Operations and Maintenance Facility South

Draft Environmental Impact Statement

Appendix G2: Noise and Vibration Technical Report

SOUNDTRANSIT

March 2021

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Summary

This technical report contains the noise and vibration impact assessment for the Central Puget Sound Regional Transit Authority (Sound Transit) Operations and Maintenance Facility South (OMF South) project. The report follows Federal Transit Administration (FTA) and Sound Transit guidance in evaluating impacts and potential mitigation measures. The FTA noise and vibration guidance has been adopted by Sound Transit in their environmental methodology to assess impacts from transit projects, regardless of the funding source. This technical report is intended to be a supplement to the noise and vibration chapter in the Draft Environmental Impact Statement.

The results of the noise and vibration impact assessment indicate that there would be no FTA noise or vibration impacts from operation of any of the three OMF South alternatives. There would also be no exceedances of the Washington Administrative Code (WAC) from operation of any of the three OMF South alternatives. There would be FTA moderate noise impacts from each of the mainline track options from the South 336th Street or South 344th Street alternatives to the Federal Way Transit Center. All exceedances and impacts can be mitigated through the implementation of noise barriers.

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Acronyms and Abbreviations

ANSI	American National Standards Institute
CSA	Cross-Spectrum Acoustics
dB	decibel
dBA	A-weighted decibel
EIS	environmental impact statement
FDL	force density level
FHWA	Federal Highway Administration
FTA	Federal Transit Administration
FWLE	Federal Way Link Extension
Hz	Hertz
I-5	Interstate 5
in/sec	inches per second
Ldn	day-night sound level
Leq	equivalent sound level
Lmax	maximum noise level
Ln	sound level exceeded n-percent of the time
LRV	light rail vehicle
LSTM	line source transfer mobility
Lv	vibration level
mph	miles per hour
NEPA	National Environmental Policy Act
NIST	National Institute of Standards and Technology
OMF	operations and maintenance facility
OMF South	Operations and Maintenance Facility South
PPV	peak particle velocity
RCNM	Roadway Construction Noise Model
RMS	root mean square
SEL	sound exposure level
Sound Transit	Central Puget Sound Regional Transit Authority

TDLE	Tacoma Dome Link Extension
TM	transfer mobility
U.F.	usage factor
VdB	vibration decibel
WAC	Washington Administrative Code

1 INTRODUCTION

This technical report contains the noise and vibration impact assessment for the Central Puget Sound Regional Transit Authority (Sound Transit) Operations and Maintenance Facility South (OMF South) project. The report follows Federal Transit Administration (FTA) and Sound Transit policies and practices in evaluating impacts and potential mitigation measures. The FTA noise and vibration guidance is used by Sound Transit in their environmental methodology to assess impacts from transit projects.

The report includes a description of the existing noise and vibration conditions near the project alternatives, the noise and vibration assessment for sensitive receptors near the three OMF South alternatives, the two mainline track options from the South 336th Street and the South 344th Street alternatives to the Federal Way Transit Center, and mitigation options for impacts identified in the assessment.

1.1 Project Description

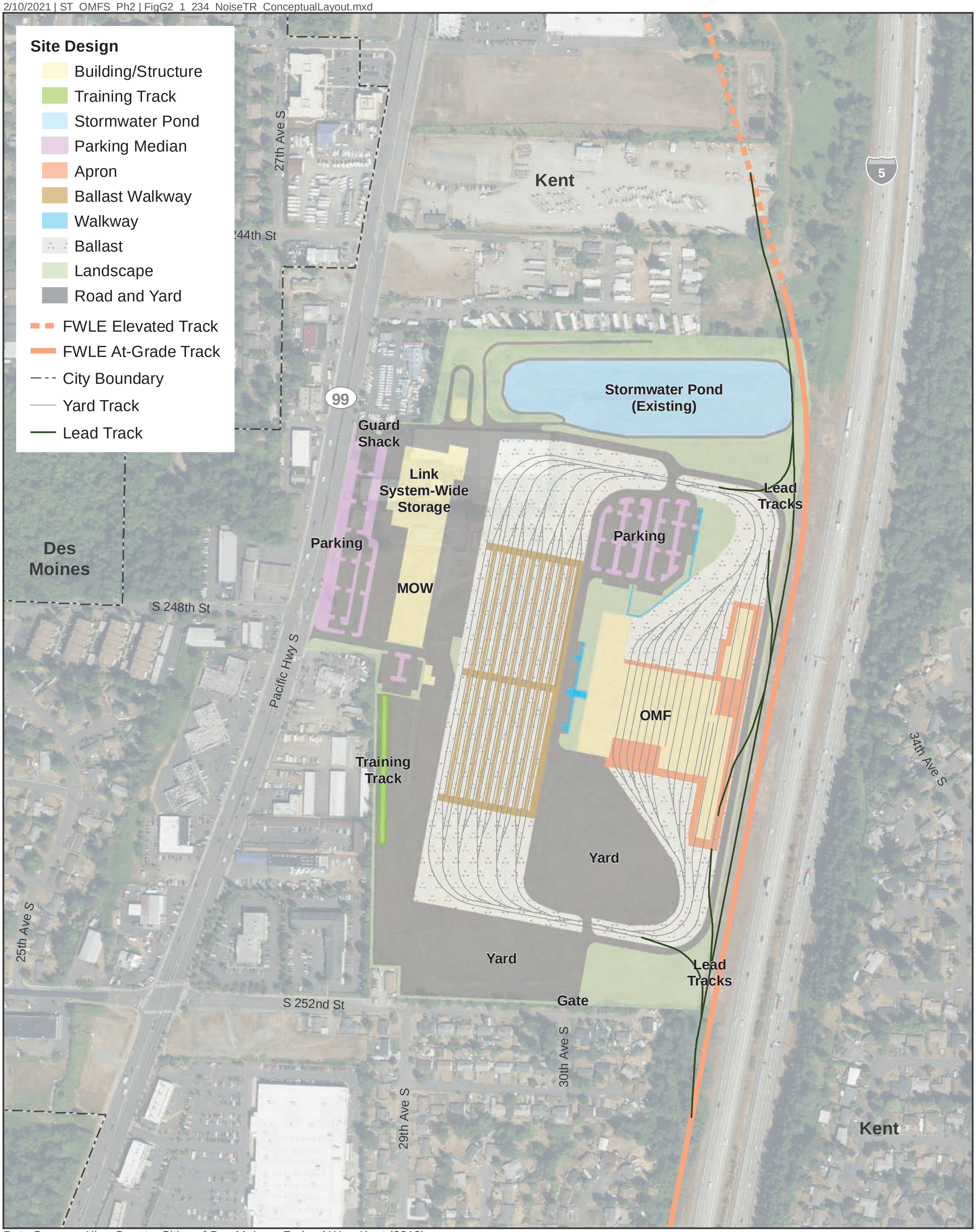
Sound Transit proposes to construct and operate an operations and maintenance facility in its South Corridor (OMF South) to meet agency needs for an expanded fleet of light rail vehicles (LRVs). The need to expand LRV maintenance capacity was identified in Sound Transit 3: The Regional Transit System Plan for Central Puget Sound (Sound Transit 3). OMF South would be used to store, maintain, and deploy about 144 LRVs for daily service. It would provide facilities for vehicle storage, inspections, maintenance and repair, interior vehicle cleaning, and exterior vehicle washing. Additionally, the facility would receive, test, and commission new LRVs for the entire light rail system.

OMF South would also be used to accommodate administrative and operational functions, such as serving as a report base for LRV operators. Included is a Maintenance of Way (MOW) building for maintenance and storage of spare parts for tracks, vehicle propulsion equipment, train signals, and other infrastructure, in addition to storage facilities for the entire Link system. Other facility elements would include employee and visitor parking, operations staff offices, maintenance staff offices, dispatcher work stations, an employee report room, and areas with lockers, showers, and restrooms for both operators and maintenance personnel.

OMF South would need to have tracks connecting to an active light rail line, which in southern King County is the Federal Way Link Extension (FWLE). The length and location of these connecting tracks varies by alternative.

Three site alternatives for the proposed project are evaluated in the Draft Environmental Impact Statement: one in Kent and two in Federal Way (Figure G2.1-1). These alternatives are named the Midway Landfill Alternative, South 336th Street Alternative, and South 344th Street Alternative, respectively (Figures G2.1-2 through G2.1-4). Figure G2.1-5 shows the mainline track options.

Figure G2.1-1 Project Vicinity: OMF South Alternatives



Data Sources: King County; Cities of Des Moines, Federal Way, Kent (2019).

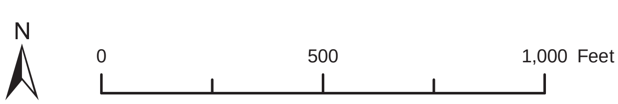
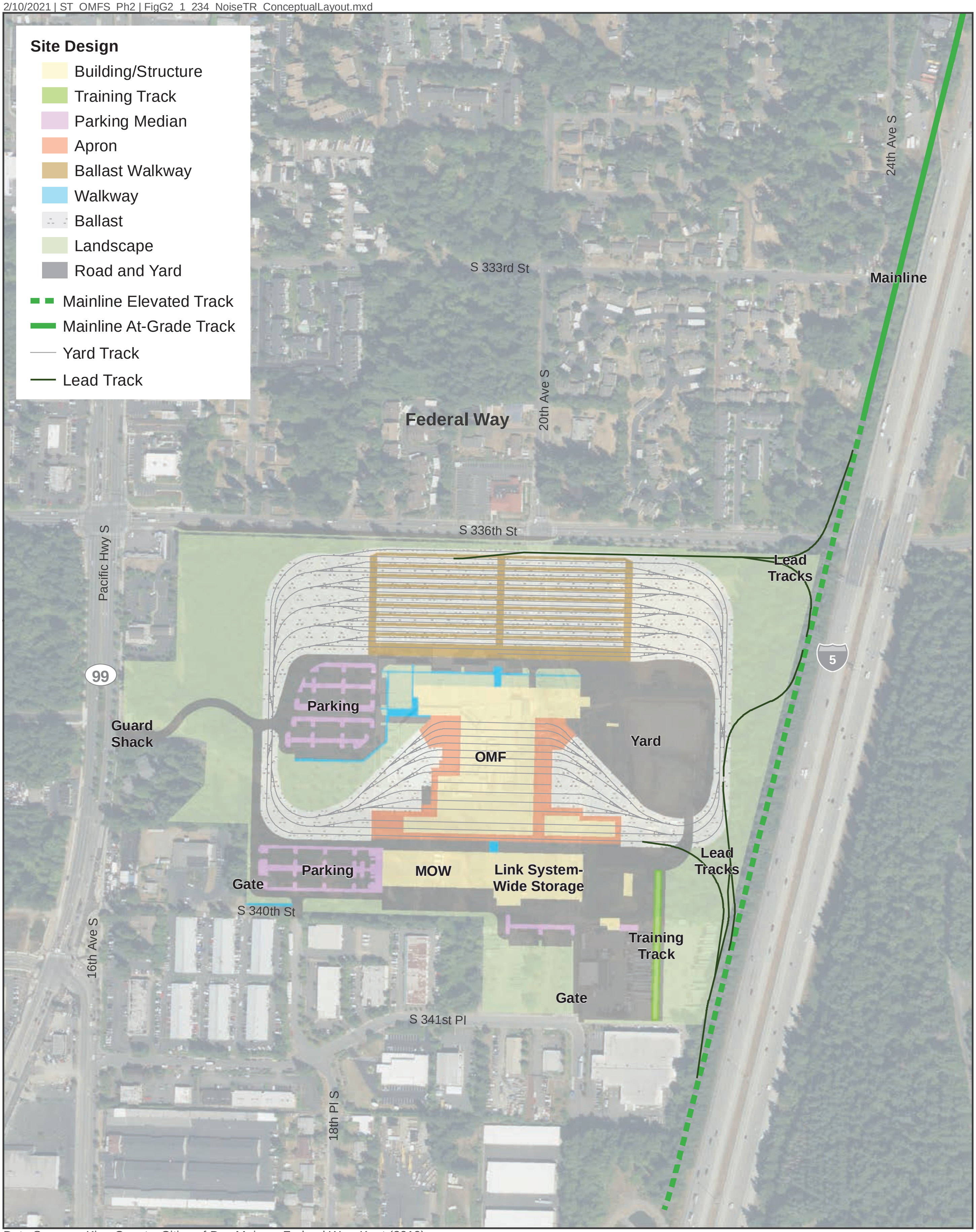


FIGURE G2.1-2
Conceptual Layout
Midway Landfill Alternative

OMF South



Data Sources: King County; Cities of Des Moines, Federal Way, Kent (2019).

FIGURE G2.1-3
Conceptual Layout
South 336th Street Alternative

OMF South

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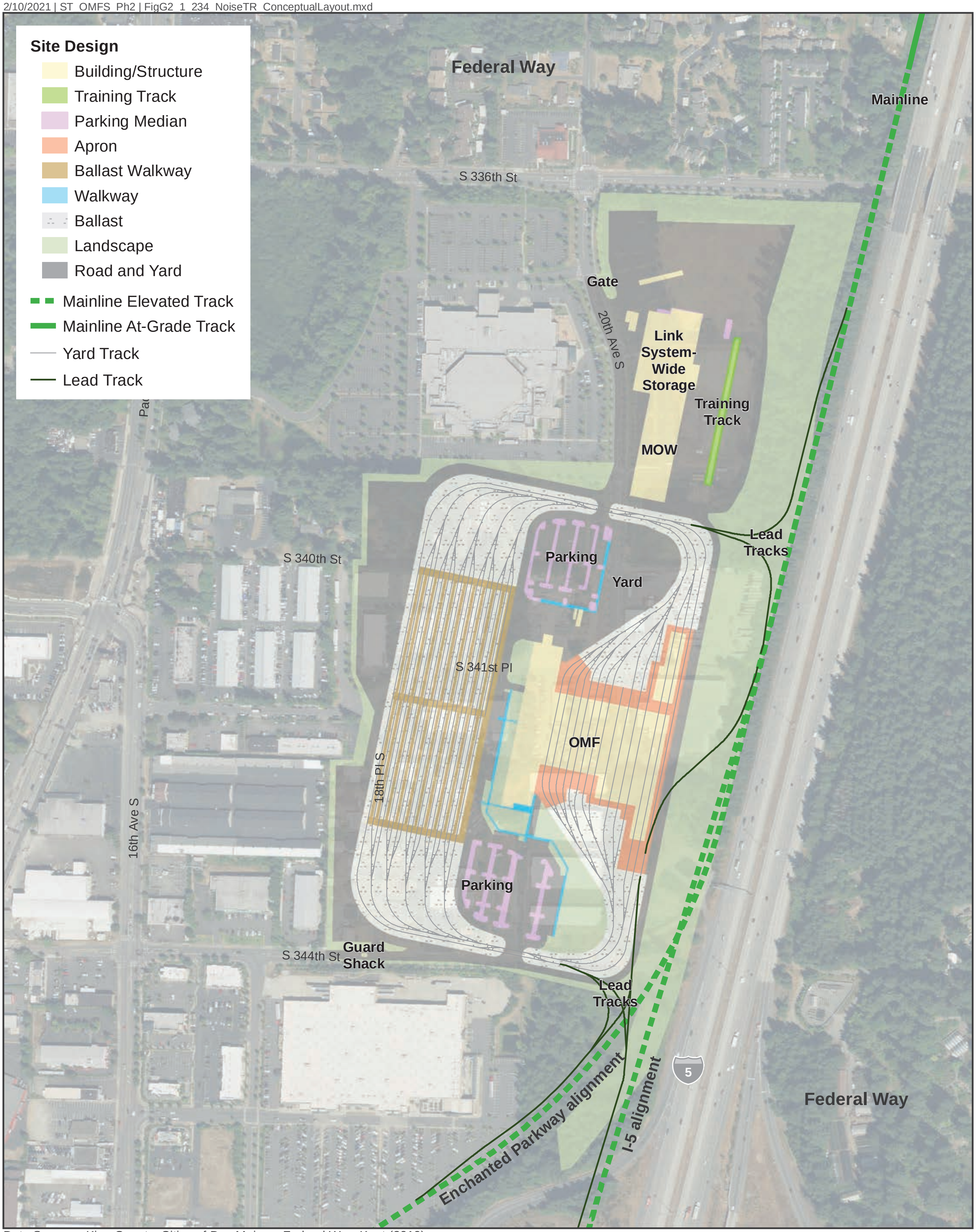


