	0	0
R-28b <sup>10</sup>	B	2	66	57	59	2	59	2	0	0
R-28c <sup>10</sup>	B	2	66	59	60	1	61	2	0	1
R-29a <sup>10</sup>	B	2	66	54	55	1	56	2	0	1
R-29b <sup>10</sup>	B	2	66	57	58	1	59	2	0	1
R-29c <sup>10</sup>	B	2	66	59	60	1	61	2	0	1
R-30a <sup>10</sup>	B	2	66	54	55	1	56	2	0	1
R-30b <sup>10</sup>	B	2	66	57	58	1	59	2	0	1
R-30c <sup>10</sup>	B	2	66	59	60	1	61	2	0	1
R-31a <sup>10</sup>	B	2	66	54	55	1	56	2	0	1
R-31b <sup>10</sup>	B	2	66	57	58	1	59	2	0	1
R-31c <sup>10</sup>	B	2	66	59	60	1	61	2	0	1
R-32	B	1	66	61	62	1	64	3	0	2
R-33	B	2	66	59	60	1	61	2	0	1
R-34	B	2	66	56	57	1	59	3	0	2
R-35	B	2	66	55	56	1	57	2	0	1
R-36	B	1	66	65	66	1	69	4	1	3
R-37	B	1	66	65	66	1	68	3	1	2
R-38	B	2	66	65	65	0	68	3	2	3
R-39	B	2	66	56	57	1	59	3	0	2
R-40	B	2	66	57	58	1	59	2	0	1
R-41	B	1	66	64	64	0	66	2	1	2
R-42	B	1	66	58	59	1	60	2	0	1
R-43	B	1	66	60	61	1	62	2	0	1
R-44	B	2	66	57	58	1	59	2	0	1
R-45	B	2	66	54	56	2	57	3	0	1
R-46	B	2	66	55	57	2	57	2	0	0
R-47	B	2	66	56	57	1	58	2	0	1
R-48	B	2	66	62	63	1	63	1	0	0
R-49a	B	1	66	64	65	1	67	3	1	2

Table 4. Traffic Noise Level Summary										
Receiver <sup>1</sup>	Land Use <sup>2</sup>	Units <sup>3</sup>	Criteria (dBA Leq) <sup>4</sup>	Existing Conditions	No-Build Conditions		Build Alternative			
				Level (Leq dBA) <sup>5</sup>	Level (Leq dBA) <sup>5</sup>	Vs. Exist (in dB) <sup>6</sup>	Level (Leq dBA) <sup>5</sup>	Vs. Exist (in dB) <sup>7</sup>	No. of Impacts <sup>8</sup>	Vs. No-Build (in dB) <sup>9</sup>
R-49b	B	1	66	65	65	0	67	2	1	2
R-50a	B	1	66	65	65	0	67	2	1	2
R-50b	B	2	66	61	62	1	63	2	0	1
R-51	B	1	66	57	58	1	59	2	0	1
R-52	B	1	66	57	58	1	59	2	0	1
R-53	B	2	66	58	59	1	59	1	0	0
R-54	B	2	66	63	64	1	64	1	0	0
R-55	B	3	66	63	64	1	64	1	0	0
R-56	B	3	66	59	60	1	60	1	0	0
R-57	B	4	66	56	57	1	57	1	0	0
R-58	B	1	66	62	62	0	62	0	0	0
R-59	B	1	66	61	62	1	61	0	0	-1
R-60	B	1	66	64	65	1	66	2	1	1
R-61	B	1	66	64	65	1	66	2	1	1
R-62	B	1	66	67	68	1	69	2	1	1
R-63	B	2	66	59	60	1	59	0	0	-1
R-64	B	3	66	63	64	1	63	0	0	-1
R-65	B	1	66	60	61	1	60	0	0	-1
R-66	B	3	66	57	58	1	57	0	0	-1
R-67	B	1	66	67	68	1	69	2	1	1
R-68	B	1	66	67	68	1	68	1	1	0
R-69	B	1	66	67	68	1	68	1	1	0
R-70	B	1	66	67	68	1	67	0	1	-1
R-71	B	2	66	59	60	1	59	0	0	-1
R-72	B	4	66	62	63	1	62	0	0	-1
R-73	B	3	66	63	63	0	62	-1	0	-1
R-74	B	5	66	60	61	1	60	0	0	-1
R-75	B	1	66	56	58	2	59	3	0	1
R-76	B	1	66	58	59	1	61	3	0	2
R-77	B	1	66	62	64	2	64	2	0	0

Receiver <sup>1</sup>	Land Use <sup>2</sup>	Units <sup>3</sup>	Criteria (dBA Leq) <sup>4</sup>	Existing Conditions	No-Build Conditions		Build Alternative			
				Level (Leq dBA) <sup>5</sup>	Level (Leq dBA) <sup>5</sup>	Vs. Exist (in dB) <sup>6</sup>	Level (Leq dBA) <sup>5</sup>	Vs. Exist (in dB) <sup>7</sup>	No. of Impacts <sup>8</sup>	Vs. No-Build (in dB) <sup>9</sup>
R-78	B	1	66	61	63	2	64	3	0	1
R-79	B	1	66	61	63	2	64	3	0	1
R-80	B	1	66	58	59	1	62	4	0	3
R-81	B	2	66	58	59	1	60	2	0	1
R-82a	B	1	66	67	68	1	67	0	1	-1
R-82b	B	1	66	67	68	1	67	0	1	-1
R-82c	B	1	66	67	68	1	67	0	1	-1
R-83	B	2	66	60	61	1	61	1	0	0
R-84	B	1	66	58	59	1	60	2	0	1
R-85	B	1	66	60	61	1	62	2	0	1
R-86	C	1	66	57	58	1	58	1	0	0
R-87	B	6	66	56	57	1	56	0	0	-1
R-88	B	4	66	57	58	1	59	2	0	1
R-89	B	1	66	56	58	2	58	2	0	0
R-90	B	1	66	59	60	1	61	2	0	1
R-91	B	3	66	55	56	1	57	2	0	1
R-92	B	2	66	55	56	1	57	2	0	1
R-93	B	4	66	54	55	1	56	2	0	1
R-94	B	1	66	58	60	2	60	2	0	0
R-95	B	1	66	55	56	1	57	2	0	1
R-96	B	2	66	52	54	2	55	3	0	1
R-97	B	1	66	61	62	1	63	2	0	1
R-98	B	1	66	59	60	1	61	2	0	1
R-99	B	2	66	58	59	1	60	2	0	1
R-100	B	2	66	57	58	1	60	3	0	2
R-101	B	1	66	61	62	1	64	3	0	2
R-102	B	1	66	55	56	1	59	4	0	3
R-103	B	1	66	54	56	2	58	4	0	2
R-104	B	1	66	59	59	0	61	2	0	2
R-105	B	1	66	62	62	0	64	2	0	2

Table 4. Traffic Noise Level Summary										
Receiver <sup>1</sup>	Land Use <sup>2</sup>	Units <sup>3</sup>	Criteria (dBA Leq) <sup>4</sup>	Existing Conditions	No-Build Conditions		Build Alternative			
				Level (Leq dBA) <sup>5</sup>	Level (Leq dBA) <sup>5</sup>	Vs. Exist (in dB) <sup>6</sup>	Level (Leq dBA) <sup>5</sup>	Vs. Exist (in dB) <sup>7</sup>	No. of Impacts <sup>8</sup>	Vs. No-Build (in dB) <sup>9</sup>
R-106	B	1	66	60	61	1	63	3	0	2
R-107	B	1	66	55	56	1	58	3	0	2
R-108	B	1	66	58	59	1	61	3	0	2
R-109	B	1	66	54	55	1	58	4	0	3
R-110	C	1	66	55	56	1	58	3	0	2
R-111	C	1	66	54	55	1	58	4	0	3
R-112	C	1	66	57	59	2	59	2	0	0
R-113	B	1	66	57	58	1	59	2	0	1
R-114	B	1	66	58	59	1	60	2	0	1
R-115	B	1	66	58	59	1	59	1	0	0
R-116	B	1	66	54	55	1	56	2	0	1
R-117	B	1	66	64	65	1	65	1	0	0
R-118	B	3	66	58	59	1	59	1	0	0
R-119	B	2	66	59	60	1	60	1	0	0
R-120	B	2	66	65	66	1	66	1	2	0
R-121	B	2	66	65	66	1	66	1	2	0
R-122	B	2	66	66	66	0	66	0	2	0
R-123	B	2	66	56	57	1	58	2	0	1
R-124	B	2	66	56	57	1	57	1	0	0
R-125	B	1	66	67	68	1	66	-1	1	-2
R-126	B	1	66	61	62	1	61	0	0	-1
R-127	B	1	66	66	67	1	66	0	1	-1
R-128	B	1	66	56	57	1	57	1	0	0
R-129	B	1	66	57	59	2	58	1	0	-1
R-130	B	1	66	57	58	1	58	1	0	0
R-131	B	1	66	56	57	1	57	1	0	0
R-132	B	1	66	66	67	1	66	0	1	-1
R-133	B	1	66	59	60	1	59	0	0	-1
R-134	B	1	66	57	58	1	58	1	0	0
R-135	B	1	66	56	58	2	58	2	0	0

<b>Table 4. Traffic Noise Level Summary</b>										
Receiver <sup>1</sup>	Land Use <sup>2</sup>	Units <sup>3</sup>	Criteria (dBA Leq) <sup>4</sup>	Existing Conditions	No-Build Conditions		Build Alternative			
				Level (Leq dBA) <sup>5</sup>	Level (Leq dBA) <sup>5</sup>	Vs. Exist (in dB) <sup>6</sup>	Level (Leq dBA) <sup>5</sup>	Vs. Exist (in dB) <sup>7</sup>	No. of Impacts <sup>8</sup>	Vs. No-Build (in dB) <sup>9</sup>
R-136a <sup>10</sup>	B	4	66	58	59	1	58	0	0	-1
R-136b <sup>10</sup>	B	4	66	60	61	1	61	1	0	0
R-137a <sup>10</sup>	B	3	66	59	60	1	60	1	0	0
R-137b <sup>10</sup>	B	3	66	62	62	0	62	0	0	0
<b>Summary</b>		<b>Minimum</b>		52	54	0	55	-1	0	-2
		<b>Maximum</b>		71	72	2	72	4	2	3
		<b>Total Meeting NAC</b>								<b>33</b>
<b>Substantial increase noise impacts with future noise levels 10 dB or more above existing = 0</b>										
Notes:										
1. All receivers are shown in Figures 4 through 7.										
2. FHWA land use: See Table 1.										
3. Number of dwellings represented by each receiver. In some cases, a single receiver is used to represent more than one residence, all expected to have similar noise levels.										
4. WSDOT traffic noise abatement criteria by land use type.										
5. Predicted peak hour noise levels in dBA Leq for condition stated, taken from TNM version 2.5 with <b>bold red</b> typeface used to indicate noise levels that are equal to or greater than the NAC of 66 dBA Leq for Category B uses.										
6. Change in noise: No-Build compared to existing conditions.										
7. Change in noise: Build compared to existing conditions with <b>bold red</b> typeface used to indicate noise level increases of 10dB or greater (substantial increase impacts).										
8. Number of uses predicted to meet or exceed the WSDOT NAC, either the level criteria or substantial increase criteria.										
9. Change in noise: Build compared to No-Build for reference only.										
10. Receivers R-Xa represent first floor apartments, R-Xb represent second floor apartments, and R-Xc represent third floor apartments.										