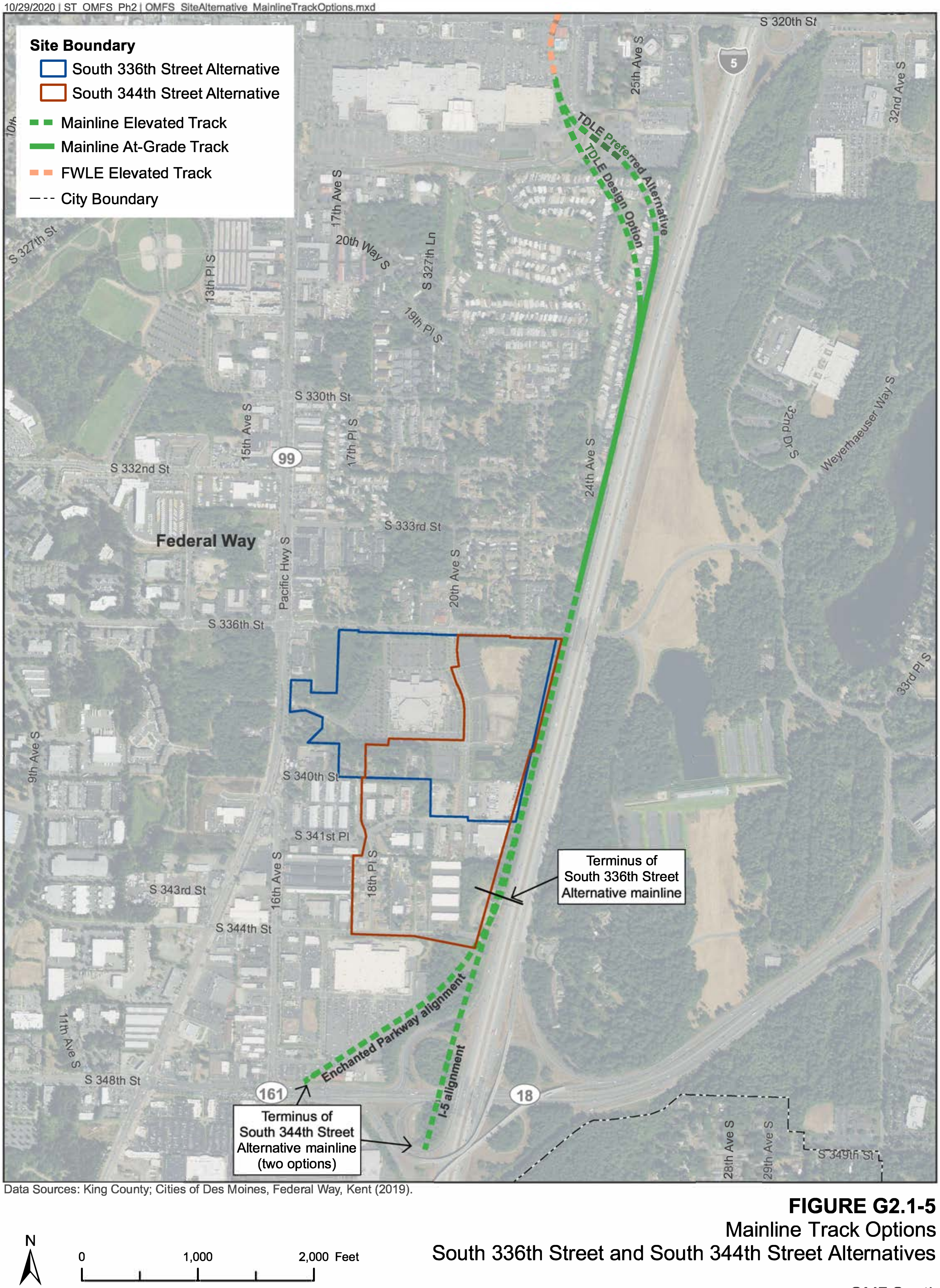
Data Sources: King County; Cities of Des Moines, Federal Way, Kent (2019).

N

0 500 1,000 Feet

FIGURE G2.1-4
Conceptual Layout
South 344th Street Alternative

OMF South



Data Sources: King County; Cities of Des Moines, Federal Way, Kent (2019).

FIGURE G2.1-5
Mainline Track Options
South 336th Street and South 344th Street Alternatives

2 NOISE AND VIBRATION BASICS

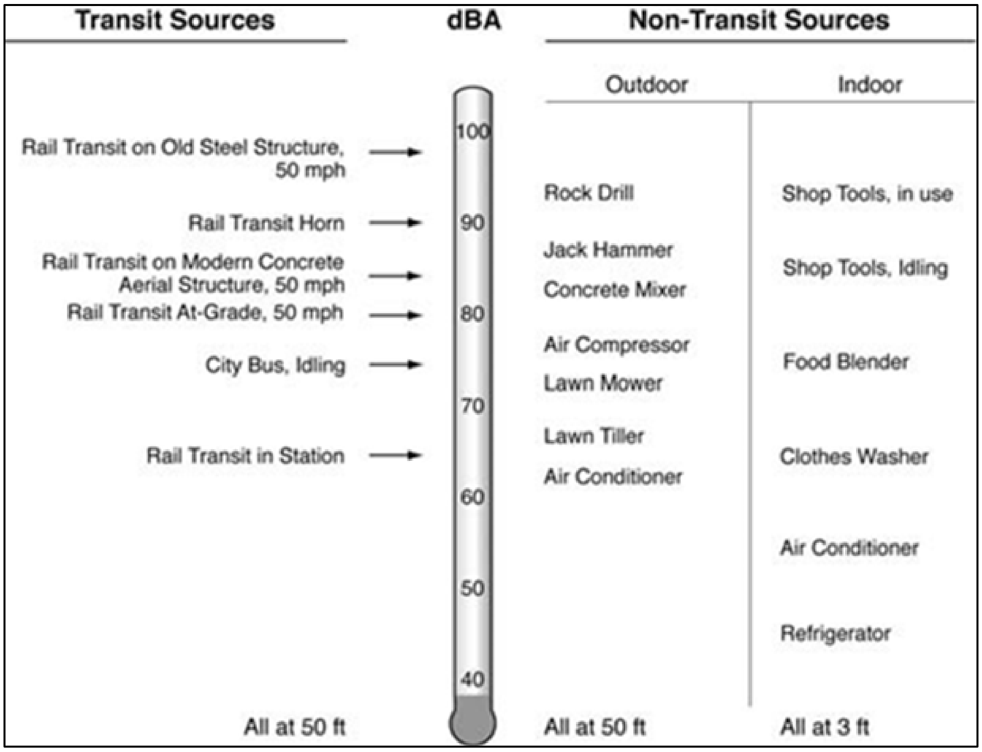
2.1 Noise Basics

Sound is defined as small changes in air pressure above and below the standard atmospheric pressure, and noise is usually considered to be unwanted sound. The three parameters that define noise include:

- **Level:** The level of sound is the magnitude of air pressure change above and below atmospheric pressure and is expressed in decibels (dB). Typical sounds fall within a range between 0 dB (the approximate lower limit of human hearing) and 120 dB (the highest sound level generally experienced in the environment). A 3-dB change in sound level is perceived as a barely noticeable change outdoors, and a 10-dB change in sound level is perceived as a doubling (or halving) of loudness.
- **Frequency:** The frequency (pitch or tone) of sound is the rate of air pressure change and is expressed in cycles per second, or Hertz (Hz). Human ears can detect a wide range of frequencies from around 20 Hz to 20,000 Hz; however, human hearing is not as sensitive at high and low frequencies, and the A-weighting system, which measures what humans hear in a more meaningful way by reducing the sound levels of higher- and lower-frequency sounds, is used to provide a measure (dBA) that correlates with human response to noise. Figure G2.2-1 shows typical maximum A-weighted sound levels for transit and nontransit sources. The A-weighted sound level has been widely adopted by acousticians as the most appropriate descriptor for environmental noise.
- **Time Pattern:** Because environmental noise is constantly changing, it is common to condense all of this information into a single number, called the equivalent sound level (Leq). The Leq represents the changing sound level over a period of time, typically 1 hour or 24 hours in transit noise assessments. For assessing the noise impact of rail projects at residential land uses, the day-night sound level (Ldn) is the noise descriptor commonly used, and it has been adopted by many agencies as the best way to describe how people respond to noise in their environment. Ldn is a 24-hour cumulative A-weighted noise level that includes all noises that occur during a day, with a 10-dB penalty for nighttime noise (10 p.m. to 7 a.m.). This nighttime penalty means that any noise events at night are equivalent to 10 similar events during the day.

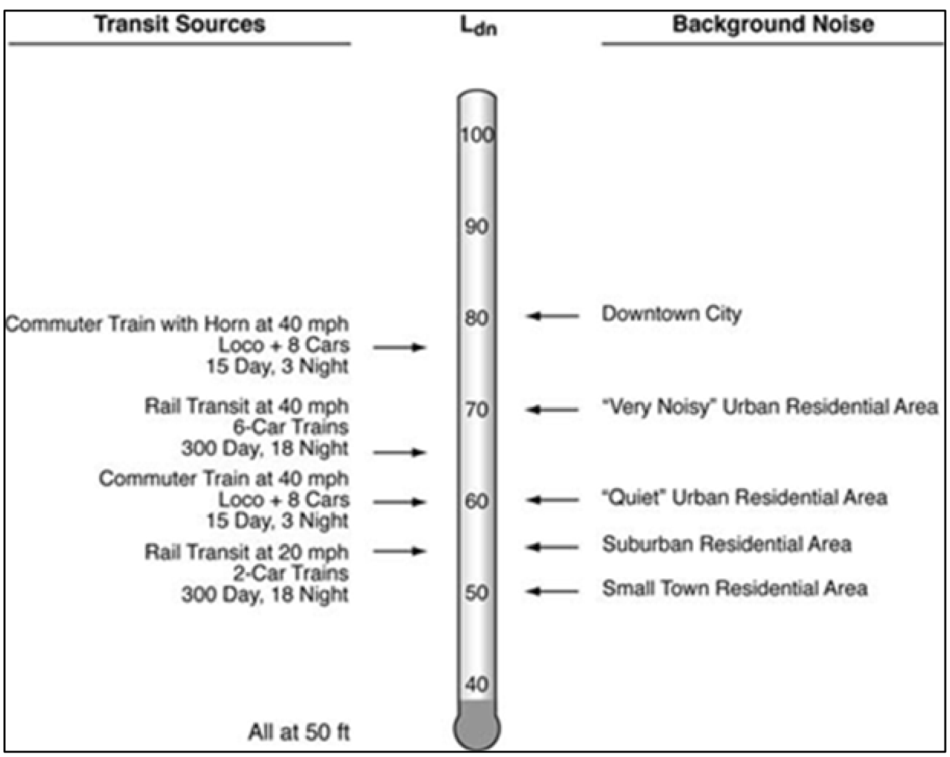
Typical Ldn values for various transit operations and environments are shown on Figure G2.2-2.

In addition to the Leq and Ldn, there are other metrics used to describe noise. The loudest 1 second of noise over a measurement period, or maximum A-weighted sound level (Lmax), is used in many local and state ordinances for noise emitted from private land uses and for construction noise impact evaluations. Environmental noise can also be viewed on a statistical basis using percentile sound levels (Ln), which refer to the sound level exceeded n-percent of the time.



Source: FTA 2018

Figure G2.2-1 Typical A-Weighted Sound Levels



Source: FTA 2018

Figure G2.2-2 Typical Ldn Noise Exposure Levels

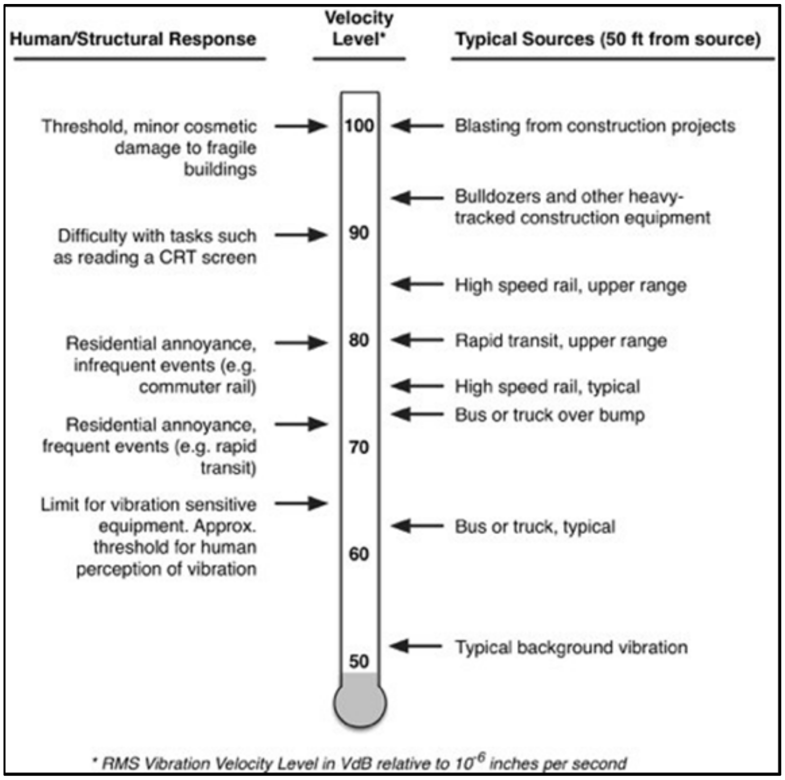
2.2 Vibration Basics

Ground-borne vibration from trains refers to the fluctuating or oscillatory motion experienced by persons on the ground and in buildings near railroad tracks. Vibration can be described in terms of displacement, velocity, or acceleration. Displacement is generally the easiest descriptor to understand. For a vibrating floor, the displacement is simply the distance that a point on the floor moves away from its static position. Velocity represents the instantaneous speed of the floor movement, and acceleration is the rate of change of the speed. Although displacement is easier to understand, the response of humans, buildings, and equipment to vibration is more accurately described using velocity or acceleration.