## 12. NOISE LEVEL IMPACT SUMMARY

The following locations were identified with noise levels meeting the WSDOT NAC:

Noise Impact Summary:

- R-1: One first row receiver representing one residence located along 200th Street NE and west of I-5, where the dominant noise source is traffic from I-5. The noise level is 72 dBA Leq.
- R-2 and R-3: Two first row receivers representing 2 residences located along Smokey Point Boulevard, where the dominant noise source is traffic from I-5. The noise levels range from 69 to 70 dBA Leq.
- R-7: One first row receiver representing 2 residences located along Smokey Point Boulevard, where the dominant noise source is from increased traffic along I-5. The noise level is 66 dBA Leq.
- R-15: One first row receiver representing one residence located along Smokey Point Boulevard, where the dominant noise source is from the realignment shifting the roadway closer to the residence and increased traffic along Smokey Point Boulevard. The noise level is 67 dBA Leq.
- R-36 through R-38: Three first row receivers representing four residences located along Smokey Point Boulevard, where the dominant noise source is from increased traffic along Smokey Point Boulevard. The noise levels range from 68 to 69 dBA Leq.
- R-41: One first row receiver representing one residence located along Smokey Point Boulevard, where the dominant noise source is from increased traffic along Smokey Point Boulevard. The noise level is 66 dBA Leq.
- R-49a, R-49b, and R-50a: Three first row receivers representing three residences located along Smokey Point Boulevard, where the dominant noise source is from increased traffic along Smokey Point Boulevard. The noise levels are all the same, at 67 dBA Leq.
- R-60 through R-62: Three first row receivers representing three residences located along Smokey Point Boulevard, where the dominant noise source is from the realignment shifting the roadway closer to the residences and increased traffic along Smokey Point Boulevard. The noise levels range from 66 to 69 dBA Leq.
- R-67 through R-70: Four first row receivers representing four residences at the Smokey Point RV Park, where the dominant noise source is from increased traffic along Smokey Point Boulevard. The noise levels range from 67 to 69 dBA Leq.
- R-82a, R-82b, and R-82c: Three first row receivers representing three residences located along 188th Street NE, where the dominant noise source is traffic along 188th Street NE. Noise levels are all the same, at 67 dBA Leq.

- R-120 through R-122: Three first row receivers representing six residences located along Smokey Point Boulevard, where the dominant noise source is from increased traffic along Smokey Point Boulevard. The noise levels are all the same, at 66 dBA Leq.
- R-125 and R-127: Two first row receivers representing two residences located along Smokey Point Boulevard, where the dominant noise source is from traffic along Smokey Point Boulevard. The noise levels are the same, at 66 dBA Leq.
- R-132: One first row receiver representing one first row residence located along Smokey Point Boulevard, where the dominant noise source is from traffic along Smokey Point Boulevard. The noise level is 66 dBA Leq.

## **13. NOISE ABATEMENT ANALYSIS**

In accordance with the current 2020 WSDOT Policy, when traffic noise impacts are identified, noise abatement measures must be considered for those developments that existed or have been issued a building permit prior to the date of public knowledge of the Project. This includes identifying noise abatement measures that are feasible and reasonable and that are likely to be incorporated into the Project. In addition, the noise analysis must also identify noise impacts for which no apparent solution is available and an explanation of why noise abatement was not recommended.

Whenever noise impacts are expected, noise abatement measures, including noise barriers and earthen berms, are evaluated. Construction of noise barriers between the roadways and the affected receivers would reduce noise levels by physically blocking the transmission of traffic-generated noise. Barriers can be constructed as walls or earthen berms. Earthen berms require more right-of-way than walls and are usually constructed with a 3-to-1 slope. Noise barriers should be high enough to break the line-of-sight between the noise source and the receiver. They must also be long enough to prevent significant flanking of noise around the ends of the barriers. Due to limited right-of-way within the study area, only noise walls were considered for noise abatement.

### **13.1. WSDOT Noise Abatement Criteria**

For noise abatement to be recommended for inclusion with a project, the abatement must meet the feasibility and reasonability criteria set forth by WSDOT. Feasibility deals primarily with engineering considerations, such as whether substantial or meaningful noise level reductions can be achieved or whether there would be a negative effect on property access. Reasonableness assesses the practicality of the abatement measure based on a number of factors. Required factors are cost-effectiveness, consideration of the viewpoints of the property owners and residents of benefiting receivers, and noise abatement performance (noise reduction design goal). Details on the requirements are provided in the following sections.

### **13.1.1. Feasibility of Noise Abatement**

In evaluating whether a particular noise abatement measure is feasible, WSDOT considered acoustic and engineering, and requires the following to occur for noise abatement to be feasible:

- Abatement must be physically constructible.
- A minimum of three (3) first row impacted receivers must obtain a minimum 5 dBA of noise reduction as a result of abatement (insertion loss), assuring that every reasonable effort will be made to assess outdoor use areas as appropriate.

In general, noise barriers are ineffective at reducing traffic noise levels when constructed along roadways that have uncontrolled access points (e.g., driveways and pedestrian access) due to the openings in the noise barrier required to accommodate access. These openings can allow sufficient noise onto the property, making it difficult if not impossible to meet the required noise reduction requirement for residences adjacent to the roadway. While noise abatement measures are considered for all project-related impacts, some noise barriers that would clearly not meet the feasibility criteria are evaluated qualitatively without extensive modeling efforts.

The noise abatement must be physically constructible as well to meet feasibility requirements. WSDOT also considers engineering factors when determining feasibility. Safety factors that should be considered in the feasibility assessment of noise abatement include: maintaining a clear recovery zone, redirection of errant vehicles, ensuring adequate sight distance, and fire/emergency vehicle access. The consideration of abatement may also include potential environmental impacts to wetlands, property access, placement of utilities and stormwater control facilities, and construction on steep slopes. Engineering considerations should be made in concert with the project engineering office.

### **13.1.2. Reasonableness of Noise Abatement**

Once noise abatement is determined feasible, the abatement is evaluated for its reasonableness. Two primary criteria are used in considering the reasonableness of a particular abatement measure: cost-effectiveness and the WSDOT design goal achievement. In areas where homes are scattered too far apart for noise barriers to be built at a reasonable cost, the noise abatement analysis is limited to qualitative discussion without extensive modeling efforts.

### **13.1.3. Cost Effectiveness**

The cost of noise abatement sufficient to provide at least the minimum feasible noise reductions must be equal to or less than the allowable cost of abatement for each noise wall location analyzed. The current average cost used for a Washington State Type I project is \$51.61 per square foot of noise wall (WSDOT 2020).

Either the barrier size or cost outlined in Table 5 below can be used to describe the reasonableness evaluation. However, a cost description must be included if there are non-

standard additional costs, or costs that would not occur “but for” the barrier (e.g., additional foundation costs for steep slopes, unique drainage requirements). Additional cost estimates for abatement are added to the planning-level costs as part of the reasonableness evaluation.

Barriers are evaluated independently for feasibility and reasonableness, with some exceptions for barrier systems. On projects where noise barriers are considered for multiple locations, a feasibility and reasonableness evaluation will be done for each area independently.

Allowable costs are shown in Table 5 and are a function of the current planning-level barrier cost (\$51.61 per square foot in 2020) multiplied by the allowable wall size for the receiver benefiting from the noise wall. The table shows the allowable costs for each receiver based on the predicted Build Alternative noise levels or sound level increases. Higher noise levels, or larger sound level increases, are allowed more money for abatement.

The cost evaluation used to determine WSDOT planning-level cost estimates for a standard noise wall includes the following:

- 1) Noise barrier construction labor and materials, including clearing and grubbing and the acquisition of property needed for the noise barrier;
- 2) Traffic management measures, as necessary only for the barrier construction;
- 3) A percent of the total project’s workforce mobilization costs; and
- 4) Sales tax.

<b>Table 5. Reasonableness Allowances</b>			
<b>Column A</b>	<b>Column B</b>	<b>Column C</b>	<b>Column D</b>
<b>Design Year Traffic Sound Decibel Level (dBA)</b>	<b>Noise level increase as a result of the Project (dBA)<sup>2</sup></b>	<b>Allowed Wall Surface Area Per Qualified Residence or Residential Equivalent</b>	<b>Allowed Cost Per Qualified Residence or Residential Equivalent<sup>1</sup></b>
66		700 Sq. Feet	\$36,127
67		768 Sq. Feet	\$39,636
68		836 Sq. Feet	\$43,146
69		904 Sq. Feet	\$46,655
70		972 Sq. Feet	\$50,165
71	10 (substantial, step 1) <sup>3</sup>	1,040 Sq. Feet	\$53,674
72	11 (substantial, step 1)	1,108 Sq. Feet	\$57,184
73	12 (substantial, step 1)	1,176 Sq. Feet	\$60,693
74	13 (substantial, step 1)	1,244 Sq. Feet	\$64,203
75	14 (substantial, step 1)	1,312 Sq. Feet	\$67,712
76	15 (substantial, step 2) <sup>4</sup>	1,380 Sq. Feet	\$71,222
<b>Notes:</b> <ol style="list-style-type: none"> <li>Current costs based on \$51.61 per square foot constructed cost developed in 2020.</li> <li>If the noise level increases 10 dBA or more as the result of the project (Column B), follow the allowed wall surface and cost for the level of increase in Column C in lieu of the total design year sound decibel level in Column A. For total highway related sound levels at 76 or more dBA or the project results in an increase of 15 or more decibels, continue increasing the allowance at the rate provided in this table unless circumstances determined on a case-by-case basis require an alternative methodology for determining allowance.</li> <li>Step 1 is when the noise levels are 10 to 14 dBA over existing conditions traffic noise as a result of the transportation project.</li> <li>Step 2 is when the noise levels are 15 or more dBA over existing conditions traffic noise as a result of the transportation project (or total highway related noise levels are between 76 and 79 decibels). Additional consideration for abatement may be considered under these circumstances.</li> <li>Sq. Feet = square feet.</li> </ol>			

### 13.1.4. Design Goal Achievement

The minimum design goal for abatement is at least 7 dBA of reduction for one receiver. Noise walls cannot be recommended if they do not achieve the design goal. In addition to the design goal requirement, WSDOT will make a reasonable effort to achieve a 10 dBA or greater insertion loss (noise reduction) at the first row of receivers for all projects where abatement is recommended.