Two methods are used for quantifying vibration. The peak particle velocity (PPV) is defined as the maximum instantaneous positive or negative peak of the vibration signal. PPV often is used in the monitoring of blasting vibration, since it is related to the stresses experienced by buildings. Although PPV is appropriate for evaluating the potential of building damage, it is not suitable for evaluating human response. It takes some time for the human body to respond to vibration impulses. In a sense, the human body responds to an average of the vibration amplitude. Because the net average of a vibration signal is zero, the root mean square (RMS) amplitude is used to describe the "smoothed" vibration amplitude.

PPV and RMS velocities are normally described in inches per second in the U.S. and in meters per second in the rest of the world. Decibel notation is in common use for vibration and has been adopted by the FTA in their guidance. Decibel notation compresses the range of numbers required to describe vibration. Vibration levels in this report are referenced to 1 x 10-6 inches per second (in/sec). The abbreviation “VdB” is used in this document for vibration decibels to reduce the potential for confusion with sound decibels. Common vibration sources and human and structural response to ground-borne vibration are illustrated in Figure G2.2-3. Typical vibration levels can range from below 50 VdB to 100 VdB (0.000316 in/sec to 0.1 in/sec). The human threshold of perception is approximately 65 VdB.

Ground-borne vibration can lead to ground-borne noise, which is a low-volume, low-frequency rumble inside buildings, resulting when ground vibration causes the flexible walls of the building to resonate and generate noise. Ground-borne noise is normally not a consideration when trains are elevated or at grade. In these situations, the airborne noise usually overwhelms ground-borne noise, so the airborne noise level is the major consideration. However, ground-borne noise becomes an important consideration where there are sections of the corridor that are in a tunnel or where sensitive interior spaces are well isolated from the airborne noise. In these situations, airborne noise is not a major path and ground-borne noise becomes the most important path into the building. In unusual situations, ground-borne noise may also need to be considered in cases where the airborne noise from a project is mitigated by a sound wall.



Source: FTA 2018

Figure G2.2-3 Typical Levels of Ground-Borne Vibration

3 IMPACT ASSESSMENT METHODOLOGY

Noise and vibration from facility and mainline track operations were modeled using the methods described in the FTA guidance manual. Noise-generating activities would include vehicles moving within the facility, vehicle washing and drying, a traction power substation, and vehicles moving on the mainline track (for the South 336th Street Alternative and the 344th Street Alternative) into service in the morning and back to the facility in the late evening. The only activity that would generate vibration would be LRVs moving on the mainline track options for the South 336th Street and the South 344th Street alternatives. The assessment described below, including all operational assumptions, is for the OMF South project only, and does not include the TDLE project, which will be assessed in a separate Environmental Impact Statement. Anticipated noise impacts from TDLE are discussed in the cumulative impacts section.

3.1 Operational Noise Assessment Methodology

3.1.1 OMF Site Noise Assessment Methodology

The OMF South noise assessment methodology was identical for each of the three alternatives. The reference noise levels were taken from the OMF East noise and vibration technical report (Sound Transit 2015), the FTA guidance manual, and the Sound Transit reference noise and vibration level report. The assessment assumes that the majority of the operations activities occur at night, when the LRVs are not in revenue service. The noise assessment includes the following assumptions:

- For the Midway Landfill Alternative, 104 LRVs would be based at the facility; 13 four-car LRVs would depart to the north and 13 four-car LRVs would depart to the south before 7 a.m. and return after midnight. With the inclusion of TDLE, the number of LRVs based at the facility would increase to 144; operations would also increase. The results of that assessment are covered in Section 7, Cumulative Impacts.
- For the South 336th Street and South 344th Street alternatives, 104 LRVs would be based at the facility; 26 four-car LRVs would depart to the north before 7 a.m. and return after midnight. With the inclusion of TDLE, the number of LRVs based at the facility would increase to 144; operations would also increase. The results of that assessment are covered in Section 7, Cumulative Impacts.
- LRVs would travel at 7 mph within the boundaries of the site. A four-car LRV traveling at 7 mph on ballast and tie tracks would generate a sound exposure level (SEL) of 77.2 dBA at 50 feet.
- All LRVs would be washed each night inside the wash building. Each four-car train takes approximately 10 minutes to be washed, and the maximum noise level for the washers is 74 dBA at 50 feet from the blower end of the wash facility (Sound Transit 2015).
- Maintenance activities would take place inside the shop building and would not generate substantial noise levels.
- Wheel squeal is possible on curves with a radius of less than 600 to 1,000 feet depending on the speed and type of trackway. Wheel squeal is not included in the noise model because Sound Transit has committed to reducing any potential wheel squeal by installing wayside lubricators on all curves in noise-sensitive areas with a radius of less than 600 feet and by preparing all curves for wayside lubricators that have a radius of between 600 and 1,000 feet.

- The slow speeds within the OMF South alternatives would reduce any impact noise associated with crossovers within the facility. Crossovers connecting to the mainline tracks would have higher speed operations and the potential for additional noise from vehicles traveling over them.
- Limited testing of LRV train-mounted bells or horns would occur during the daytime.
- The traction power substation would generate a maximum noise level of 49 dBA at a distance of 50 feet and would operate 24 hours per day (Sound Transit 2015).

3.1.2 Mainline Track Noise Assessment Methodology

For the South 336th Street and the South 344th Street alternatives, trains would depart to the north on the mainline track to the Federal Way Transit Center. The projection of noise levels from light rail operations at sensitive receptors was determined using the model specified in the FTA guidance manual and current design of the proposed project, with the following assumptions:

- For the South 336th Street and South 344th Street alternatives, 26 four-car LRVs would depart on the mainline track to the north before 7 a.m. and return after midnight.
- LRV train speeds will be 25 mph on the mainline track.
- The SEL for four-car LRV trains on at-grade ballast and tie tracks traveling at 25 mph would be 82.7 dBA at 50 feet (Sound Transit 2019).
- The SEL for four-car LRV trains on direct fixation tracks on a concrete structure are increased by 4 dB relative to ballast and tie tracks (Sound Transit 2019).
- Locations of elevated structures, crossovers, and ballast and tie track were identified based on plan and profile maps provided. No crossovers are located on the mainline track other than where they connect with the lead track.

3.1.3 Noise Measurement Procedures and Equipment Methodology

The noise measurement program consisted of long-term (24-hour) monitoring of the A-weighted sound level. All the measurement sites were located in or near noise-sensitive areas and were selected to represent a range of existing noise conditions near the OMF South alternatives and mainline track. Long-term noise measurements were conducted at eight locations near the three alternatives and mainline track. The noise measurement locations are shown in Figures G2.5-1 through G2.5-3, photographs of the measurement sites are included in Attachment G2-1, and detailed noise measurement data are presented in Attachment G2-2. Summary information regarding the noise measurements for each OMF South alternative and the mainline track is presented below in Sections 5.2.1.1 through 5.2.1.4.

At each of the measurement sites, the A-weighted sound levels were continuously monitored during the measurement periods. The noise measurements were performed with NTi Audio Model XL2 noise monitors that conform to American National Standards Institute (ANSI) Standard S1.4 for Type 1 (Precision) sound level meters. Calibrations, traceable to the U.S. National Institute of Standards and Technology (NIST), were carried out in the field before and after each set of measurements using an acoustical calibrator.

In all cases, the measurement microphone was protected by a windscreen and supported on a tripod at a height of 4 to 6 feet above the ground and was positioned to characterize the exposure of the site to the dominant noise sources in the area. For example, microphones were located at the approximate setback lines of the receptors from adjacent roads and were positioned to avoid acoustic shielding by landscaping, fences, or other obstructions.

3.2 Operational Vibration Assessment Methodology

The projection of ground-borne vibration from train operations was carried out using the model specified in the FTA guidance manual, supplemented by LRV vibration measurement data provided by Sound Transit, with the following assumptions:

- For the South 336th Street and South 344th Street alternatives, 26 four-car LRVs would depart on the mainline track options to the north before 7 a.m. and return after midnight.
- Vibration source (force density) levels were based on test data provided in the Sound Transit reference noise and vibration level report for both ballast and tie tracks and direct fixation tracks. The vehicle force density includes a 3 VdB safety factor.
- A vibration propagation test was conducted at a location near the mainline track options, as described in Section 3.2.1. The result of this test was combined with the LRV vibration source level measurement data to provide projections of vibration levels from trains operating on the mainline track. For the impact assessment, a 3 VdB safety factor has been added to the vibration test results.
- Vehicle operating speeds on the mainline track would be 25 mph.
- Locations of elevated structures, crossovers, and ballast and tie track were identified based on plan and profile maps.
- Vibration levels are reduced by 10 VdB for operations on elevated structures.

The assumed vehicle vibration characteristics are represented by the force density levels (FDL) spectra at 25 mph in Figure G2.3-1 for both ballast and tie tracks and direct fixation tracks. The force density is the vehicle input force, by frequency, which is measured for vehicles operating on different track structures. The results were combined with the ground vibration propagation test results (represented by transfer mobility spectra shown in Attachment G2-3) to project vibration levels as a function of distance. The formula for calculating the future vibration levels is as follows:

$$Lv = FDL + LSTM$$

Where:

Lv = projected train vibration level,
FDL = vehicle force density, and
LSTM = line source transfer mobility at a given site.

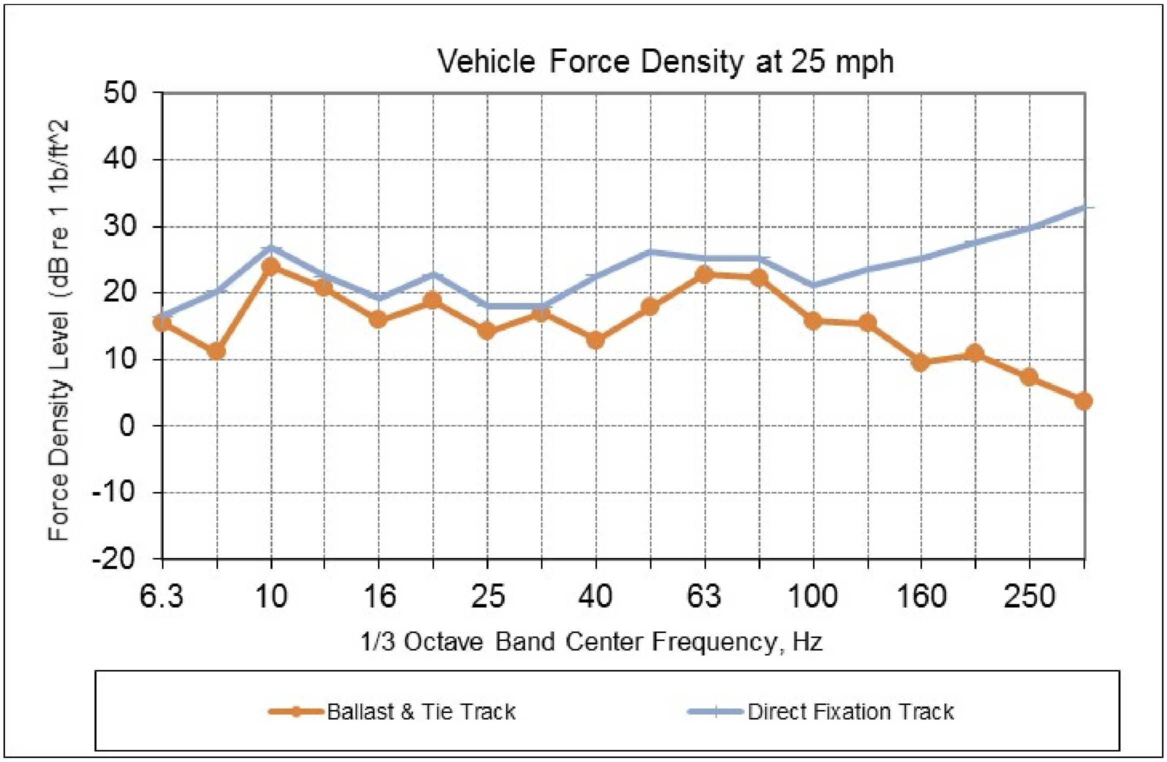


Figure G2.3-1 Vehicle Force Density Levels at 25 mph

3.2.1 Vibration Measurement Procedures Methodology

A vibration propagation measurement was conducted during November 2019 to determine the vibration response characteristics of the ground near vibration-sensitive locations close to the proposed mainline track design options. A custom-built instrumented hammer was used to impart an impulsive force to the ground to determine the ground response. The magnitude of the force was calculated based on the acceleration and mass of the falling hammer. The resulting vibration signals were measured using high-sensitivity accelerometers (PCB Models 393C and 393B05) mounted in a vertical direction on pavement or on steel spikes driven into the ground. The signals from the hammer and accelerometers were recorded using Data Translation DT9837A digital acquisition hardware. Data Translation's QuickDAQ software, running on a laptop computer, was used to review the measurement data.

The vibration propagation test procedure is shown schematically in Figure G2.3-2. The instrumented hammer was used to generate impulses at specific locations spaced 15 feet apart along a line on or parallel to the proposed alignment. A line of accelerometers was placed perpendicular to the line of impacts, as shown in the figure. The relationship between the input force and the resulting vibration measured by the accelerometers, called the transfer mobility (TM), was calculated using proprietary software in the Cross-Spectrum Acoustics (CSA) laboratory. The transfer mobility represents the vibration propagation characteristics of the ground at the measurement site and along the mainline track design options.

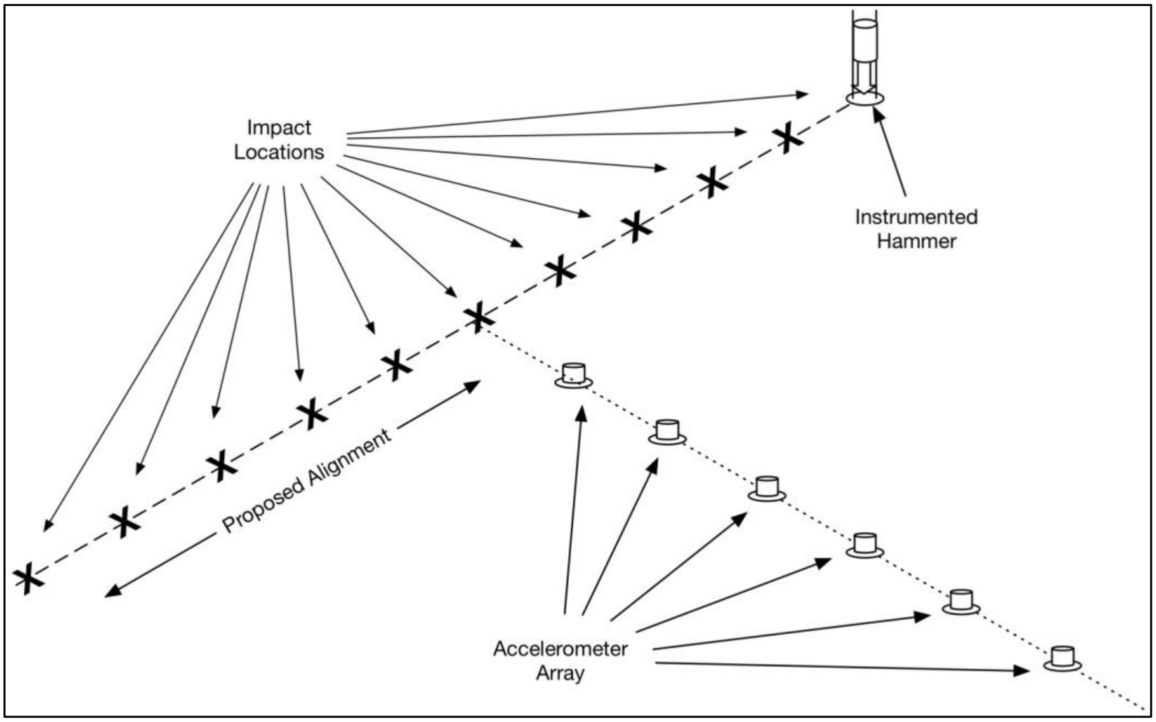


Figure G2.3-2 Vibration Propagation Measurement Schematic

3.3 Construction Noise Assessment Methodology

Construction noise and impacts are assessed using a combination of the methods and construction source data contained in the FTA guidance manual and the Federal Highway Administration (FHWA) Roadway Construction Noise Model (RCNM) from the FHWA Construction Noise Handbook (FHWA 2006). Typical noise levels generated by representative pieces of equipment are listed in Table G2.3-1. The noise exposure at a receiver location may be calculated using decibel addition of all operating construction equipment using the following equation:

$$Leq(n) = Lmax + 10\times Log(U.F.) - 20\times Log(D/50) - A_{shielding}$$

where:

Leq(n) = noise exposure at a receiver resulting from the operation of a single piece of equipment over n hours,

Lmax = noise emission level of the particular piece of equipment at the reference distance of 50 feet (taken from Table G2.3-1),

$A_{shielding}$ = shielding provided by barriers, building, or terrain,

D = distance from the receiver to the piece of equipment in feet, and

U.F. = usage factor that accounts for the fraction of time that the equipment is in use over the specified time period. For Leq (1) assume a U.F. equal to 100%, and for 8 hours or more use the values in Table G2.3-1.

The combination of noise from several pieces of equipment operating during the same time period is obtained from decibel addition of the Leq of each single piece of equipment calculated using the above equations.

Table G2.3-1 Construction Equipment Noise Emission Levels

Equipment	Typical Noise Level (dBA) 50 Feet	Usage Factor (U.F.), %
Air compressor	80	40
Backhoe	80	40
Ballast equalizer	82	50
Ballast tamper	83	50
Compactor	82	20
Concrete mixer	85	40
Concrete pump	82	20
Crane, derrick	88	16
Crane, mobile	83	16
Dozer	85	16
Generator	82	50
Grader	85	40
Impact wrench	85	50
Jack hammer	88	20
Loader	80	40
Paver	85	50
Pile driver (impact)	101	20
Pile driver (vibratory)	95	20
Pneumatic tool	85	50
Pump	77	50
Rail saw	90	20
Rock drill	85	20
Roller	85	20
Saw	76	20
Scarifier	83	20
Scraper	85	40
Shovel	82	40
Spike driver	77	20
Tie cutter	84	20
Tie handler	80	20
Tie inserter	85	20
Truck	84	40

Source: FTA 2018; FHWA 2006

3.4 Construction Vibration Assessment Methodology

Construction vibration is assessed for areas where there is potential for impact from construction activities. Such activities include blasting, pile driving, demolition, and drilling or excavation in close proximity to sensitive structures. Typical vibration levels generated by representative pieces of equipment are listed in Table G2.3-2. For damage assessment, the following equation is used:

$$PPV_{equip} = PPV_{ref} \times [(25/D)]^{1.5}$$

where:

PPV_{equip} = the peak particle velocity in in/sec of the equipment adjusted for distance,
PPV_{ref} = the reference vibration level in in/sec at 25 feet from Table G2.3-2, and
D = the distance from the equipment to the receiver in feet.

For annoyance assessment, the following equation is used:

$$Lv(D) = Lv(25\ ft) - 30 \times Log(D/25)$$

where:

Lv(D) = RMS vibration level at distance D,
Lv(25 ft) = RMS vibration level at 25 feet from Table G2.3-2, and
D = the distance from the equipment to the receiver in feet.

Table G2.3-2 Construction Equipment Vibration Source Levels

Equipment	PPV at 25 Feet (in/sec)	Approximate Level 1 at 25 Feet (VdB)
Pile driver (impact) – upper range	1.518	112
Pile driver (impact) – typical	0.644	104
Pile driver (vibratory) – upper range	0.734	105
Pile driver (vibratory) – typical	0.170	93
Clam shovel drop (slurry wall)	0.202	94
Hydromill (slurry wall) – in soil	0.008	66
Hydromill (slurry wall) – in rock	0.017	75
Vibratory roller	0.210	94
Hoe ram	0.089	87
Large bulldozer	0.089	87
Caisson drilling	0.089	87
Loaded trucks	0.076	86
Jackhammer	0.035	79
Small bulldozer	0.003	58

Source: FTA 2018

Note:

(1) RMS velocity in decibels (VdB) re 1 micro-inch/second.

4 IMPACT CRITERIA

4.1 FTA Operational Noise Impact Criteria

The FTA operational noise impact criteria are based on well-documented research on community response to noise and are based on both the existing level of noise and the change in noise exposure due to a project. The FTA noise criteria compare the project noise with the existing noise (not the No-Build noise). This is because comparison of a noise projection with an existing noise condition is more accurate than comparison of a projection with another noise projection. Because background noise may increase by the time the project is operational, this approach of using existing noise conditions can possibly overestimate the number of impacts.

The FTA noise criteria are based on the land use category of the sensitive receptor. The descriptors and criteria for assessing noise impact vary according to land use categories adjacent to the project. For Category 2, land uses where people live and sleep (e.g., residential neighborhoods, hospitals, and hotels), the Ldn is the assessment parameter. For other land use types (Category 1 or 3) where there are noise-sensitive uses (e.g., outdoor concert areas, schools, and libraries), the Leq for an hour of noise sensitivity that coincides with train activity is the assessment parameter. Table G2.4-1 summarizes the three land use categories.

Table G2.4-1 Land Use Categories and Metrics for Transit Noise Impact Criteria

Land Use Category	Land Use Type	Noise Metric (dBA)	Description of Land Use Category
1	High Sensitivity	Outdoor Leq(h) [1]	Land where quiet is an essential element of its intended purpose. Example land uses include preserved land for serenity and quiet, outdoor amphitheaters and concert pavilions, and National Historic Landmarks with considerable outdoor use. Recording studios and concert halls are also included in this category.
2	Residential	Outdoor Ldn	This category is applicable to all residential land use and buildings where people normally sleep, such as hotels and hospitals.
3	Institutional	Outdoor Leq(h) [1]	This category is applicable to institutional land uses with primarily daytime and evening use. Example land uses include schools, libraries, theaters, and churches, where it is important to avoid interference with such activities as speech, meditation, and concentration on reading material. Places for meditation or study associated with cemeteries, monuments, museums, campgrounds, and recreational facilities are also included in this category.

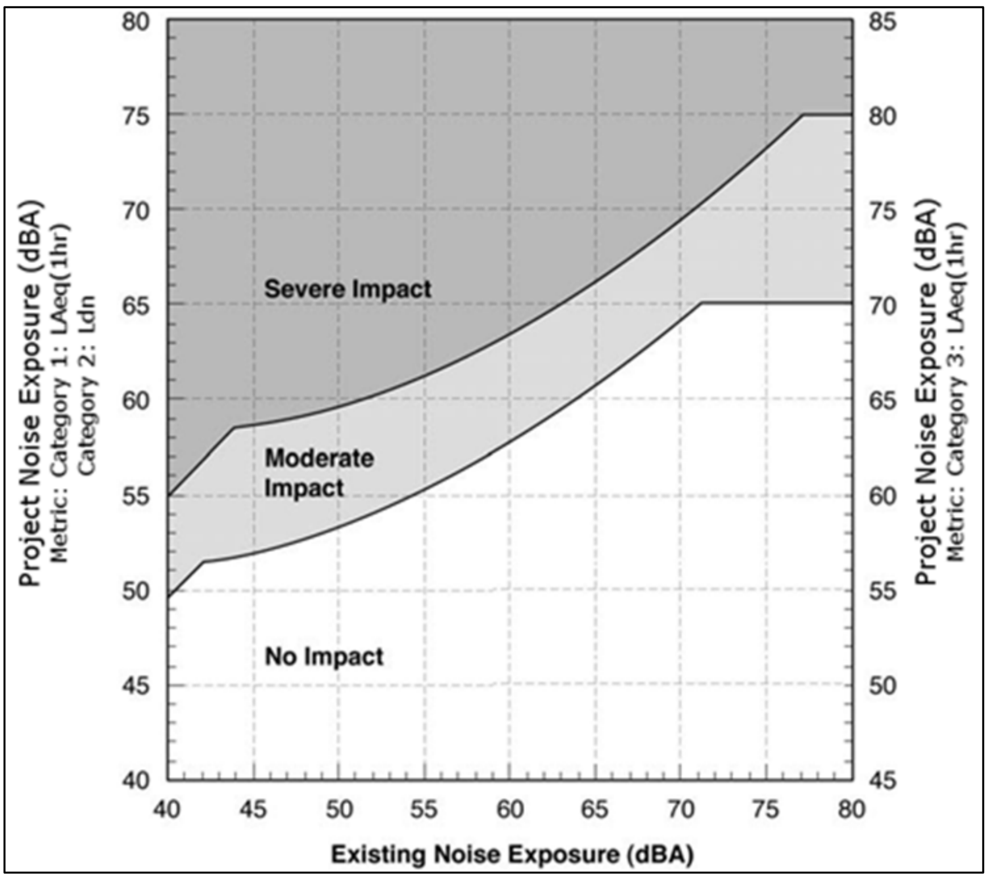
Source: FTA 2018

Note:

(1) Leq (1hr) for the loudest hour of project-related activity during hours of noise sensitivity.

The noise impact criteria are defined by the two curves in Figure G2.4-1, which allow increasing project noise as existing noise levels increase, up to a point at which impact is determined based on project noise alone. The FTA noise impact criteria include three levels of impact, as shown on Figure G2.4-1. The three levels of impact include:

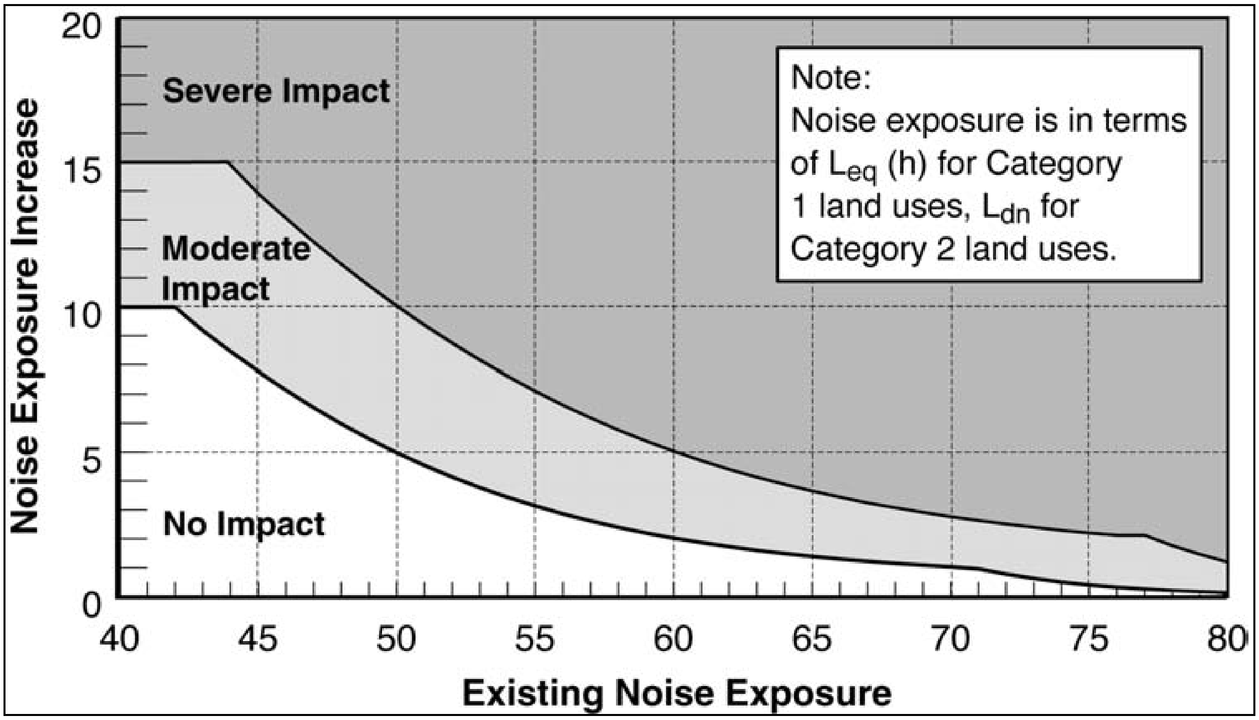
- **No Impact:** In this range, the project is considered to have no impact since, on average, the introduction of the project will result in an insignificant increase in the number of people highly annoyed by the new project noise.
- **Moderate Impact:** Project-generated noise in this range is considered to cause impact at the threshold of measurable annoyance. Moderate impacts serve as an alert to project planners for potential adverse impacts and complaints from the community. Mitigation should be considered at this level of impact based on project specifics and details concerning the affected properties.
- **Severe Impact:** Project-generated noise in this range is likely to cause a high level of community annoyance. Noise mitigation should be applied for severe impacts where feasible.



Source: FTA 2018

Figure G2.4-1 FTA Noise Impact Criteria

Although the curves in Figure G2.4-1 are defined in terms of the project noise exposure and the existing noise exposure, the increase in the cumulative noise — when project-generated noise is added to existing noise levels — is the basis for the criteria. To illustrate this point, Figure G2.4-2 shows the noise impact criteria for Category 1 and Category 2 land uses in terms of the allowable increase in the cumulative noise exposure. Because Ldn and Leq are measures of total acoustic energy, any new noise source in a community will cause an increase, even if the new source level is lower than the existing level. In Figure G2.4-2, the criterion for a moderate impact allows a noise exposure increase of 10 dB if the existing noise exposure is 42 dBA or less, but only a 1 dB increase when the existing noise exposure is 70 dBA.



Source: FTA 2018

Figure G2.4-2 FTA Cumulative Noise Impact Criteria

As the existing level of ambient noise increases, the allowable level of transit noise increases, but the total amount that community noise exposure is allowed to increase is reduced. This accounts for the unexpected result that a project noise exposure that is lower than the existing noise exposure can still cause an effect.