### 13.1.5. Other Considerations

A larger noise barrier than the minimum feasible and reasonable size shall be constructed when a barrier is highly cost-effective. A barrier is considered highly cost-effective when it reduces noise levels behind the barrier by 10 dBA, or more, for the majority of first row receivers at less than 75 percent of the maximum reasonable cost allowed for abatement.

### 13.1.6. Summary of Abatement Requirements

In summary, in order to be recommended for construction, noise abatement must meet the three criteria:

- 1) **Feasibility:** At least three first row receivers with noise impacts must have an insertion loss (noise reduction) of 5 dB or more.
- 2) **Reasonableness:** The total allowable cost or square footage (SF) for benefited receivers (using the allowable cost or SF from Table 5), must equal or exceed the costs or SF of the noise abatement measure (noise barrier).
- 3) **Design Goal (falls under the Reasonableness criteria):** At least one receiver must have a noise reduction of 7 dB (insertion loss of 7 dB or more).

For any considered noise abatement, these three criteria are reviewed, in order. If, for example, the Feasibility Criteria cannot be met, there will be no comparison of the Reasonability or Design Goal criteria.

## 13.2. Noise Abatement Measures

Noise abatement was not modeled for receivers R-1 through R-3, R-7, R-15, R-41, R-60 through R-62, R-67 through R-70, R-125, R-127, and R-132. WSDOT policy requires at least three first row receivers in an area with noise impacts before a wall can be considered or where receivers are not separated by driveways. Therefore, abatement in these areas would not meet the feasibility requirement since there would only be groups of 1 or 2 receivers or receivers separated by driveways for any potential noise wall.

### 13.2.1. 188th Wall

Under WSDOT policy, project noise impacts within the study area must be considered for noise abatement even if they are outside the project construction limits. For this project this would include receivers along 188th Street that are approximately 185 feet from the construction limits. Because there are impacts, noise abatement must be considered and continued with logical termini for the abatement, which is the next intersection or where there are no additional impacts.

Noise impacts were identified at three receivers (R-82a, R-82b, and R-82c) representing three residences along 188th Street NE and east of Smokey Point Boulevard. A noise wall was modeled R-82a through R-82c, which are all first row receivers. Figure 8 shows the location of the wall on an aerial photo with the proposed roadway improvements and nearby receiver locations. The wall location on Figure 8, which follows the fence line, is approximate and provided for informational purposes only.

The noise wall has a total length of approximately 157 feet and has panel heights of 7 to 8-feet. Using the standard cost from WSDOT of \$51.61 per square foot, the cost of the wall is \$57,752, with an available capital of \$118,908, making the wall cost effective. The wall would also meet WSDOT requirements for feasible noise abatement by reducing noise levels by 5 to 7 dB at the three impacted first row residences, meeting the necessary insertion loss

requirement of at least 5 dB at three residences and the required 7 dB insertion loss for at least one receiver. Therefore, the wall is both reasonable and feasible under WSDOT criteria.

A summary of the noise wall performance is provided in Table 6. The table provides the receiver numbers, units represented, future noise levels, future noise levels with the noise wall, noise reduction, and receivers benefited. The noise wall length and heights may be revised during final design. During final design additional elevations for the base of the wall will be provided and the updated elevations could result in a slight change in the noise wall heights.

<b>Table 6. 188th Wall: Receivers R-82a, R-82b, and R-82c</b>								
<b>Receiver Information</b>			<b>Abatement Noise Levels (dBA Leq) and Benefit</b>				<b>Wall Sq Ft and Cost</b>	
<b>Rec#<sup>1</sup></b>	<b>Units<sup>2</sup></b>	<b>First Row<sup>3</sup></b>	<b>Future Build<sup>4</sup></b>	<b>Build with Wall<sup>5</sup></b>	<b>Insertion Loss<sup>6</sup></b>	<b>Benefited (&gt;5 dB)<sup>7</sup></b>	<b>Allowed \$<sup>8</sup></b>	<b>Allowed Sq Ft<sup>9</sup></b>
R-82a	1	Y	67	62	5	Yes	\$39,636	768
R-82b	1	Y	67	62	5	Yes	\$39,636	768
R-82c	1	Y	67	60	7	Yes	\$39,636	768
<b>Criteria Verification Noise Abatement Measure</b>								
<b>Requirement for at least three first row impacts &gt;5dB<sup>10</sup></b>							<b>3 of 3</b>	<b>Yes</b>
<b>Requirement for reasonable noise abatement cost (Sq.-Ft)<sup>11</sup></b>				<b>Available Capital (Sq Ft) (from benefited receivers)</b>			<b>\$118,908</b>	<b>2,304</b>
				<b>Wall Cost (Sq Ft)</b>			<b>\$57,752</b>	<b>1,119</b>
				<b>Available minus Cost &gt; 0: Yes</b>			<b>\$61,156</b>	<b>1,185</b>
<b>Max insertion loss from abatement<sup>12</sup></b>							<b>&gt;=7</b>	<b>Yes (7 dB)</b>
<b>Notes:</b> <ol style="list-style-type: none"> <li>Receivers shown in Figure 8 with the noise wall evaluated.</li> <li>Number of units with the same noise level.</li> <li>First row receivers are directly adjacent to the project roadway.</li> <li>Future Build Noise levels from TNM.</li> <li>Future Build noise levels with the noise wall evaluated from TNM.</li> <li>Insertion loss, in decibels, of the noise wall evaluated.</li> <li>Identifies receivers that are considered benefited under WSDOT policy (5 dB or more insertion loss).</li> <li>Allowable cost per qualified residence from Table 5.</li> <li>Allowable wall surface area per qualified residence from Table 5.</li> <li>Insertion loss for three first row receivers with impacts must be 5 dB or more.</li> <li>Comparison of the allowable cost/sq. ft. to the actual cost/sq. ft. must be a positive number to meet the criteria.</li> <li>Maximum insertion loss, must be 7 dB or more.</li> </ol>								



<p>0 25 50</p> <p>Approximate Scale</p> <p>N</p>	<p>Michael Minor &amp; Associates Sound, Vibration, Air Portland, Oregon</p>	<p>R-X = Noise Modeling Location</p> <p>--- = Noise Wall Location and Height</p>	<p>Figure 8. 188th Wall</p>
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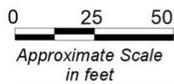
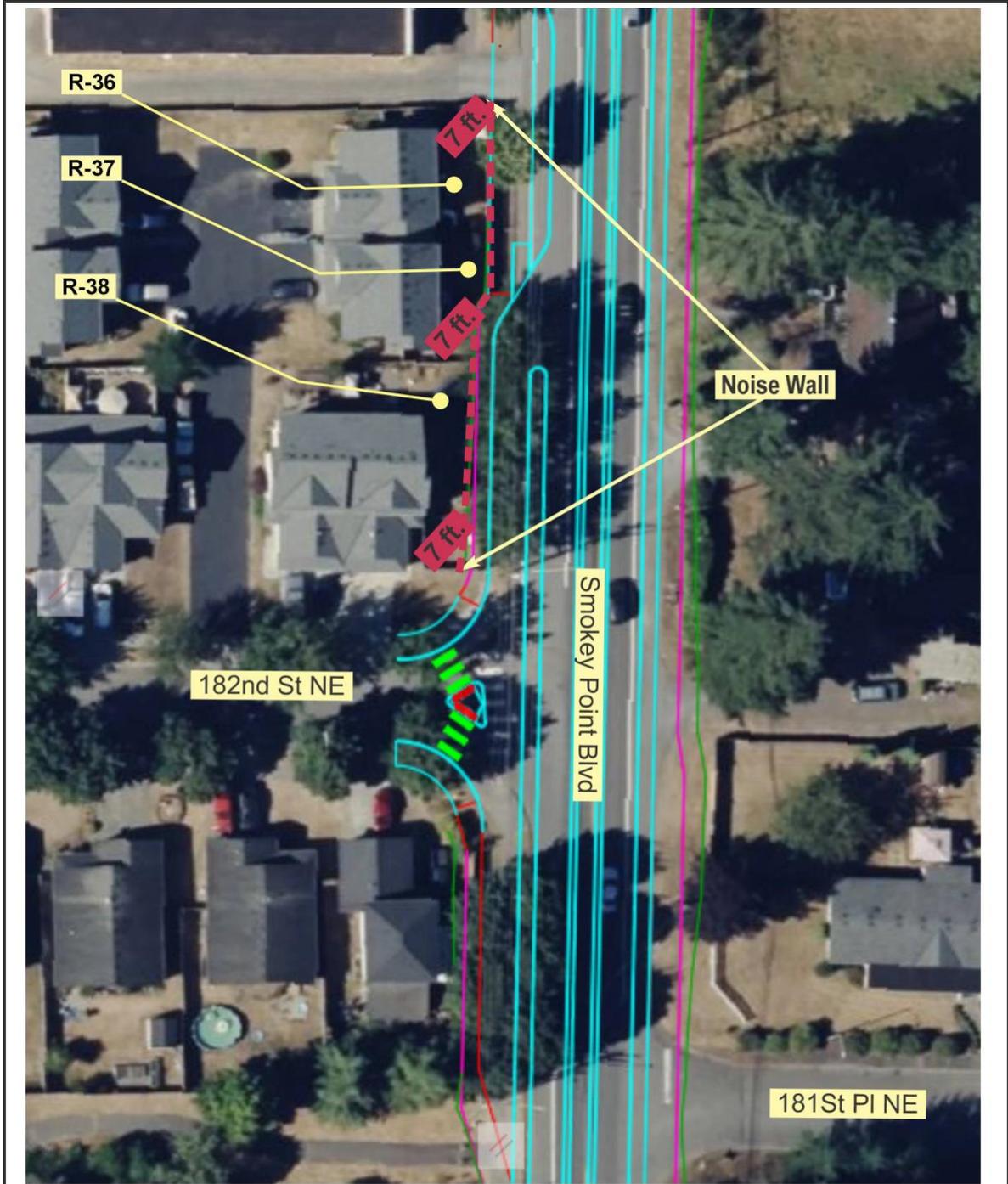
### **13.2.2. Smokey Point Wall 1**

Noise impacts were identified at three receivers (R-36, R-37, and R-38) representing four residences along the west side of Smokey Point Boulevard and north of 182nd Street NE. A noise wall was modeled for R-36 through R-38, which are all first row receivers. Figure 9 shows the location of the wall on an aerial photo with the proposed roadway improvements and nearby receiver locations. The wall location on Figure 9, which follows the back of the proposed sidewalk, is approximate and provided for informational purposes only.