4.2 FTA Operational Vibration Impact Criteria

The operational vibration impact criteria used for the project are based on the information contained in Section 6 of the FTA Transit Noise and Vibration Impact Assessment Manual (FTA 2018). The criteria for a general vibration assessment are based on land use and train frequency, as shown in Table G2.4-2. Some buildings, such as concert halls, recording studios, and theaters, can have a higher sensitivity to vibration (or ground-borne noise) but do not fit into the three vibration categories listed below in Table G2.4-2. Because of the sensitivity of these buildings, special attention is paid to these buildings during the environmental assessment of a project.

Table G2.4-2 Ground-Borne Vibration and Noise Impact Criteria for General Assessment

Land Use Category	Ground-Borne Vibration Impact Levels for Frequent Events [1,3]	Ground-Borne Vibration Impact Levels for Occasional Events [1,4]	Ground-Borne Vibration Impact Levels for Infrequent Events [1,5]	Ground-Borne Noise Impact Levels for Frequent Events [2,3]	Ground-Borne Noise Impact Levels for Occasional Events [2,4]	Ground-Borne Noise Impact Levels for Infrequent Events [2,5]
Category 1: Buildings where vibration would interfere with interior operations	65 [6]	65 [6]	65 [6]	N/A [7]	N/A [7]	N/A [7]
Category 2: Residences and buildings where people normally sleep	72	75	80	35	38	43
Category 3: Institutional land uses with primarily daytime use	75	78	83	40	43	48

Source: FTA 2018

Notes:

(1) Ground-borne vibration impact levels = VdB re 1 micro-inch/sec.

(2) Ground-borne noise impact levels = dBA re 20 micro Pascals.

(3) “Frequent Events” is defined as more than 70 vibration events of the same source per day. Most rapid transit projects fall into this category.

(4) “Occasional Events” is defined as between 30 and 70 vibration events of the same source per day. Most commuter trunk lines have this many operations.

(5) “Infrequent Events” is defined as fewer than 30 vibration events of the same kind per day. This category includes most commuter rail branch lines.

(6) This criterion limit is based on levels that are acceptable for most moderately sensitive equipment, such as optical microscopes. Vibration-sensitive manufacturing or research will require detailed evaluation to define the acceptable vibration levels. Ensuring lower vibration levels in a building often requires special design of the HVAC systems and stiffened floors.

(7) Vibration-sensitive equipment is generally not sensitive to ground-borne noise.

Table G2.4-3 shows the FTA criteria for acceptable levels of vibration for several types of special buildings.

Table G2.4-3 Ground-Borne Vibration and Noise Impact Criteria for Special Buildings

Land Use Category	Ground-Borne Vibration Impact Levels for Frequent Events [1,3]	Ground-Borne Vibration Impact Levels for Occasional or Infrequent Events [1,4]	Ground-Borne Noise Impact Levels for Frequent Events [2,3]	Ground-Borne Noise Impact Levels for Occasional or Infrequent Events [2,4]
Concert halls	65	65	25	25
TV studios	65	65	25	25
Recording studios	65	65	25	25
Auditoriums	72	80	30	38
Theaters	72	80	35	43

Source: FTA 2018

Notes:

(1) Ground-borne vibration impact levels = VdB re 1 micro-inch/sec.

(2) Ground-borne noise impact levels = dBA re 20 micro Pascals.

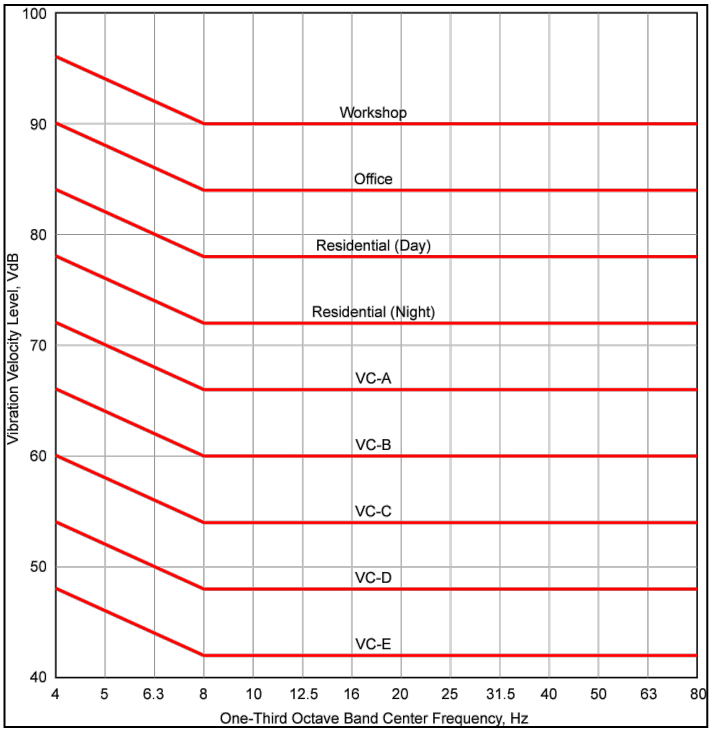
(3) “Frequent Events” is defined as more than 70 vibration events of the same source per day. Most rapid transit projects fall into this category.

(4) “Occasional or Infrequent Events” is defined as fewer than 70 vibration events per day. This category includes most commuter rail system. If the building will rarely be occupied when the trains are operating, there is no need to consider impact. As an example, consider locating a commuter rail line next to a concert hall. If no commuter trains will operate after 7 p.m., it should be rare that the trains interfere with the use of the hall.

Table G2.4-2 and Table G2.4-3 also include additional criteria for ground-borne noise, which is a low-frequency noise that is radiated from the motion of room surfaces, such as walls and ceilings, in buildings due to ground-borne vibration. Ground-borne noise is defined in terms of dBA, which emphasizes middle and high frequencies and is more audible to human ears. The criteria for ground-borne noise are much lower than for airborne noise to account for the low-frequency character of ground-borne noise; however, because airborne noise typically masks ground-borne noise for above ground (at-grade or elevated) transit systems, ground-borne noise is assessed only for operations in tunnels, where airborne noise is not a factor, or at locations such as recording studios, which are well insulated from airborne noise.

The criteria for a detailed vibration assessment are shown in Figure G2.4-3, and descriptions of the curves are shown in Table G2.4-4. The curves in Figure G2.4-3 are applied to the projected vibration spectrum for the project. If the vibration level at any one frequency exceeds the criteria, there is an impact. Conversely, if the entire proposed vibration spectrum of the project is below the curve, there will be no impact.

For the project, the detailed vibration assessment criteria will be used to assess operational ground-borne vibration, except at special buildings where the general vibration assessment criteria will be used.



Source: FTA 2018

Figure G2.4-3 FTA Detailed Vibration Criteria

Table G2.4-4 Interpretation of Vibration Criteria for Detailed Analysis

Criterion Curve (See Figure 3-3)	Max. Level (VdB) [1]	Description of Use
Workshop	90	Vibration that is distinctly felt. Appropriate for workshops and similar areas not as sensitive to vibration.
Office	84	Vibration that can be felt. Appropriate for offices and other areas not as sensitive to vibration.
Residential Day	78	Vibration that is barely felt. Adequate for computer equipment and low-power optical microscopes (up to 20X).
Residential Night, Operating Rooms	72	Vibration is not felt, but ground-borne noise may be audible inside quiet rooms. Suitable for medium-power optical microscopes (100X) and other equipment of low sensitivity.
VC-A	66	Adequate for medium- to high-power optical microscopes (400X), microbalances, optical balances, and similar specialized equipment.
VC-B	60	Adequate for high-power optical microscopes (1000X) and inspection and lithography equipment to 3-micron line widths.
VC-C	54	Appropriate for most lithography and inspection equipment to 1-micron detail size.
VC-D	48	Suitable in most instances for the most demanding equipment, including electron microscopes operating to the limits of their capabilities.
VC-E	42	The most demanding criterion for extremely vibration-sensitive equipment.

Source: FTA 2018

Note:

(1) As measured in 1/3-octave bands of frequency over the frequency range 8 to 80 Hz.

4.3 FTA Construction Noise Impact Criteria

FTA has developed methods for evaluating construction noise levels. These methods are not standardized criteria, but they include noise impact guidelines for sensitive land uses that describe levels having the potential to result in a negative community reaction. Table G2.4-5 shows the FTA noise assessment criteria for construction. The last column applies to construction activities that extend over 30 days near any given receiver. The Ldn is used to assess impacts in residential areas and 24-hour Leq is used in commercial and industrial areas. The 8-hour Leq and the 30-day average Ldn noise exposure from construction noise calculations use the noise emission levels of the construction equipment, their location, and operating hours. The construction noise limits are normally assessed at the noise-sensitive receiver property line.

Table G2.4-5 FTA Construction Noise Criteria

Land Use	8-Hour Leq, dBA Day	8-Hour Leq, dBA Night	Noise Exposure, dBA 30-Day Average
Residential	80	70	75
Commercial	85	85	80
Industrial	90	90	85

Source: FTA 2018

4.4 FTA Construction Vibration Impact Criteria

In addition to the vibration criteria for human annoyance and interference with equipment and spaces described above, there are also vibration criteria for building damage from construction activities. Typical transit operations do not have the potential for damage, so only certain construction activities are assessed for their potential to generate vibration that could cause building damage.

The thresholds for damage to structures are typically several orders of magnitude above the thresholds for human response to vibration. Table G2.4-6 shows the FTA criteria for vibration damage to structures. This is based on the structure and construction type (and not a designation as historic). Table G2.4-6 includes criteria in both VdB and PPV.

Table G2.4-6 FTA Construction Vibration Damage Criteria

Building Category	PPV (in/sec)	Approximate Level [1] (VdB)
I. Reinforced-concrete, steel, or timber (no plaster)	0.5	102
II. Engineered concrete and masonry (no plaster)	0.3	98
III. Non-engineered timber and masonry buildings	0.2	94
IV. Buildings extremely susceptible to vibration damage	0.12	90

Source: FTA 2018

Note:

(1) RMS velocity in VdB re 1 micro-inch/second.

4.5 Traffic Noise Criteria

Because the project, at this level of design, does not include any modifications to existing roadways that might change the vertical or horizontal alignment, add new lanes, or include new roadways, the FHWA standards and regulations do not need to be considered. Traffic within the sites was assessed using FTA noise impact criteria, along with other project components.

4.6 Local Ordinances

The Washington Administrative Code (WAC) noise regulations (which have been adopted by the cities of Federal Way and Kent) are taken from Chapter 173-60, Maximum Environmental Noise Levels. The noise control ordinance provides three different Environmental Designations for Noise Abatement based on zoning, which are defined as residential, commercial, and industrial. The ordinance is then written to define the maximum allowable noise level from one designation to another. For example, the noise caused by an industrial use, like the proposed project, must be less than 60 dBA at the closest residential property line, 65 dBA at the closest commercial use, and 70 dBA at the closest industrial use. These noise levels apply to stationary land uses, like the OMF South, with noises originating from outside public roadways and rights-of-way. Table G2.4-7 provides the property line noise standards provided in the WAC.

Table G2.4-7 Washington State Noise Control Regulation

Source of Noise	Maximum Allowable Sound Level (Leq, dBA) [1] Residential Receiver	Maximum Allowable Sound Level (Leq, dBA) [1] Commercial Receiver	Maximum Allowable Sound Level (Leq, dBA) [1] Industrial Receiver
Residential	55	57	60
Commercial	57	60	65
Industrial	60	65	70

Note:

(1) Between 10 p.m. and 7 a.m., the levels given above are reduced by 10 dB for residential receiving property.

In addition to the property-line noise standards listed in Table G2.4-7, there are exemptions for short-term noise exceedance, including those outlined in Table G2.4-8, which are based on the minutes per hour that the noise limit is exceeded. Based on the operations of LRVs moving on the tracks within the facility, the 5 dB adjustment is applied to the levels shown in Table G2.4-7.

Table G2.4-8 Washington State Exemptions for Short-Term Noise Exceedances

Minutes per Hour	Ln Value	Adjustment to Maximum Sound Level
15	L_{25}	+5 dB
5	$L_{8.3}$	+10 dB
1.5	$L_{1.5}$	+15 dB

Construction noise is exempt from the WAC noise limits, except at residential land uses during nighttime hours (10 p.m. to 7 a.m.). If construction is performed during nighttime hours, the contractor must still meet the WAC noise level requirements presented in Table G2.4-7 or obtain a noise variance from the governing jurisdiction.

Maximum permissible sound levels for haul trucks on public roadways are limited to 86 dBA for speeds of 35 mph or less and 90 dBA for speeds over 35 mph when measured at 50 feet (Chapter 173-62, WAC).

Sounds created by backup alarms are exempt, except between 10 p.m. and 7 a.m. when “beep-beep” backup alarms are essentially prohibited by the WAC in urban areas and would be replaced with smart backup alarms, which automatically adjust the alarm level based on the background level or would be switched off and replaced with spotters. This condition is included because, just like noise from construction activities, noise from backup beepers would exceed the WAC nighttime criteria, even with the allowable exceedance, at large distances from the construction site.

5 AFFECTED ENVIRONMENT

The affected noise and vibration environment in the vicinity of the OMF South build alternatives and mainline track options to the Federal Way Transit Center was investigated based on a review of current project and land use information, GIS data, a windshield survey, and measurements conducted during November 2019. Land use in the OMF South study area includes a combination of residential, institutional, commercial, and industrial zones. Noise-sensitive and vibration-sensitive land uses in the study area were identified based on alignment drawings, aerial photographs, visual surveys, and land use information. Sensitive receptors located near the proposed alternatives include single-family and multi-family residences, hotels, and places of worship.

A summary of noise- and vibration-sensitive land uses adjacent to the OMF South build alternatives and mainline track is provided below, followed by descriptions of the existing noise and vibration conditions in the study area. There are no special buildings, such as recording studios, or highly vibration-sensitive buildings with specialized equipment known to be near any of the OMF South alternatives or the mainline track.

5.1 Noise and Vibration Sensitive Land Use

5.1.1 Midway Landfill Alternative

The land use around the Midway Landfill Alternative includes primarily commercial land uses to the west on both sides of SR 99, along with three religious facilities that are noise sensitive: the Great Commission Presbyterian Church, the New Jerusalem Haitian Baptist Church, and the Seattle Full Gospel Church. Noise-sensitive uses also include a small mobile home park to the north and hotels and a single-family residential community to the south. To the east of the site is I-5.

5.1.2 South 336th Street Alternative

The study area around the South 336th Street Alternative OMF South site and lead tracks includes a mix of commercial and noise-sensitive residential land uses. To the north of the site is a noise-sensitive residential community with a mix of single- and multi-family residences and the Russian-Ukrainian Seventh-Day Adventist Church. To the south is a mix of commercial uses with a few scattered noise-sensitive residences and the Restoration Life Church. To the west are commercial uses on both sides of SR 99 along with the KAC Baptist Church. I-5 is to the east.

5.1.3 South 344th Street Alternative

The study area around the South 344th Street Alternative OMF South site and lead tracks includes a mix of commercial, institutional, and noise-sensitive residential land uses. To the north of the site is a noise-sensitive residential community with a mix of single- and multi-family residences, the Christian Faith Center and associated school, the Russian-Ukrainian Seventh-Day Adventist Church, and the KAC Baptist Church. To the south are commercial uses. To the west are commercial uses on both sides of SR 99, and I-5 is to the east.