The noise wall has a total length of approximately 159 feet and has panel heights of 7-feet throughout. Using the standard cost from WSDOT of \$51.61 per square foot, the cost of the wall is \$57,597, with an available capital of \$176,093, making the wall cost effective. The wall would also meet WSDOT requirements for feasible noise abatement by reducing noise levels by 7 dB at all three impacted first row residences, meeting the necessary insertion loss requirement of at least 5 dB at three residences and the required 7 dB insertion loss for at least one receiver. Therefore, the wall is both reasonable and feasible under WSDOT criteria.

A summary of the noise wall performance is provided in Table 7. The table provides the receiver numbers, units represented, future noise levels, future noise levels with the noise wall, noise reduction, and receivers benefited. The noise wall length and heights may be revised during final design. During final design additional elevations for the base of the wall will be provided and the updated elevations could result in slight changes in the noise wall heights.

<b>Table 7. Smokey Point Wall 1: Receivers R-36 through R-38</b>								
<b>Receiver Information</b>			<b>Abatement Noise Levels (dBA Leq) and Benefit</b>				<b>Wall Sq Ft and Cost</b>	
<b>Rec#<sup>1</sup></b>	<b>Units<sup>2</sup></b>	<b>First Row<sup>3</sup></b>	<b>Future Build<sup>4</sup></b>	<b>Build with Wall<sup>5</sup></b>	<b>Insertion Loss<sup>6</sup></b>	<b>Benefited (&gt;5 dB)<sup>7</sup></b>	<b>Allowed \$<sup>8</sup></b>	<b>Allowed Sq Ft<sup>9</sup></b>
R-36	1	Y	69	62	7	Yes	\$46,655	904
R-37	1	Y	68	61	7	Yes	\$43,146	836
R-38	2	Y	68	61	7	Yes	\$86,292	1,672
<b>Criteria Verification Noise Abatement Measure</b>								
<b>Requirement for at least three first row impacts &gt;5dB<sup>10</sup></b>							<b>4 of 4</b>	<b>Yes</b>
<b>Requirement for reasonable noise abatement cost (Sq.-Ft)<sup>11</sup></b>				<b>Available Capital (Sq Ft) (from benefited receivers)</b>			<b>\$176,093</b>	<b>3,412</b>
				<b>Wall Cost (Sq Ft)</b>			<b>\$57,597</b>	<b>1,116</b>
				<b>Available minus Cost &gt; 0: Yes</b>			<b>\$118,496</b>	<b>2,296</b>
<b>Max insertion loss from abatement<sup>12</sup></b>							<b>&gt;=7</b>	<b>Yes (7 dB)</b>
<b>Notes:</b> <ol style="list-style-type: none"> <li>1. Receivers shown in Figure 9 with the noise wall evaluated.</li> <li>2. Number of units with the same noise level.</li> <li>3. First row receivers are directly adjacent to the project roadway.</li> <li>4. Future Build Noise levels from TNM.</li> <li>5. Future Build noise levels with the noise wall evaluated from TNM.</li> <li>6. Insertion loss, in decibels, of the noise wall evaluated.</li> <li>7. Identifies receivers that are considered benefited under WSDOT policy (5 dB or more insertion loss).</li> <li>8. Allowable cost per qualified residence from Table 5.</li> <li>9. Allowable wall surface area per qualified residence from Table 5.</li> <li>10. Insertion loss for three first row receivers with impacts must be 5 dB or more.</li> <li>11. Comparison of the allowable cost/sq. ft. to the actual cost/sq. ft. must be a positive number to meet the criteria.</li> <li>12. Maximum insertion loss, must be 7 dB or more.</li> </ol>								



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-  = Noise Modeling Location
-  = Noise Wall Location and Height

Figure 9. Smokey Point Wall 1

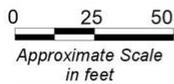
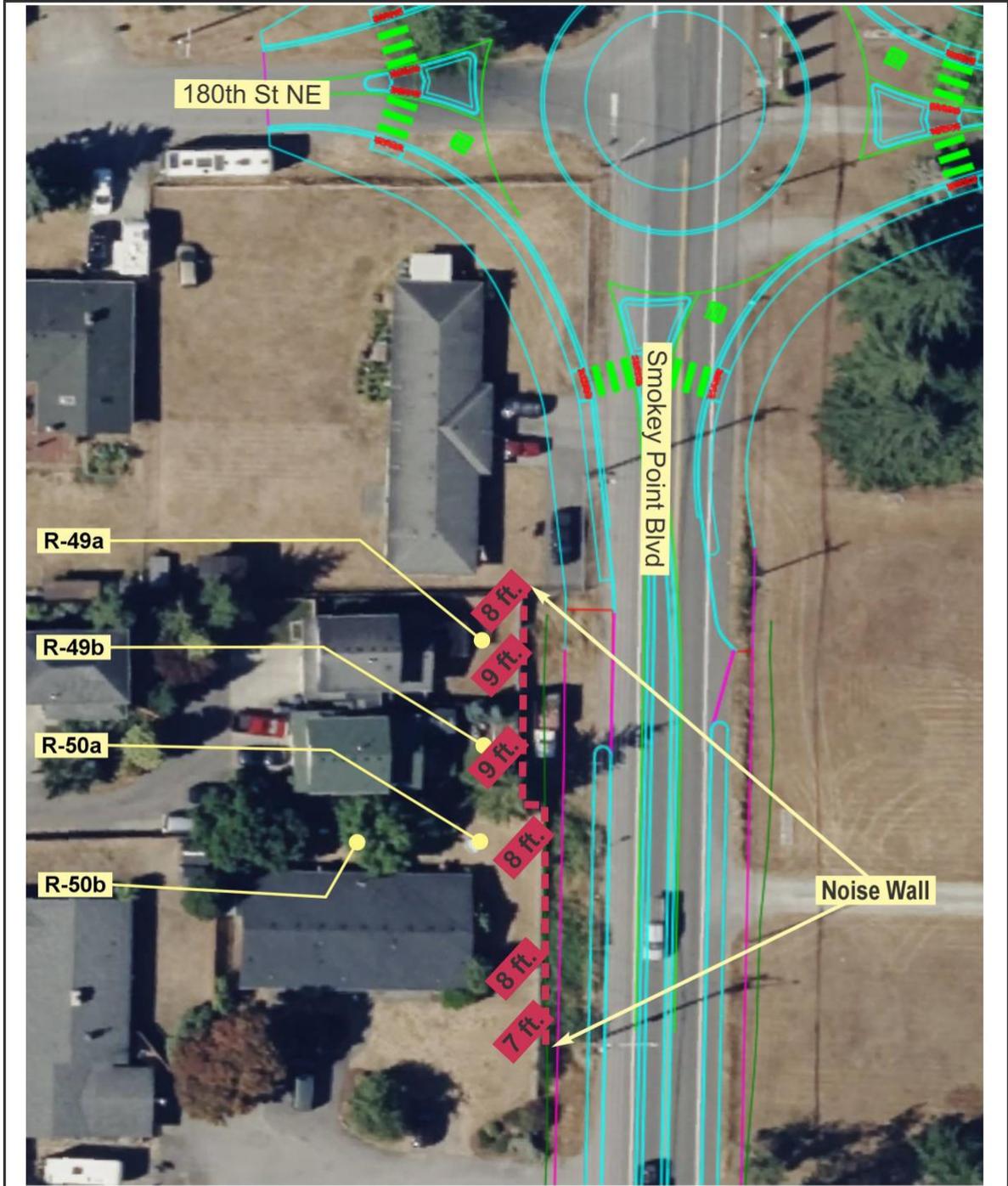
### 13.2.3. Smokey Point Wall 2

Noise impacts were identified at three receivers (R-49a, R-49b, and R-50a) representing three residences along the west side of Smokey Point Boulevard and south of 180th Street NE. A wall was modeled for R-49a, R-49b, R-50a, and R-50b, all but R-50b are first row receivers. For this analysis the wall was located along the existing fence line, however, during final design the actual location of the wall may change due to right-of-way requirements and property lines. Modification to the wall location is not expected to affect the overall effectiveness or cost of the wall. Figure 10 shows the location of the wall on an aerial photo with the proposed roadway improvements and nearby receiver locations. The wall location on Figure 10 is approximate and provided for informational purposes only.

The noise wall has a total length of approximately 155 feet and has panel heights of 6- to 9-feet. Using the standard cost from WSDOT of \$51.61 per square foot, the cost of the wall is \$65,338, with an available capital of \$118,908, making the wall cost effective. The wall would also meet WSDOT requirements for feasible noise abatement by reducing noise levels by 5 to 7 dB at all impacted first row residences, meeting the necessary insertion loss requirement of at least 5 dB at three residences and the required 7 dB insertion loss for at least one receiver. Therefore, the wall is both reasonable and feasible under WSDOT criteria.

A summary of the noise wall performance is provided in Table 8. The table provides the receiver numbers, units represented, future noise levels, future noise levels with the noise wall, noise reduction, and receivers benefited. The noise wall length and heights may be revised during final design. During final design additional elevations for the base of the wall will be provided and the updated elevations could result in slight changes in the noise wall location and heights.

Receiver Information			Abatement Noise Levels (dBA Leq) and Benefit				Wall Sq Ft and Cost	
Rec# <sup>1</sup>	Units <sup>2</sup>	First Row <sup>3</sup>	Future Build <sup>4</sup>	Build with Wall <sup>5</sup>	Insertion Loss <sup>6</sup>	Benefited (>5 dB) <sup>7</sup>	Allowed \$ <sup>8</sup>	Allowed Sq Ft <sup>9</sup>
R-49a	1	Y	67	62	5	Yes	\$39,636	768
R-49b	1	Y	67	60	7	Yes	\$39,636	768
R-50a	1	Y	67	62	5	Yes	\$39,636	768
R-50b	2	N	63	59	4	No	\$0	0
<b>Criteria Verification Noise Abatement Measure</b>								
<b>Requirement for at least three first row impacts &gt;5dB<sup>10</sup></b>							<b>3 of 3</b>	<b>Yes</b>
<b>Requirement for reasonable noise abatement cost (Sq.-Ft)<sup>11</sup></b>				<b>Available Capital (Sq Ft) (from benefited receivers)</b>			<b>\$118,908</b>	<b>2,304</b>
				<b>Wall Cost (Sq Ft)</b>			<b>\$65,338</b>	<b>1,266</b>
				<b>Available minus Cost &gt; 0: Yes</b>			<b>\$53,570</b>	<b>1,038</b>
<b>Max insertion loss from abatement<sup>12</sup></b>							<b>&gt;=7</b>	<b>Yes (7 dB)</b>
Notes: <ol style="list-style-type: none"> <li>1. Receivers shown in Figure 10 with the noise wall evaluated.</li> <li>2. Number of units with the same noise level.</li> <li>3. First row receivers are directly adjacent to the project roadway.</li> <li>4. Future Build Noise levels from TNM.</li> <li>5. Future Build noise levels with the noise wall evaluated from TNM.</li> <li>6. Insertion loss, in decibels, of the noise wall evaluated.</li> <li>7. Identifies receivers that are considered benefited under WSDOT policy (5 dB or more insertion loss).</li> <li>8. Allowable cost per qualified residence from Table 5.</li> <li>9. Allowable wall surface area per qualified residence from Table 5.</li> <li>10. Insertion loss for three first row receivers with impacts must be 5 dB or more.</li> <li>11. Comparison of the allowable cost/sq. ft. to the actual cost/sq. ft. must be a positive number to meet the criteria.</li> <li>12. Maximum insertion loss, must be 7 dB or more.</li> </ol>								



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R-X = Noise Modeling Location

--- = Noise Wall Location and Height

Figure 10. Smokey Point Wall 2

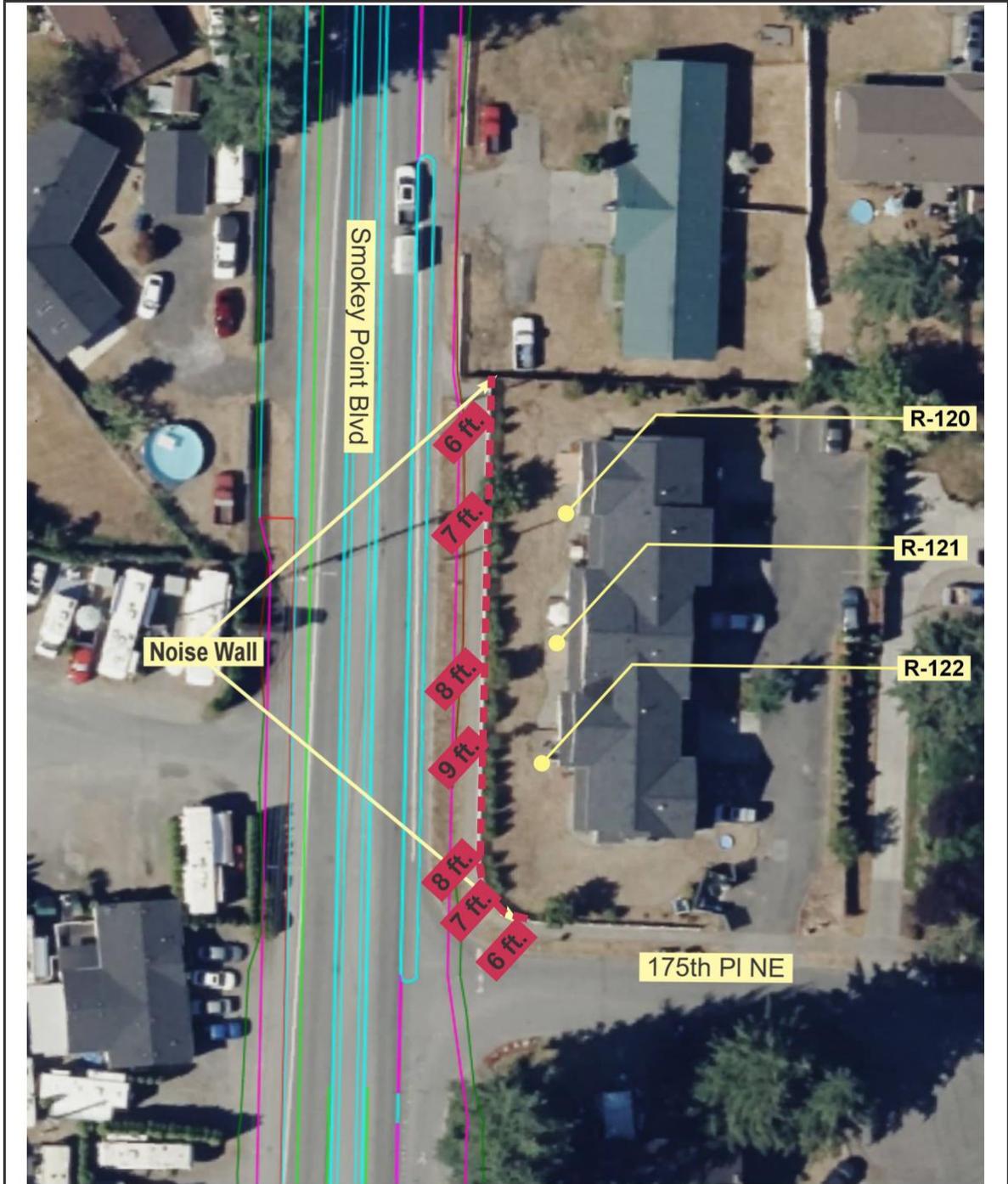
### 13.2.4. Smokey Point Wall 3

Noise impacts were identified at three receivers (R-120 through R-122) representing six residences along the east side of Smokey Point Boulevard and north of 175th Place NE. A wall was modeled for R-120 through R-122, all are first row receivers. Figure 11 shows the location of the wall on an aerial photo with the proposed roadway improvements and nearby receiver locations. The wall location on Figure 11, which follows the fence line, is approximate and provided for informational purposes only.

The noise wall has a total length of approximately 186 feet and has panel heights of 6- to 9- feet. Using the standard cost from WSDOT of \$51.61 per square foot, the cost of the wall is \$72,615, with an available capital of \$216,762, making the wall cost effective. The wall would also meet WSDOT requirements for feasible noise abatement by reducing noise levels by 5 to 7 dB at all impacted first row residences, meeting the necessary insertion loss requirement of at least 5 dB at three residences and the required 7 dB insertion loss for at least one receiver. Therefore, the wall is both reasonable and feasible under WSDOT criteria.

A summary of the noise wall performance is provided in Table 9. The table provides the receiver numbers, units represented, future noise levels, future noise levels with the noise wall, noise reduction, and receivers benefited. The noise wall length and heights may be revised during final design. During final design additional elevations for the base of the wall will be provided and the updated elevations could result in a slight change in the noise wall heights.

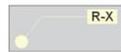
<b>Table 9. Smokey Point Wall 3: Receivers R-120 through R-122</b>								
<b>Receiver Information</b>			<b>Abatement Noise Levels (dBA Leq) and Benefit</b>				<b>Wall Sq Ft and Cost</b>	
<b>Rec#<sup>1</sup></b>	<b>Units<sup>2</sup></b>	<b>First Row<sup>3</sup></b>	<b>Future Build<sup>4</sup></b>	<b>Build with Wall<sup>5</sup></b>	<b>Insertion Loss<sup>6</sup></b>	<b>Benefited (&gt;5 dB)<sup>7</sup></b>	<b>Allowed \$<sup>8</sup></b>	<b>Allowed Sq Ft<sup>9</sup></b>
R-120	2	Y	66	61	5	Yes	\$72,254	1,400
R-121	2	Y	66	60	6	Yes	\$72,254	1,400
R-122	2	Y	66	59	7	Yes	\$72,254	1,400
<b>Criteria Verification Noise Abatement Measure</b>								
<b>Requirement for at least three first row impacts &gt;5dB<sup>10</sup></b>							<b>3 of 3</b>	<b>Yes</b>
<b>Requirement for reasonable noise abatement cost (Sq.-Ft)<sup>11</sup></b>				<b>Available Capital (Sq Ft) (from benefited receivers)</b>			<b>\$216,762</b>	<b>4,200</b>
				<b>Wall Cost (Sq Ft)</b>			<b>\$72,615</b>	<b>1,407</b>
				<b>Available minus Cost &gt; 0: Yes</b>			<b>\$144,147</b>	<b>2,793</b>
<b>Max insertion loss from abatement<sup>12</sup></b>							<b>&gt;=7</b>	<b>Yes (7 dB)</b>
<b>Notes:</b> <ol style="list-style-type: none"> <li>1. Receivers shown in Figure 11 with the noise wall evaluated.</li> <li>2. Number of units with the same noise level.</li> <li>3. First row receivers are directly adjacent to the project roadway.</li> <li>4. Future Build Noise levels from TNM.</li> <li>5. Future Build noise levels with the noise wall evaluated from TNM.</li> <li>6. Insertion loss, in decibels, of the noise wall evaluated.</li> <li>7. Identifies receivers that are considered benefited under WSDOT policy (5 dB or more insertion loss).</li> <li>8. Allowable cost per qualified residence from Table 5.</li> <li>9. Allowable wall surface area per qualified residence from Table 5.</li> <li>10. Insertion loss for three first row receivers with impacts must be 5 dB or more.</li> <li>11. Comparison of the allowable cost/sq. ft. to the actual cost/sq. ft. must be a positive number to meet the criteria.</li> <li>12. Maximum insertion loss, must be 7 dB or more.</li> </ol>								



0 25 50  
Approximate Scale  
in feet



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= Noise Modeling Location

--- = Noise Wall Location and Height

Figure 11. Smokey Point Wall 3

## 14. 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 90 dBA at sites 50 feet from the activities. Table 10 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.