5.1.4 Mainline Track

The noise-sensitive land uses adjacent to the mainline track design options between the Federal Way Transit Center and the South 336th Street and South 344th Street alternatives are a mix of single- and multi-family residences, including the residences within the Belmor Park Golf & Country Club (Belmor). The land use around the mainline tail track alignments is commercial, with no noise-sensitive land uses.

5.2 Existing Noise Conditions

Existing noise sources in the project area include traffic on I-5, local roadway traffic, aircraft overflights, and local community activities. The existing ambient sound levels vary by location, depending on the proximity to I-5, and are generally typical of a suburban environment near a busy interstate. Existing ambient noise levels were characterized through direct measurements at selected sites in the area near the OMF South alternatives and mainline track during November 2019.

5.2.1 Noise Measurement Results

5.2.1.1 Midway Landfill Alternative

Table G2.5-1 summarizes the results of the existing noise measurement program, and Figure G2.5-1 shows the locations of the three measurements for the Midway Landfill Alternative. The results of the existing noise measurements were used to characterize the existing noise levels at all noise-sensitive locations near the Midway Landfill.

Site A: Midway Landfill Southwest Corner. The Ldn measured at this location was 65 dBA, and the measured peak hour Leq was 62 dBA. This location is representative of the hotels and the residences to the south of the Midway Landfill away from I-5. The ambient noise levels were dominated by local traffic and traffic on I-5.

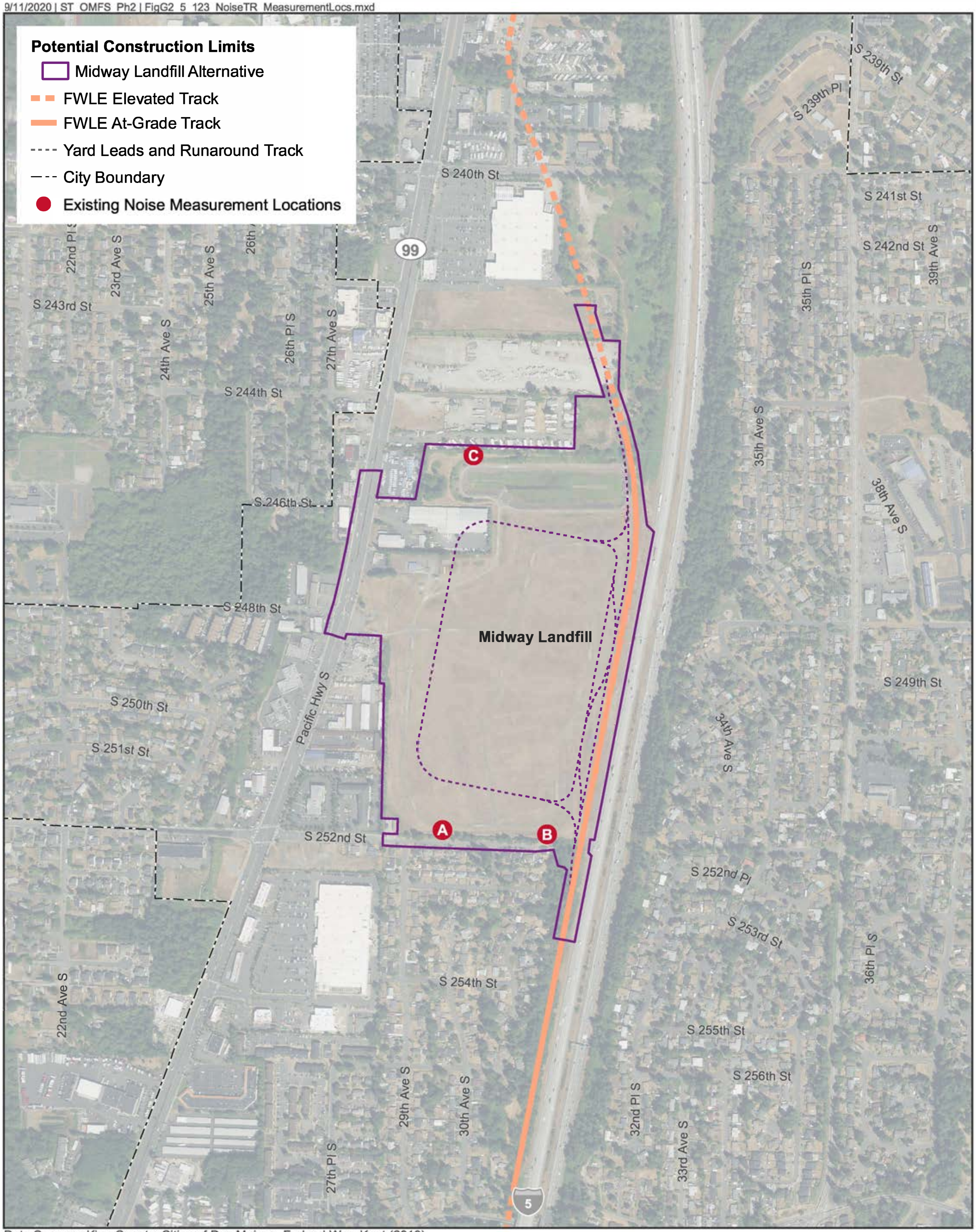
Site B: Midway Landfill Southeast Corner. The Ldn measured at this location was 71 dBA, and the measured peak hour Leq was 66 dBA. This location is representative of the residences to the south of the Midway Landfill near I-5. The ambient noise levels were dominated by traffic on I-5.

Site C: Midway Landfill North Side. The Ldn measured at this location was 67 dBA, and the measured peak hour Leq was 62 dBA. This location is representative of the residences to the north of the Midway Landfill and the religious facilities on SR 99. The ambient noise levels were dominated by local traffic and traffic on I-5.

Table G2.5-1 Summary of Existing Ambient Noise Measurements Results for the Midway Landfill Alternative

Site No.	Measurement Location Description	Start Date	Start Time	Meas. Duration (hours)	Noise Exposure (dBA) Ldn	Noise Exposure (dBA) 1 Hour Leq
A	Midway Landfill Southwest Corner	11/18/19	13:00	24	65	62
B	Midway Landfill Southeast Corner	11/18/19	13:00	24	71	66
C	Midway Landfill North Side	11/18/19	13:00	24	67	62

9/11/2020 | ST_OMFS_Ph2 | FigG2_5_123_NoiseTR_MeasurementLocs.mxd



Data Sources: King County; Cities of Des Moines, Federal Way, Kent (2019).

FIGURE G2.5-1
Existing Noise Measurement Locations
Midway Landfill Alternative

N
0 1,000 2,000 Feet

OMF South

5.2.1.2 South 336th Street Alternative

Table G2.5-2 summarizes the results of the existing noise measurement program, and Figure G2.5-2 shows the locations of the three measurements for the South 336th Street Alternative. The results of the existing noise measurements were used to characterize the existing noise levels at all noise-sensitive locations near the South 336th Street Alternative.

Site F: Christian Faith Center West. The Ldn measured at this location was 67 dBA, and the peak hour Leq was 62 dBA. This location is representative of the residences to the north of the South 336th Street Alternative away from I-5 and the KAC Baptist Church. The ambient noise levels were dominated by local traffic and traffic on I-5.

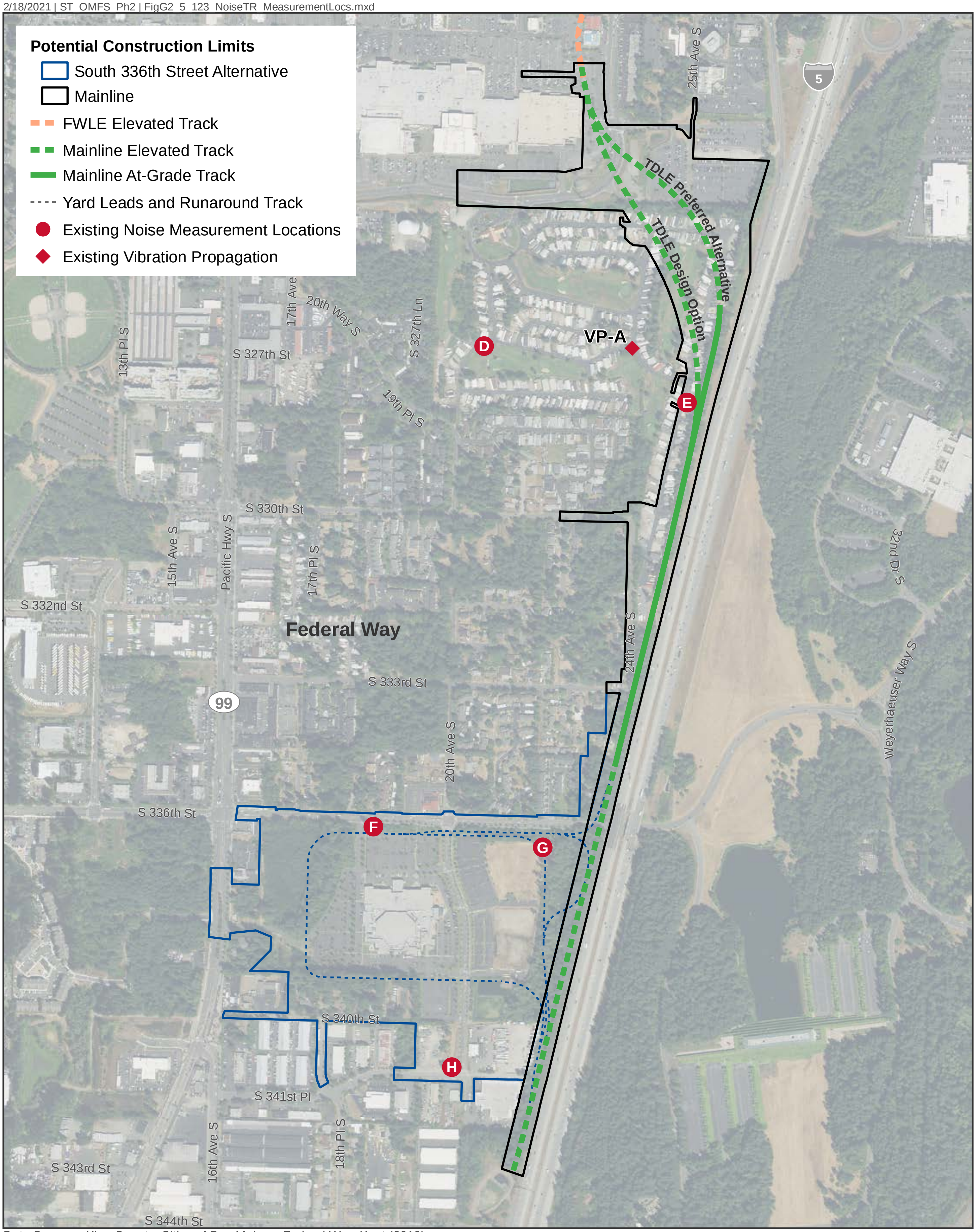
Site G: Christian Faith Center East. The Ldn measured at this location was 72 dBA, and the peak hour Leq was 66 dBA. This location is representative of the residences to the north of the South 336th Street Alternative near I-5. The ambient noise levels were dominated by traffic on I-5.

Site H: 20th Avenue S and S 31st Place. The Ldn measured at this location was 73 dBA, and the peak hour Leq was 67 dBA. This location is representative of the residences to the south of the South 336th Street Alternative. The ambient noise levels were dominated by traffic on I-5.

Table G2.5-2 Summary of Existing Ambient Noise Measurements Results for South 336th Street Alternative

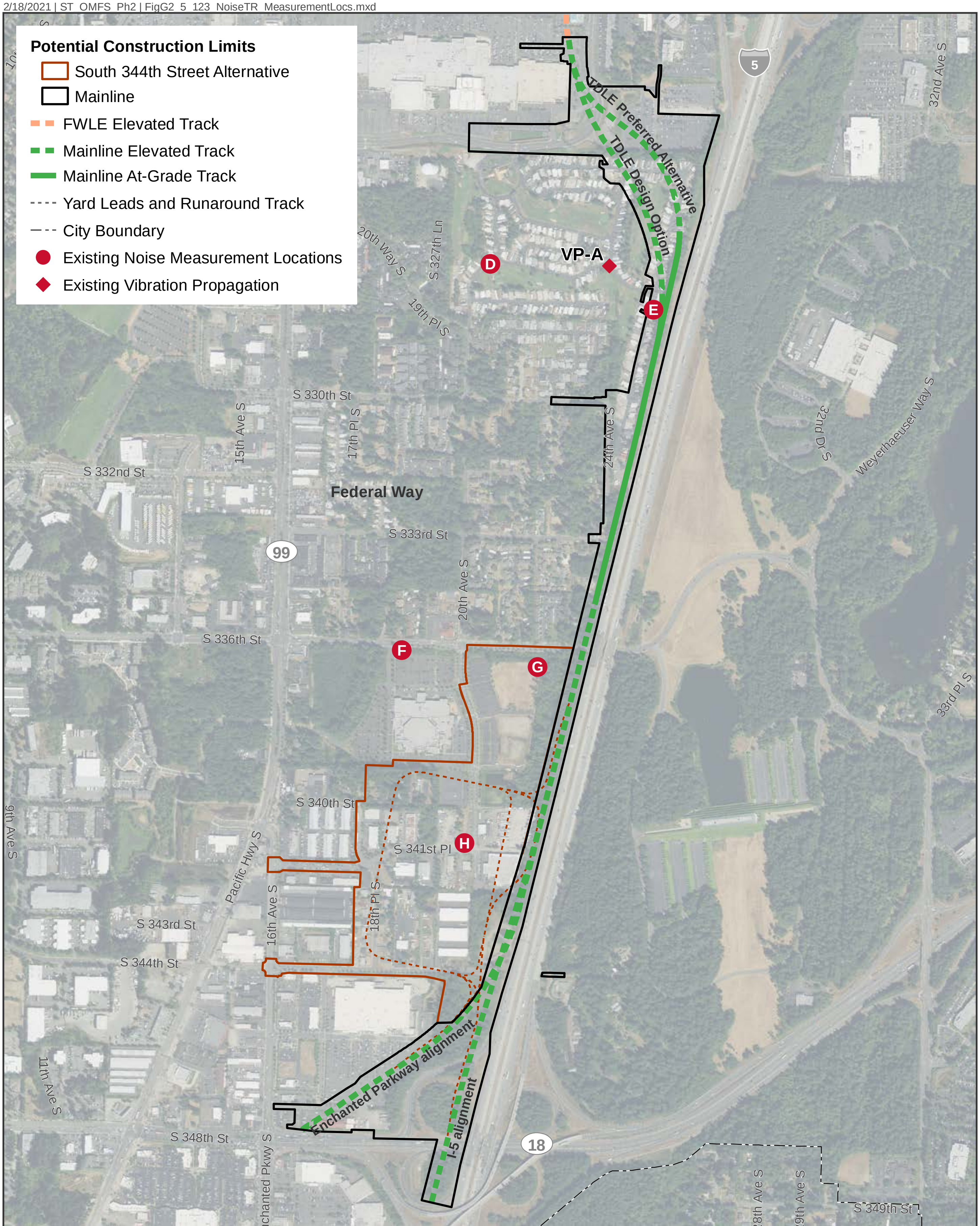
Site No.	Measurement Location Description	Start Date	Start Time	Meas. Duration (hours)	Noise Exposure (dBA) Ldn	Noise Exposure (dBA) 1 Hour Leq
F	Christian Faith Center West	11/19/19	14:00	24	67	62
G	Christian Faith Center East	11/19/19	14:00	24	72	66
H	20th Avenue S and S 31st Place	11/19/19	14:00	24	73	67

2/18/2021 | ST_OMFS_Ph2 | FigG2_5_123_NoiseTR_MeasurementLocs.mxd



Data Sources: King County; Cities of Des Moines, Federal Way, Kent (2019).

FIGURE G2.5-2
Existing Noise and Vibration Propagation Measurement Locations
South 336th Street Alternative
OMF South



Data Sources: King County; Cities of Des Moines, Federal Way, Kent (2019).

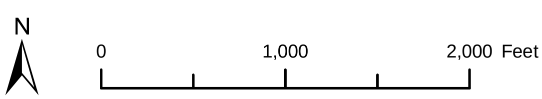


FIGURE G2.5-3
Existing Noise and Vibration Propagation Measurement Locations
South 344th Street Alternative
OMF South

5.2.1.3 South 344th Street Alternative

Table G2.5-3 summarizes the results of the existing noise measurement program, and Figure G2.5-3 shows the locations of the two measurements for the South 344th Street Alternative. The results of the existing noise measurements were used to characterize the existing noise levels at all noise-sensitive locations near the South 344th Street Alternative.

Site F: Christian Faith Center West. The Ldn measured at this location was 67 dBA, and the peak hour Leq was 62 dBA. This location is representative of the residences to the north of the South 336th Street Alternative away from I-5, the Christian Faith Center, and the KAC Baptist Church. The ambient noise levels were dominated by local traffic and traffic on I-5.

Site G: Christian Faith Center East. The Ldn measured at this location was 72 dBA, and the peak hour Leq was 66 dBA. This location is representative of the residences to the north of the South 336th Street alternative near I-5. The ambient noise levels were dominated by traffic on I-5.

Table G2.5-3 Summary of Existing Ambient Noise Measurements Results for South 344th Street Alternative

Site No.	Measurement Location Description	Start Date	Start Time	Meas. Duration (hours)	Noise Exposure (dBA) Ldn	Noise Exposure (dBA) 1 Hour Leq
F	Christian Faith Center West	11/19/19	14:00	24	67	62
G	Christian Faith Center East	11/19/19	14:00	24	72	66

5.2.1.4 Mainline Track Design Options

Table G2.5-4 summarizes the results of the existing noise measurement program, and Figures G2.5-2 and G2.5-3 show the locations of the two measurements for the mainline track design options. The results of the existing noise measurements were used to characterize the existing noise levels at all noise-sensitive locations near each option.

Site D: 11 The Dunes Court, Belmor. The Ldn measured at this location was 65 dBA, and the peak hour Leq was 59 dBA. This location is representative of the residences farther from I-5 near the mainline track design options. The ambient noise levels were dominated by local traffic and traffic on I-5.

Site E: 326 Oakland Hills Boulevard, Belmor. The Ldn measured at this location was 70 dBA, and the peak hour Leq was 65 dBA. This location is representative of the residences closer to I-5 near the mainline track design options. The ambient noise levels were dominated by traffic on I-5.

Table G2.5-4 Summary of Existing Ambient Noise Measurements Results for Mainline Track Options

Site No.	Measurement Location Description	Start Date	Start Time	Meas. Duration (hours)	Noise Exposure (dBA) Ldn	Noise Exposure (dBA) 1 Hour Leq
D	11 The Dunes Court, Belmor	11/19/19	12:00	24	65	59
E	326 Oakland Hills Boulevard, Belmor	11/19/19	12:00	24	70	65

5.3 Existing Vibration Conditions

Vibration-sensitive land uses for the project alternatives are the same as the noise-sensitive land uses described above. Existing vibration sources along the project alignments include auto, bus, and truck traffic on local streets. However, vibrations from street traffic are not generally perceptible at receivers in the study area unless streets have substantial bumps, potholes, or other uneven surfaces. Furthermore, the FTA vibration impact criteria are not ambient based; that is, future project vibrations are not compared with existing vibrations to assess impact. Therefore, the vibration measurements for the project focused on characterizing the soil conditions along the mainline track rather than on characterizing the existing vibration levels as described below.

One vibration propagation test site was selected for the 2019 measurements. The location of the site is shown on Figures G2.5-2 and G2.5-3, a site photograph is included in Attachment G2-1, and detailed propagation information is included in Attachment G2-3.

Site VP-A: Belmor. The vibration propagation measurement at this location was conducted in the vicinity of the mainline track design options in Belmor.

6 IMPACT ASSESSMENT

6.1 No-Build Alternative

Under the No-Build Alternative, noise impacts from the construction or operation of OMF South would not occur. However, for the purposes of this Draft Environmental Impact Statement the No-Build Alternative assumes that by the design year 2042, all planned ST3 projects, including FWLE and TDLE, are built, along with the other public and private projects planned within the study area.

The noise and vibration effects of FWLE on sensitive receptors near the Midway Landfill Alternative have been addressed in the Federal Way Link Extension Final Environmental Impact Statement. FWLE was predicted to have moderate impacts to three residential areas near the Midway Landfill, which would be mitigated with noise walls. No vibration impacts are anticipated in the area. The noise and vibration effects of TDLE on sensitive receptors near the mainline and the South 336th Street and South 344th Street alternatives are discussed in Section 7, Cumulative Impacts, and will be further detailed in the Tacoma Dome Link Extension Draft Environmental Impact Statement, expected to be published in 2022.

In addition, there would likely be increases in highway and local roadway noise due to increased traffic volumes as a result of anticipated population and job growth in the study areas.

6.2 Build Alternatives

Detailed noise and vibration impact assessments were performed based on the criteria discussed in Section 4 and the prediction methodology described in Section 3. The assessment results are presented in this section. The FTA guidance manual is the primary source for the noise methodology. The noise and vibration assessments included the following steps:

- Noise- and vibration-sensitive land uses were identified using aerial photography, GIS data, and field surveys. See Section 5.1.
- Existing noise levels along the corridor were measured at sensitive receptors. See Section 5.2.
- Vibration-propagation characteristics of the soil along the corridor were measured at a representative sensitive receptor. See Section 5.3.
- Project noise and vibration levels from transit operations were predicted using project drawings and information on speeds, headways, track type, vehicle type, crossover locations, and facility operations.
- The noise impact from transit operations and facility operations was assessed by comparing the project noise with the existing noise (not the No-Build Alternative noise) using the FTA noise impact criteria. See Figure G2.4-1.
- The vibration impact from transit operations was assessed by comparing the project vibration levels with the FTA vibration impact criteria in Figure G2.4-3.
- Project noise levels were also compared with the WAC noise criteria for exceedances.
- Mitigation was recommended at locations where project noise or vibration levels exceed the impact criteria.

- Wheel squeal for tight radius curves is not included in the noise model because Sound Transit has committed to reducing any potential wheel squeal by installing wayside lubricators on all curves in noise-sensitive areas with a radius of less than 600 feet and by preparing all curves for wayside lubricators that have a radius of between 600 and 1,000 feet, including those in the OMF. On the mainline tracks, the curves north of S 324th Street, from S 324th Street to Oakland Hills Boulevard and across S 348th Street, would have a radius between 600 and 1,000 feet on the Enchanted Parkway Alternative and would be prepared for wayside lubricators. There are numerous tight radius curves within the sites for all three OMF build alternatives that would also be prepared for wayside lubricators.

6.2.1 Midway Landfill Alternative

Comparisons of the existing and future noise levels are presented in Table G2.6-1 and Table G2.6-2 for the Midway Landfill Alternative. Table G2.6-1 includes the results for FTA Category 2 (residential) receptors with both daytime and nighttime sensitivity to noise, and Table G2.6-2 includes the results for FTA Category 3 (institutional) receptors with daytime and evening use. There were no FTA Category 1 (high sensitivity) receptors in the study area for this alternative. In addition to the distances to the nearest track, the tables include the existing noise levels, the projected noise levels from facility operations, and the FTA noise impact criteria. Based on a comparison of the predicted project noise levels with the impact criteria, the tables also include an inventory of the moderate and severe noise impacts for the Midway Landfill Alternative.

Table G2.6-1 Summary of FTA Category 2 Noise Impacts for the Midway Landfill Alternative

Location	Side of OMF	Dist to Near Track (feet)	Existing Noise Level (Ldn, dBA)	Project Noise Level (Ldn, dBA)	Mod. Noise Criteria	Sev. Noise Criteria	# of Mod. Impacts	# of Sev. Impacts
Midway Mobile Mansions	North	490	67	45	62	67	0	0
SR 99 Motels	West	230	65	40	61	66	0	0
S 252nd Street	South	270	71	40	65	70	0	0
Total:							**0**	**0**

Table G2.6-2 Summary of FTA Category 3 Noise Impacts for the Midway Landfill Alternative

Location	Side of OMF	Dist to Near Track (feet)	Existing Noise Level (Ldn, dBA)	Project Noise Level (Ldn, dBA)	Mod. Noise Criteria	Sev. Noise Criteria	# of Mod. Impacts	# of Sev. Impacts
New Jerusalem Haitian Baptist Church	West	640	62	<20	64	69	0	0
Seattle Full Gospel Church	West	860	62	<20	64	69	0	0
Great Commission Presbyterian Church	West	780	62	<20	64	69	0	0
Total:							**0**	**0**

Table G2.6-3 shows a comparison of the maximum noise levels from facility operations with the WAC thresholds for residential land uses at night. Because the majority of the activity at the facility would occur at night, and commercial and industrial uses typically do not have activity at night, only the residential night threshold is assessed.

Table G2.6-3 Summary of WAC Nighttime Noise Exceedances for the Midway Landfill Alternative

Location	Side of OMF	Dist to Near Track (feet)	Project Noise Level (Leq, dBA)	Noise Level for Impact	# of Exceedances
Midway Mobile Mansions	North	490	41	55	0
SR 99 Motels	West	230	41	55	0
S 252nd Street	South	270	40	55	0
Total:					**0**

There are no FTA noise impacts or WAC exceedances for the Midway Landfill Alternative.

6.2.2 South 336th Street Alternative

Comparisons of the existing and future noise levels are presented in Table G2.6-4 and Table G2.6-5 for the South 336th Street Alternative. Table G2.6-6 includes the results for FTA Category 2 (residential) receptors with both daytime and nighttime sensitivity to noise, and Table G2.6-7 includes the results for FTA Category 3 (institutional) receptors with daytime and evening use. There were no FTA Category 1 (high sensitivity) receptors in the study area for this alternative. In addition to the distances to the nearest track, the tables include the existing noise levels, the projected noise levels from facility operations, and the FTA noise impact criteria. Based on a comparison of the predicted project noise levels with the impact criteria, the tables also include an inventory of the moderate and severe noise impacts for the South 336th Street Alternative.

Table G2.6-4 Summary of FTA Category 2 Noise Impacts for the South 336th Street Alternative

Location	Side of OMF	Dist to Near Track (feet)	Existing Noise Level (Ldn, dBA)	Project Noise Level (Ldn, dBA)	Mod. Noise Criteria	Sev. Noise Criteria	# of Mod. Impacts	# of Sev. Impacts
S 336th Street	North	150	67	50	62	68	0	0
18th Place S	South	1600	73	41	65	71	0	0
Total:							**0**	**0**

Table G2.6-5 Summary of FTA Category 3 Noise Impacts for the South 336th Street Alternative

Location	Side of OMF	Dist to Near Track (feet)	Existing Noise Level (Ldn, dBA)	Project Noise Level (Ldn, dBA)	Mod. Noise Criteria	Sev. Noise Criteria	# of Mod. Impacts	# of Sev. Impacts
Russian-Ukrainian Seventh-Day Adventist Church	North	150	62	<20	64	70	0	0
KAC Baptist Church	West	1060	62	<20	64	70	0	0
Restoration Life Church	South	1650	67	<20	67	72	0	0
Total:							**0**	**0**

Table G2.6-6 shows a comparison of the maximum noise levels from facility operations with the WAC thresholds for residential land uses at night. Because the majority of the activity at the facility would occur at night, and commercial and industrial uses typically do not have activity at night, only the residential night threshold is assessed.

Table G2.6-6 Summary of WAC Nighttime Noise Exceedances for the South 336th Street Alternative

Location	Side of OMF	Dist to Near Track (feet)	Project Noise Level (Leq, dBA)	Noise Level for Impact	# of Exceedances
S 336th Street	North	150	44	55	0
18th Place S	South	1600	36	55	0
Total:					**0**

There are no FTA noise impacts or WAC exceedances for the South 336th Street Alternative.

6.2.3 South 344th Street Alternative

Comparisons of the existing and future noise levels are presented in Table G2.6-7 and Table G2.6-8 for the South 344th Street Alternative. Table G2.6-7 includes the results for FTA Category 2 (residential) receptors with both daytime and nighttime sensitivity to noise, and Table G2.6-8 includes the results for FTA Category 3 (institutional) receptors with daytime and evening use. There were no FTA Category 1 (high sensitivity) receptors in the study area for this alternative. In addition to the distances to the nearest track, the tables include the existing noise levels, the projected noise levels from facility operations, and the FTA noise impact criteria. Based on a comparison of the predicted project noise levels with the impact criteria, the tables also include an inventory of the moderate and severe noise impacts for the South 344th Street Alternative.

Table G2.6-7 Summary of FTA Category 2 Noise Impacts for the South 344th Street Alternative

Location	Side of OMF	Dist to Near Track (feet)	Existing Noise Level (Ldn, dBA)	Project Noise Level (Ldn, dBA)	Mod. Noise Criteria	Sev. Noise Criteria	# of Mod Impacts	# of Sev Impacts
S 336th Street	North	1210	67	40	62	68	0	0
S 340th Street	West	510	67	44	62	68	0	0
Total:							**0**	**0**

Table G2.6-8 Summary of FTA Category 3 Noise Impacts for the South 344th Street Alternative

Location	Side of OMF	Dist to Near Track (feet)	Existing Noise Level (Ldn, dBA)	Project Noise Level (Ldn, dBA)	Mod. Noise Criteria	Sev. Noise Criteria	# of Mod Impacts	# of Sev Impacts
Russian-Ukrainian Seventh-Day Adventist Church	North	1130	62	<20	64	70	0	0
KAC Baptist Church	West	970	62	<20	64	70	0	0
Christian Faith Center	West	240	62	<20	64	70	0	0
Restoration Life Church	West	1060	67	<20	67	73	0	0
Total:							**0**	**0**

Table G2.6-9 shows a comparison of the maximum noise levels from facility operations with the WAC thresholds for residential land uses at night. Because the majority of the activity at the facility would occur at night, and commercial and industrial uses typically do not have activity at night, only the residential night threshold is assessed.