<b>Table 10. Construction Equipment List, Use, and Reference Maximum Noise Levels</b>		
<b>Equipment</b>	<b>Typical Expected Project Use</b>	<b>Lmax<sup>a</sup></b>
Air Compressor	Used for pneumatic tools and general maintenance	78-80
Backhoe	General construction and yard work	78-80
Compactor	Roadway surfacing	80-83
Concrete Pump	Pumping concrete	81-82
Concrete Saw	Concrete removal, utilities access	90
Crane	Materials handling, removal, and replacement	81-85
Excavator	General construction and materials handling	81-85
Haul Truck	Materials handling, general hauling	76-84
Jackhammer	Pavement removal	85-89
Loader	General construction and materials handling	79-80
Paving	Roadway paving	77-85
Power Plant	General construction use, nighttime work	70-73
Pump	General construction use, water removal	77-81
Pneumatic Tools	Miscellaneous construction work	85
Service Truck	Repair and maintenance of equipment	55-75
Tractor Trailer	Material removal and delivery	74-84
Welder	General project work	76
Source: FHWA RCNM User's Guide		

### 14.1. Construction Noise Levels

Major noise-producing equipment in use during initial site preparation would include saw cutters, concrete pumps, cranes, excavators, haul trucks, loaders, tractor-trailers, and vibratory equipment. Maximum noise levels could reach 82 to 90 dBA at the nearest noise sensitive areas (i.e., within 50 to 100 feet) for normal construction activities during this phase. Other less notable noise-producing equipment expected to be used during this phase would be backhoes, air compressors, forklifts, pumps, power plants, service trucks and utility trucks.

Following heavy construction, general construction would still be required, such as installation of signage as well as other miscellaneous activities such as roadway stripping. These less intensive activities are not expected to produce noise levels above 80 dBA at 50 feet except during rare occasions. Even then, noise levels from these activities would exceed 80 dBA at 50 feet only for short periods of time, during which combined maximum noise levels could reach 86 dBA Lmax at 50 feet.

## **14.2. Construction Noise Mitigation Measures**

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 Environmental Protection Agency (EPA) equipment noise standards.
- Any nighttime work would require a noise variance from the city of Arlington. The contractor would be required to follow all procedures and requirements provided in any noise variance if received from the city.
- Minimize noise by regular inspection and replacement of defective mufflers and parts that do not meet the manufacturer's specifications.
- All truck tailgates shall be secured to prevent excessive noise from banging.
- 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.
- Additional noise mitigation measures might be implemented as more details on the actual construction processes are identified.

## Appendix A: References

American National Standards Institute. Quantities and Procedures for Description and Measurement of Environmental Sound - Part 1: Basic Quantities and Definitions. Ansi/ASA S12.9-2013/Part1. February 27, 2013.

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Institute of Noise Control Engineering. Noise and Vibration Control Revised Edition. Beranek, Leo L., 1988 Edition, Cambridge, MA.

Washington State. Administrative Code Section 173-60-050(3)(a) – Maximum Environmental Noise Levels – Exemptions. 2023.

Washington State Department of Transportation. 2020 Traffic Noise Policy and Procedures. WSDOT. March 2020.

US Code of Federal Regulations (CFR) Part 772 (23 CFR Part 772), July 2010.

US Department of Transportation. FHWA Roadway Construction Noise Model User Guide. Federal Highway Administration, Washington, D.C. June 2017.

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  $\mu\text{Pa}$  ( $20 \times 10^{-6}$  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  $\mu\text{Pa}$ .

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

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.

### General Measurement Descriptors

- **$L_{eq}$  (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.

$$L_{eq} = 20 \text{Log}_{10} \frac{1}{T} \int_T^0 \left( \frac{p(t)}{p_o} \right)^2 dt$$

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

### 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:

- **L01** 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 L01 of 95 dBA means the sound level was at or above 95 dBA for 36 seconds.
- **L50** 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 L50 of 67 dBA means the sound level was at or above 67 dBA for 30 minutes.
- **L90** 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 L90 of 50 dBA means the sound level was at or above 50 dBA for 54 minutes.

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.

### Typical Sound Levels

Table B-1 contains some common noise sources, their nominal maximum sound level in dBA, and the usual public response. The levels in this graph are comparable to the Lmax noise level descriptor. This graph would be useful when comparing the loudest noise produced with other familiar noise sources a person may have experienced. Noise levels in the table are derived from information found in *Noise and Vibration Control Revised Edition*,

Institute of Noise Control Engineering, Beranek, Leo L., 1988 Edition, Cambridge, MA and over 30 years of measured data performed by Michael Minor & Associates, Inc.

**Table B-1. Typical Maximum Sound Levels**

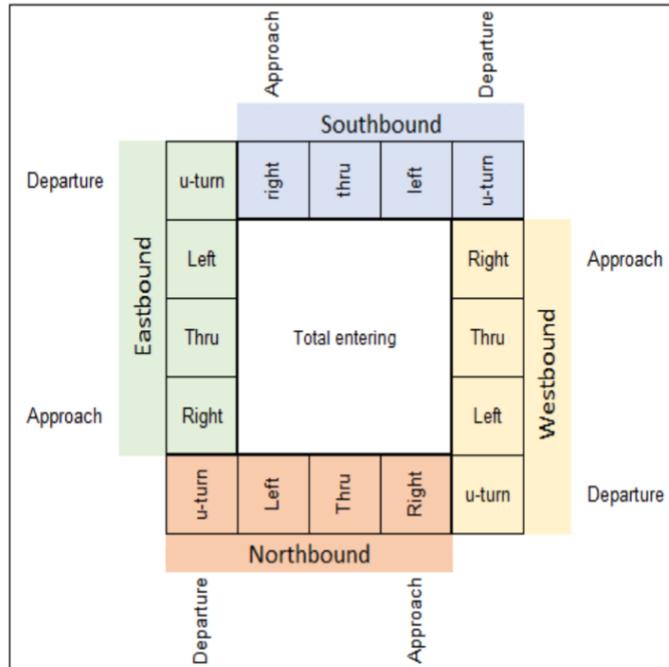
Noise Source or Activity	Sound Level (dBA)	Subjective Impression	Relative Loudness (human judgment of different sound levels)
Jet aircraft takeoff from carrier (50 feet)	140	Threshold of pain	64 times as loud
50-horse power siren (100 feet)	130		32 times as loud
Loud rock concert near stage, Jet takeoff (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: Derived from Beranek (1988) and noise measurements by Michael Minor & Associates, Inc.

## Appendix C: Traffic Data

**LEGEND**

#	N-S Roadway
	E-W Roadway



## 2020 Existing PM Peak Traffic Volumes

1		Smokey Point Blvd 200th St NE				
		NB+SB		EB+WB		
		224			292	
70	0	40	184	0	0	0
	23	574			0	
51	0				269	
	28	0				
	0	30	0	0		
		212			299	

1				
Vehicle Class Percentage				
Vehicle Speeds				
Movement Direction	Passenger Vehicles	Medium Trucks	Heavy Trucks	Speeds
Eastbound	98%	0%	2%	25
Westbound	98%	0%	2%	25
Northbound	97%	0%	3%	35
Southbound	95%	0%	5%	35

2		Smokey Point Blvd 188th St NE				
		NB+SB		EB+WB		
		250			348	
32	0	7	202	41	0	228
	8	1,036			49	
38	7				291	
	23	174				
	0	20	209	0		
		399			520	

2				
Vehicle Class Percentage				
Vehicle Speeds				
Movement Direction	Passenger Vehicles	Medium Trucks	Heavy Trucks	Speeds
Eastbound	91%	0%	9%	35/25*
Westbound	96%	0%	4%	35/25*
Northbound	98%	0%	2%	35
Southbound	100%	0%	0%	35

\* Speed limit is 35 MPH along the east leg of 188th Street NE and 25 MPH along the west leg of 188th Street NE.

3		Smokey Point Blvd 183rd Pl NE				
		NB+SB		EB+WB		
		464			607	
0	0	0	458	6	0	8
	0	1,084			3	
0	0				604	
	0	5				
	0	0	8	0		
		463			612	

3				
Vehicle Class Percentage				
Vehicle Speeds				
Movement Direction	Passenger Vehicles	Medium Trucks	Heavy Trucks	Speeds
Eastbound	98%	0%	2%	25
Westbound	98%	0%	2%	25
Northbound	98%	0%	2%	35
Southbound	98%	0%	2%	35

Traffic data provided by the city of Arlington.

### 2020 Existing PM Peak Traffic Volumes

4		NB+SB	Smokey Point Bld			EB+WB	180th Pl NE		
		479			625				
36	0	7	472	0	0			0	
	11	1,163					0		
	0						0		
41	30						0		
	0	29	614	0	0			0	
		502			643				

4				
Vehicle Class Percentage				
Vehicle Speeds				
Movement Direction	Passenger Vehicles	Medium Trucks	Heavy Trucks	Speeds
Eastbound	98%	0%	2%	25
Westbound	98%	0%	2%	25
Northbound	98%	0%	2%	35
Southbound	98%	0%	2%	35

5		NB+SB	Smokey Point Bld			EB+WB	174th Pl NE		
		597			855				
177	0	46	549	2	0			16	
	58	1,712					6		
	0						0		
154	96						10		
	0	131	791	23	0			25	
		655			945				

5				
Vehicle Class Percentage				
Vehicle Speeds				
Movement Direction	Passenger Vehicles	Medium Trucks	Heavy Trucks	Speeds
Eastbound	95%	0%	5%	25
Westbound	100%	0%	0%	25
Northbound	98%	0%	2%	35
Southbound	97%	0%	3%	35

Traffic data provided by the city of Arlington.

## 2040 No-Build PM Peak Traffic Volumes

1		Smokey Point Blvd 200th St NE				
		NB+SB		EB+WB		
		269			351	
84	0	48	221	0	0	0
	28	690			0	
62	0				690	
	34	0				
	0	36	323	0		
		255			359	

1				
Vehicle Class Percentage				
Vehicle Speeds				
Movement Direction	Passenger Vehicles	Medium Trucks	Heavy Trucks	Speeds
Eastbound	98%	0%	2%	25
Westbound	98%	0%	2%	25
Northbound	97%	0%	3%	35
Southbound	95%	0%	5%	35

2		Smokey Point Blvd 188th St NE				
		NB+SB		EB+WB		
		299			418	
38	0	8	242	49	0	274
	10	1,243			59	
46	8				1,243	
	28	209				
	0	24	349	251		
		479			624	

2				
Vehicle Class Percentage				
Vehicle Speeds				
Movement Direction	Passenger Vehicles	Medium Trucks	Heavy Trucks	Speeds
Eastbound	91%	0%	9%	35/25*
Westbound	96%	0%	4%	35/25*
Northbound	98%	0%	2%	35
Southbound	100%	0%	0%	35

\* Speed limit is 35 MPH along the east leg of 188th Street NE and 25 MPH along the west leg of 188th Street NE.

3		Smokey Point Blvd 183rd Pl NE				
		NB+SB		EB+WB		
		557			729	
0	0	0	550	7	0	10
	0	1,302			4	
0	0				1,302	
	0	6				
	0	0	725	10		
		556			735	

3				
Vehicle Class Percentage				
Vehicle Speeds				
Movement Direction	Passenger Vehicles	Medium Trucks	Heavy Trucks	Speeds
Eastbound	98%	0%	2%	25
Westbound	98%	0%	2%	25
Northbound	98%	0%	2%	35
Southbound	98%	0%	2%	35

Traffic data provided by Perteet, Inc.

### 2040 No-Build PM Peak Traffic Volumes

4		Smokey Point Bld				
NB+SB		180th PI NE				
EB+WB		180th PI NE				
		574			750	
43	0	8	566	0	0	0
	13	1,395			0	
	0				0	
49	36	1,395			0	
	0				35	737
		602			772	

4				
Vehicle Class Percentage				
Vehicle Speeds				
Movement Direction	Passenger Vehicles	Medium Trucks	Heavy Trucks	Speeds
Eastbound	98%	0%	2%	25
Westbound	98%	0%	2%	25
Northbound	98%	0%	2%	35
Southbound	98%	0%	2%	35

5		Smokey Point Bld				
NB+SB		174th PI NE				
EB+WB		174th PI NE				
		716			1,026	
212	0	55	659	2	0	19
	70	2,054			7	
	0				0	
185	115	2,054			12	
	0				157	949
		786			1,134	

5				
Vehicle Class Percentage				
Vehicle Speeds				
Movement Direction	Passenger Vehicles	Medium Trucks	Heavy Trucks	Speeds
Eastbound	95%	0%	5%	25
Westbound	100%	0%	0%	25
Northbound	98%	0%	2%	35
Southbound	97%	0%	3%	35

Traffic data provided by Perteet, Inc.

## 2040 Future Build Peak Traffic Volumes

1		NB+SB		Smokey Point Blvd			EB+WB		200th St NE		
		627			1,093						
100	0	98	529	0	0			0			
	40	1,835			0						
153	0							0			
	113				0						
	0	2	1,053	0	0			0			
		642			1,055						

1				
Vehicle Class Percentage				
Vehicle Speeds				
Movement Direction	Passenger Vehicles	Medium Trucks	Heavy Trucks	Speeds
Eastbound	97%	0%	3%	25
Westbound	97%	0%	3%	25
Northbound	97%	0%	3%	35
Southbound	97%	0%	3%	35

2		NB+SB		Smokey Point Blvd			EB+WB		188th St NE		
		446			928						
391	0	49	299	98	0			608			
	37	2,124			228						
179	89							228			
	53				152						
	0	114	663	114	0			301			
		504			891						

2				
Vehicle Class Percentage				
Vehicle Speeds				
Movement Direction	Passenger Vehicles	Medium Trucks	Heavy Trucks	Speeds
Eastbound	97%	0%	3%	35/25
Westbound	97%	0%	3%	35/25
Northbound	97%	0%	3%	35
Southbound	97%	0%	3%	35

3		NB+SB		Smokey Point Blvd			EB+WB		183rd Pl NE		
		538			962						
0	0	0	462	76	0			538			
	0	1,907			310						
0	0							0			
	0				228						
	0	0	652	179	0			255			
		690			831						

3				
Vehicle Class Percentage				
Vehicle Speeds				
Movement Direction	Passenger Vehicles	Medium Trucks	Heavy Trucks	Speeds
Eastbound	97%	0%	3%	25
Westbound	97%	0%	3%	25
Northbound	97%	0%	3%	35
Southbound	97%	0%	3%	35

Traffic data provided by Transpo Group.

### 2040 Future Build Peak Traffic Volumes

4		Smokey Point Bld					
NB+SB		180th Pl NE					
EB+WB		180th Pl NE					
		646		989			
93	0	5	630	11	0	327	
	11	2,034			163		
	1				1		
45	33	2,034			163		
	0				87	815	114
		826		1,016			

4				
Vehicle Class Percentage				
Vehicle Speeds				
Movement Direction	Passenger Vehicles	Medium Trucks	Heavy Trucks	Speeds
Eastbound	98%	0%	2%	25
Westbound	98%	0%	2%	25
Northbound	98%	0%	2%	35
Southbound	98%	0%	2%	35

5		Smokey Point Bld					
NB+SB		174th Pl NE					
EB+WB		174th Pl NE					
		885		945			
610	0	75	770	40	0	310	
	80	2,660			50		
	55				220		
295	160	2,660			40		
	0				315	815	40
		970		1,170			

5				
Vehicle Class Percentage				
Vehicle Speeds				
Movement Direction	Passenger Vehicles	Medium Trucks	Heavy Trucks	Speeds
Eastbound	98%	0%	2%	25
Westbound	98%	0%	2%	25
Northbound	98%	0%	2%	35
Southbound	98%	0%	2%	35

Traffic data provided by Transpo Group.

## **Appendix D: Noise Monitoring Sites and Traffic Count**



Photo 1: Aerial View



Photo 2: Looking Southeast



Photo 3: Looking Northeast



Photo 4: Looking West

Monitoring Location M-1  
Southwest corner of Smokey Point Blvd  
and 193rd St NE



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Sound, Vibration, Air  
Portland, Oregon

Detailed Noise Monitoring Site Photos  
Smokey Point Boulevard Project



Photo 1: Aerial View



Photo 2: Looking West



Photo 3: Looking East



Photo 4: Looking Southeast

Monitoring Location M-2  
Northeast corner of Smokey Point Blvd  
and 188th St NE



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Detailed Noise Monitoring Site Photos  
Smokey Point Boulevard Project



Photo 1: Aerial View



Photo 2: Looking West



Photo 3: Looking East



Photo 4: Looking Southwest

Monitoring Location M-3  
 Northeast corner of Smokey Point Blvd  
 and 183rd PI NE



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Detailed Noise Monitoring Site Photos  
 Smokey Point Boulevard Project



Photo 1: Aerial View



Photo 2: Looking West



Photo 3: Looking Northeast



Photo 4: Looking Northwest

Monitoring Location M-4  
 Northeast corner of Smokey Point Blvd  
 and 178th PI NE



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Detailed Noise Monitoring Site Photos  
 Smokey Point Boulevard Project



Photo 1: Aerial View



Photo 2: Looking West



Photo 3: Looking East



Photo 4: Looking Northeast

Monitoring Location M-5  
Northeast corner of Smokey Point Blvd  
and 175th PI NE



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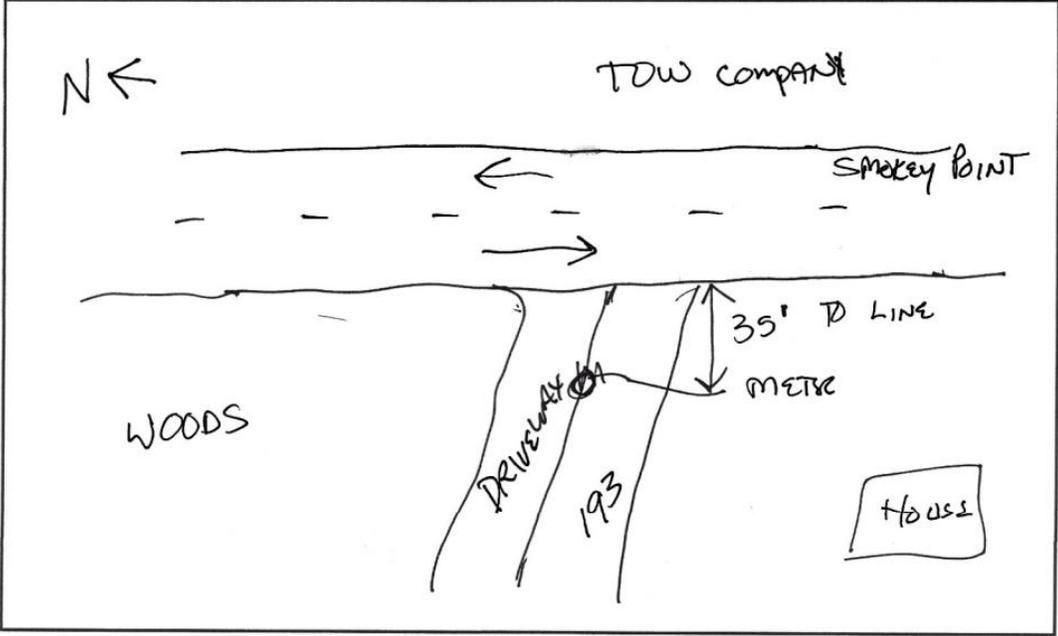
Traffic Noise Monitoring Information Sheet

Project Name: \_\_\_\_\_ Date: 11-17-23 Site Number: M-1  
 Monitoring Location: 193rd & Smokey Point Meter: 2238 Color: BLUE  
 Start Time: 13:12:10 End Time: 13:27:9 Last 1-Second Leq: \_\_\_\_\_ Overall Leq: FILE - 2  
 Temp: 52 Cloud Cover: NONE Wind: Ø Precipitation: Ø

**Traffic Counts:**  
 Roadway Name: Smokey Point N Cars 106 MedTrucks 1 HvyTrucks Ø Speeds: 50+  
 Roadway Name: Smokey Point S Cars 76 MedTrucks 4 HvyTrucks 1 Speeds: 50+  
 Roadway Name: \_\_\_\_\_ Cars \_\_\_\_\_ MedTrucks \_\_\_\_\_ HvyTrucks \_\_\_\_\_ Speeds: \_\_\_\_\_  
 Roadway Name: \_\_\_\_\_ Cars \_\_\_\_\_ MedTrucks \_\_\_\_\_ HvyTrucks \_\_\_\_\_ Speeds: \_\_\_\_\_

Area Observations: \_\_\_\_\_

Site Sketch





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**Traffic Noise Monitoring Information Sheet**

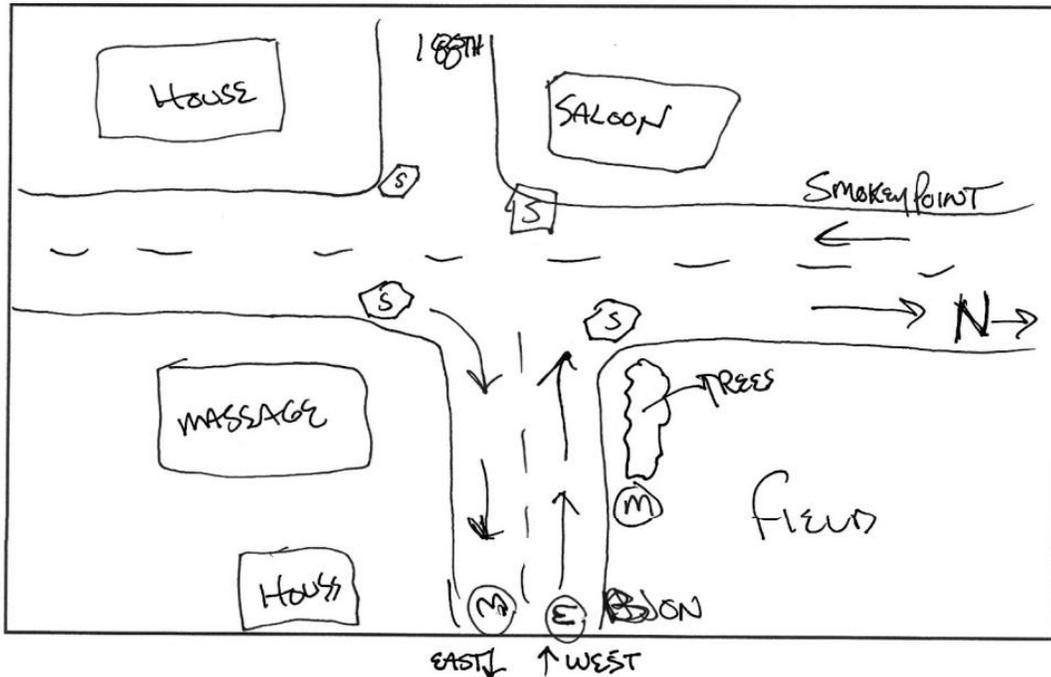
Project Name: Smoky Point & Bion Rd Date: 11-17-23 Site Number: M-2  
 Monitoring Location: Smoky Point & Bion Rd. Meter: 2238 Color: BLUE  
 Start Time: 13:46:30 End Time: 14:01:07 Last 1-Second Leq: \_\_\_\_\_ Overall Leq: File-3  
 Temp: 52 Cloud Cover: NONE Wind: Ø Precipitation: Ø

**Traffic Counts:**

Roadway Name: Smoky Point N Cars 39 MedTrucks 2 HvyTrucks 1 Speeds: 0-35  
 Roadway Name: Smoky Point S Cars 42 MedTrucks 2 HvyTrucks 4 Speeds: 35-0  
 Roadway Name: Bion E Cars 52 MedTrucks 0 HvyTrucks 2 Speeds: 30-0  
 Roadway Name: ~~W Bion~~ W Bion Cars 55 MedTrucks 1 HvyTrucks 1 Speeds: ~~30~~-30

Area Observations: 4 way stop 1 BUS  
(POSTED 35 MPH)

**Site Sketch**





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**Traffic Noise Monitoring Information Sheet**

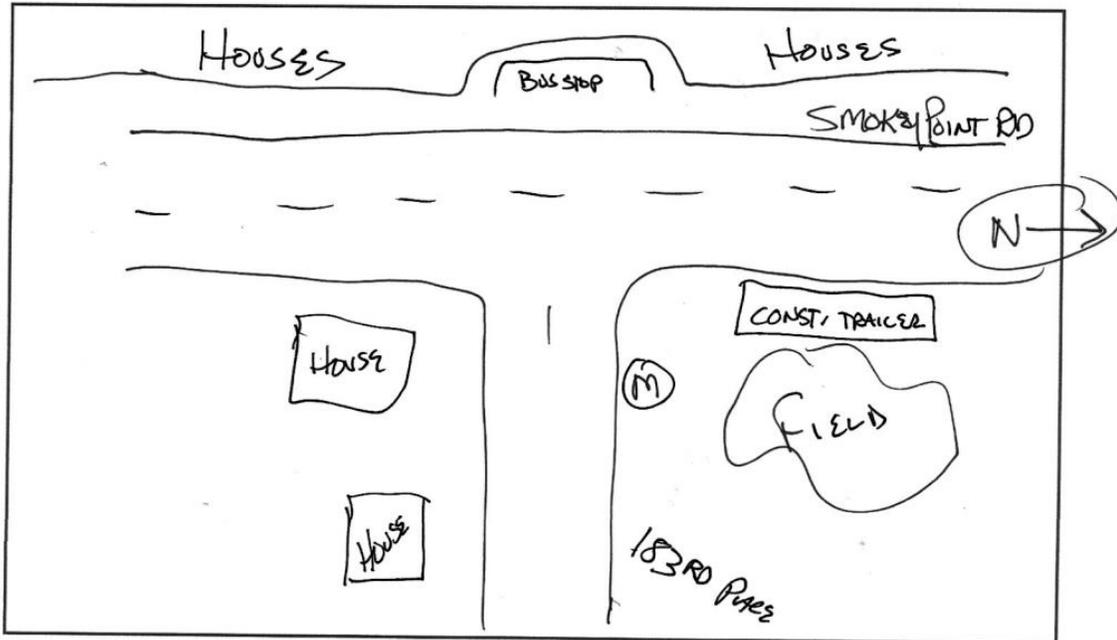
Project Name: \_\_\_\_\_ Date: 11-17-23 Site Number: M-3  
 Monitoring Location: SMOKEY POINT Meter: 2288 Color: BLUE  
 Start Time: 14:20:00 End Time: 14:35:03 Last 1-Second Leq: \_\_\_\_\_ Overall Leq: FILS-4  
 Temp: 52 Cloud Cover: NONE Wind: ∅ Precipitation: ∅

**Traffic Counts:**

Roadway Name: SMOKEY POINT N Cars 123 MedTrucks 3 HvyTrucks 2 Speeds: 50+/-  
 Roadway Name: SMOKEY POINT S Cars 108 MedTrucks 2 HvyTrucks 0 Speeds: 50+/-  
 Roadway Name: 183RD E Cars 1 MedTrucks 0 HvyTrucks 0 Speeds: 20  
 Roadway Name: 183RD W Cars N/A MedTrucks \_\_\_\_\_ HvyTrucks \_\_\_\_\_ Speeds: \_\_\_\_\_

Area Observations: \_\_\_\_\_  
FREQUENT SMALL PLANE FLYOVERS

**Site Sketch**





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**Traffic Noise Monitoring Information Sheet**

Project Name: \_\_\_\_\_ Date: 11-17-23 Site Number: M-4

Monitoring Location: 178th Pl. & Smokey Point Meter: 2238 Color: BLUE

Start Time: 14:50:30 End Time: 15:05:34 Last 1-Second Leq: \_\_\_\_\_ Overall Leq: FILE-5

Temp: 50 Cloud Cover: NONE Wind: ∅ Precipitation: ∅

Traffic Counts:

Roadway Name: SMOKEY POINT N Cars 151 MedTrucks 0 HvyTrucks 1 Speeds: 50+

Roadway Name: SMOKEY POINT S Cars 120 MedTrucks 5 HvyTrucks 1 Speeds: 50+

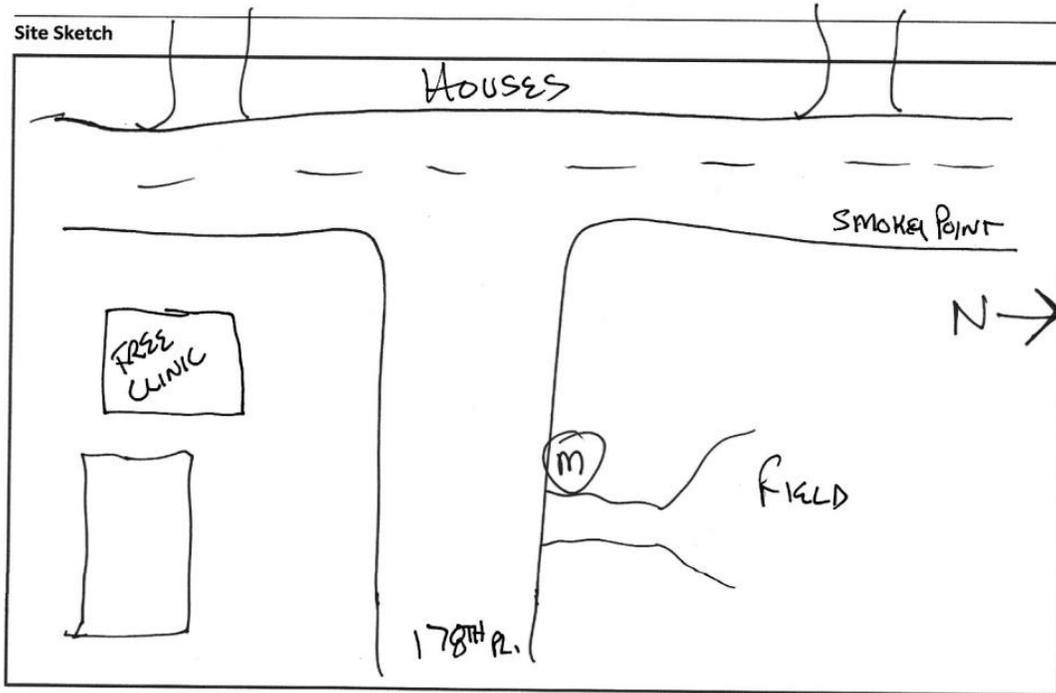
Roadway Name: 178th E Cars 3 MedTrucks 0 HvyTrucks 0 Speeds: 0-20

Roadway Name: \_\_\_\_\_ Cars \_\_\_\_\_ MedTrucks \_\_\_\_\_ HvyTrucks \_\_\_\_\_ Speeds: \_\_\_\_\_

Area Observations: \_\_\_\_\_

FREQUENT SMALL PLANES

Site Sketch





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**Traffic Noise Monitoring Information Sheet**

Project Name: \_\_\_\_\_ Date: 11-17-23 Site Number: M-5

Monitoring Location: 175th Pl & Smokey Point Meter: 2238 Color: BLUE

Start Time: 15:21:20 End Time: 15:36:22 Last 1-Second Leq: \_\_\_\_\_ Overall Leq: FILE-6

Temp: 50 Cloud Cover: NONE Wind: Ø Precipitation: Ø

**Traffic Counts:**

Roadway Name: 8 Smokey Point N Cars 105 MedTrucks 6 HvyTrucks 4 Speeds: 50+  
 Roadway Name: Smokey Point S Cars 117 MedTrucks 3 HvyTrucks 2 Speeds: 50+  
 Roadway Name: 175th Pl E Cars 4 MedTrucks 0 HvyTrucks 0 Speeds: 0-20  
 Roadway Name: 175 Pl W Cars 0 MedTrucks 0 HvyTrucks 0 Speeds: \_\_\_\_\_

Area Observations: \_\_\_\_\_

small Planes

**Site Sketch**