Table G2.6-9 Summary of WAC Nighttime Noise Exceedances for the South 344th Street Alternative

Location	Side of OMF	Dist to Near Track (feet)	Project Noise Level (Leq, dBA)	Noise Level for Impact	# of Exceedances
S 336th Street	North	1210	34	55	0
S 340th Street	West	510	41	55	0
Total:					**0**

There are no FTA noise impacts or WAC exceedances for the South 344th Street Alternative.

6.3 Mainline Track Noise

For the mainline track design options, comparisons of the existing and future noise levels are presented in Table G2.6-10 and Table G2.6-11. Table G2.6-10 includes the results for FTA Category 2 (residential) receptors with both daytime and nighttime sensitivity to noise for the TDLE Preferred Alternative, and Table G2.6-11 includes the results for FTA Category 2 receptors for the TDLE Design Option. There are no FTA Category 1 (high sensitivity) or Category 3 (industrial) land uses near the mainline track design options.

In addition to the distances to the nearest track, Table G2.6-10 and Table G2.6-11 include the existing noise levels, the projected noise levels from LRV operations, and the FTA noise impact criteria. Based on a comparison of the predicted project noise levels with the impact criteria, the table also includes an inventory of the moderate and severe noise impacts for the mainline tracks.

The noise impacts are at single-family residences and are due to the proximity to the proposed tracks. The noise impact locations are shown in Figure G2.6-1 for the TDLE Preferred Alternative and Figure G2.6-2 for the TDLE Design Option, and the projected noise impacts are described below.

Table G2.6-10 Summary of FTA Category 2 Noise Impacts for the TDLE Preferred Alternative Mainline Track

Location	Side of Track	Dist to Near Track (feet)	Existing Noise Level (Ldn, dBA)	Project Noise Level (Ldn, dBA)	Mod. Noise Criteria	Sev. Noise Criteria	# of Mod Impacts	# of Sev Impacts
S 324th Street to Burning Tree Boulevard	SB	40	70	65	64	69	3	0
Burning Tree Boulevard to S 330th Street	SB	32	70	62	64	69	0	0
S 330th Street to S 333rd Street	SB	90	72	55	64	69	0	0
S 333rd Street to S 336th Street	SB	208	72	55	65	71	0	0
Total:							**3**	**0**

S 324th Street to Burning Tree Boulevard (SB): Several single-family residences between S 324th Street and Burning Tree Boulevard on the southbound side of the mainline track are projected to have moderate noise impacts. These impacts are due to the proximity of the tracks.

Table G2.6-11 Summary of FTA Category 2 Noise Impacts: TDLE Design Option Mainline Track

Location	Side of Track	Dist to Near Track (feet)	Existing Noise Level (Ldn, dBA)	Project Noise Level (Ldn, dBA)	Mod. Noise Criteria	Sev. Noise Criteria	# of Mod Impacts	# of Sev Impacts
S 324th Street to Burning Tree Boulevard	NB	50	70	63	64	69	0	0
S 324th Street to Burning Tree Boulevard	SB	43	65	64	61	66	4	0
Burning Tree Boulevard to S 330th Street	SB	54	70	59	64	69	0	0
S 330th Street to S 333rd Street	SB	93	72	55	65	71	0	0
S 333rd Street to S 336th Street	SB	209	72	55	65	71	0	0
Total:							**4**	**0**

S 324th Street to Burning Tree Boulevard (SB): Several single-family residences between S 324th Street and Burning Tree Boulevard on the southbound side of the mainline track are projected to have moderate noise impacts. These impacts are due to the proximity of the tracks.

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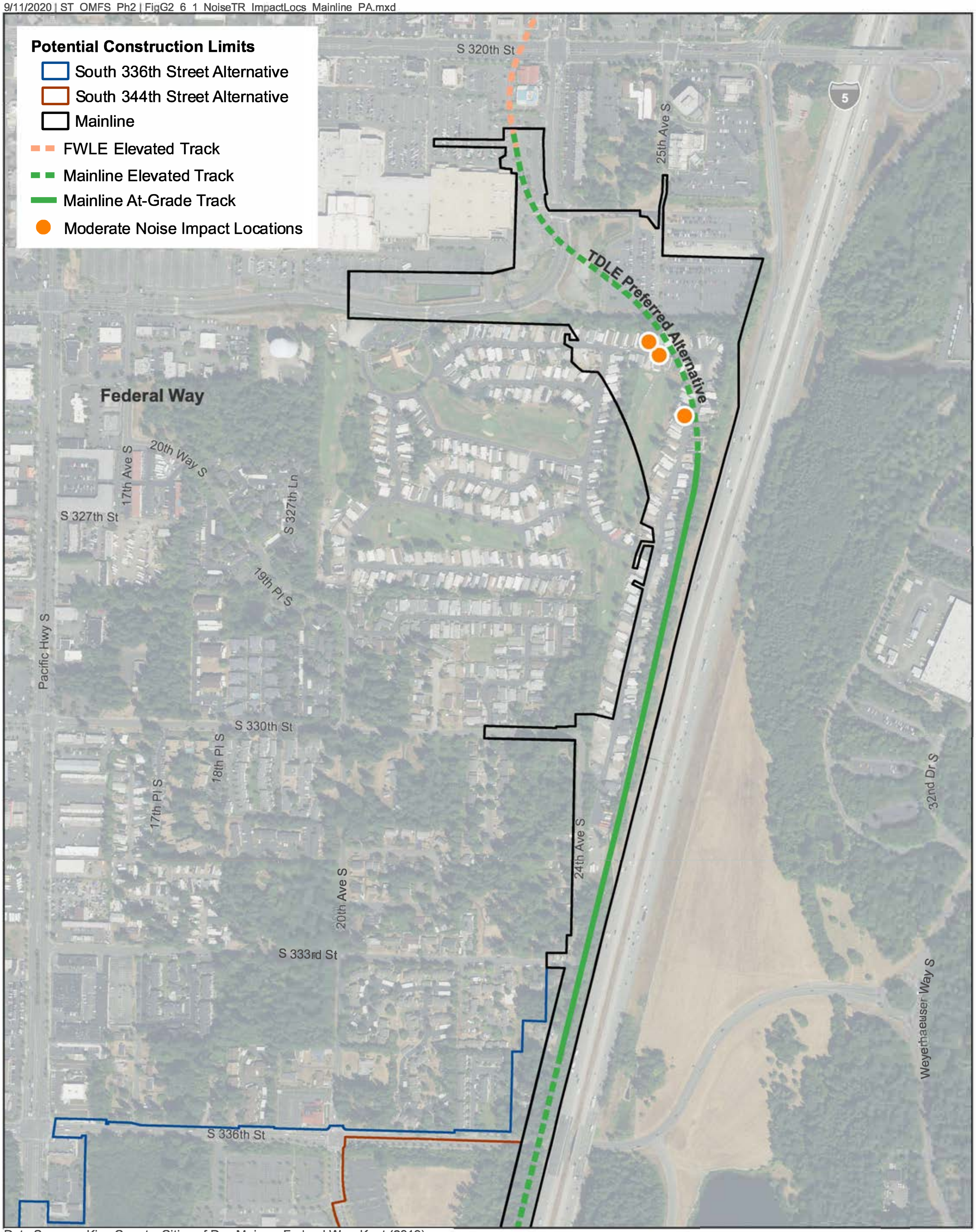


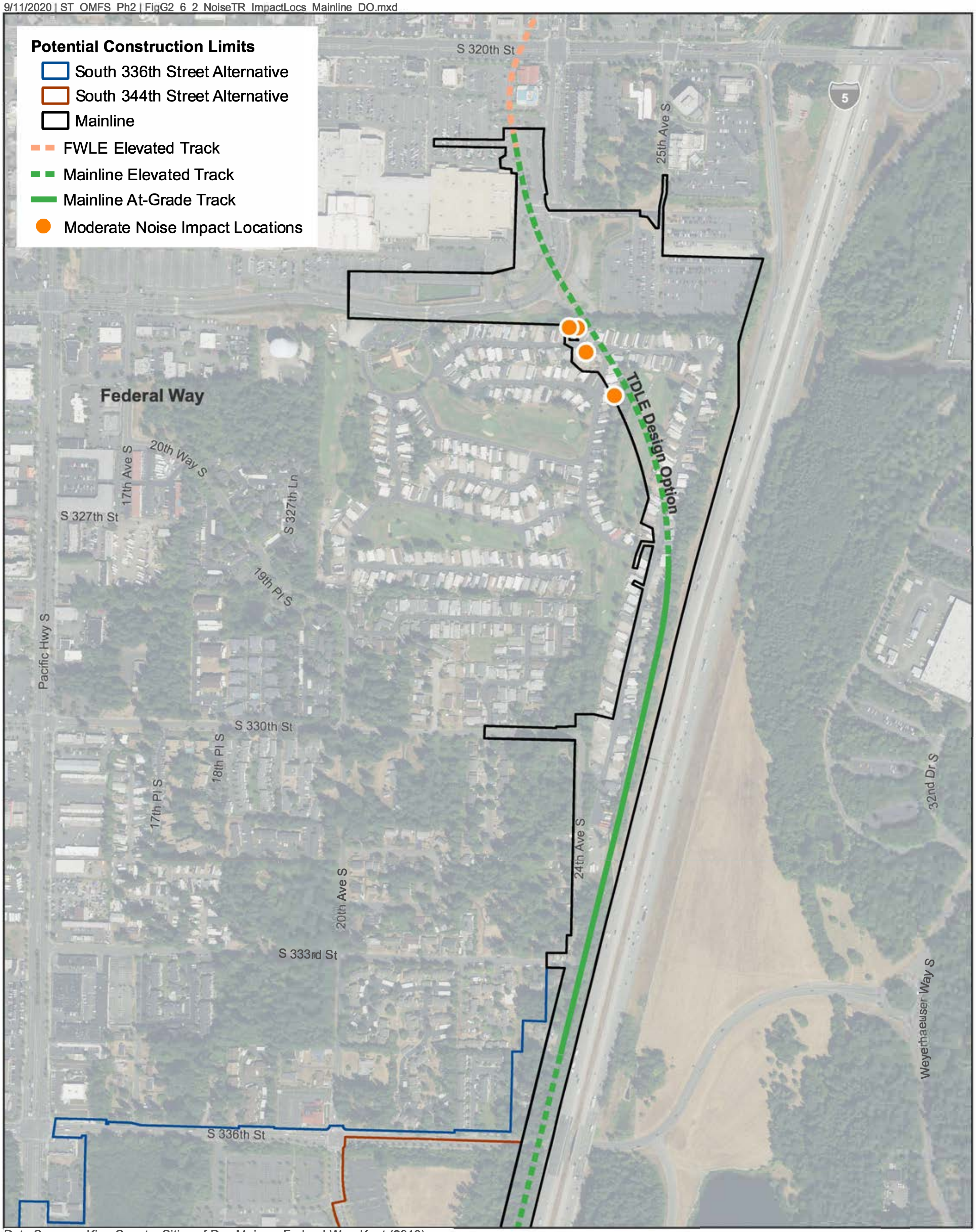
Data Sources: King County; Cities of Des Moines, Federal Way, Kent (2019).

N

0 500 1,000 Feet

FIGURE G2.6-1
Noise Impact Locations
TDLE Preferred Alternative
OMF South

9/11/2020 | ST_OMFS_Ph2 | FigG2_6_2_NoiseTR_ImpactLocs_Mainline_DO.mxd



Data Sources: King County; Cities of Des Moines, Federal Way, Kent (2019).

N

0 500 1,000 Feet

FIGURE G2.6-2
Noise Impact Locations
TDLE Design Option
OMF South

6.4 Vibration

Because there are no highly vibration-sensitive land uses located near the OMF South alternatives, and due to the very low train speeds within the facility, vibration levels would be well below the impact thresholds for sensitive receptors near the three site alternatives and have not been assessed. However, vibration has been assessed for the LRV operations on the mainline tracks between the South 336th Street and the South 344th Street alternatives and the Federal Way Transit Center.

This section describes the vibration impacts for the LRV operations on the mainline track design options. Table G2.6-12 includes the results for FTA Category 2 (residential) receptors with both daytime and nighttime sensitivity to vibration for the TDLE Preferred Alternative, and Table G2.6-13 includes the results for FTA Category 2 receptors for the TDLE Design Option. There are no FTA Category 1 (high sensitivity) or Category 3 (industrial) land uses near the mainline track design options.

The results include a tabulation of location information for each sensitive receptor group, the projections of future vibration levels, the impact criteria, and whether there will be vibration impacts. The tables also show the total number of vibration impacts for each location. There are no vibration impacts projected for either mainline track design option.

Table G2.6-12 Summary of FTA Category 2 Vibration Impacts for the TDLE Preferred Alternative Mainline Track

Location	Side of Track	Dist to Near Track (feet)	Project Vibration Level (VdB)	FTA Criterion (VdB)	# of Impacts
S 324th Street to Burning Tree Boulevard	SB	40	51	72	0
Burning Tree Boulevard to S 330th Street	SB	32	57	72	0
S 330th Street to S 333rd Street	SB	90	44	72	0
S 333rd Street to S 336th Street	SB	208	43	72	0
Total:					**0**

Table G2.6-13 Summary of FTA Category 2 Vibration Impacts for the TDLE Design Option Mainline Track

Location	Side of Track	Dist to Near Track (feet)	Project Vibration Level (VdB)	FTA Criterion (VdB)	# of Impacts
S 324th Street to Burning Tree Boulevard	NB	50	52	72	0
S 324th Street to Burning Tree Boulevard	SB	43	49	72	0
Burning Tree Boulevard to S 330th Street	SB	54	51	72	0
S 330th Street to S 333rd Street	SB	93	43	72	0
S 333rd Street to S 336th Street	SB	209	43	72	0
Total:					**0**

6.5 Construction Noise

Elevated noise levels from construction activities are, to a degree, unavoidable for this type of project. For most construction equipment, diesel engines are typically the dominant noise source. For other activities, such as impact pile driving and jackhammering, noise generated by the actual process dominates. Short-term noise during construction of the project can be intrusive to residents near the construction sites. Most of the construction will consist of site preparation and laying new tracks and would primarily occur during daytime hours within local noise ordinance requirements for a waiver. At some locations, more extensive work will occur, such as pile driving for elevated structures and retaining walls.

Table G2.3-1 in Section 3 lists noise levels of typical construction equipment from the FTA guidance manual in terms of the maximum levels at 50 feet. Construction noise predictions at noise-sensitive locations depend on the amount of noise during each construction phase, the duration of the noise, and the distance from the construction activities to the sensitive receptor. Conducting a construction noise impact assessment requires knowledge of the equipment likely to be used, the duration of its use, and the way it will be used by a contractor. Table G2.6-14 provides an example of a construction noise projection for typical at-grade track construction. Construction for other project features, such as buildings, would have similar results. Specific construction scenarios would be developed when more information on methods, equipment, and durations is available. Using these assumptions, an 8-hour Leq of 88 dBA would be projected at a distance of 50 feet from the construction site.

Using the criteria in Section 4.3 and the example for at-grade construction in Table G2.6-14, screening distances for at-grade track construction noise impact can be determined. For residential land use, the potential for short-term at-grade track construction noise impact could extend to approximately 120 feet from the corridor or OMF South site; however, if nighttime construction is conducted (when sensitivity to noise is higher and the criteria for impact are lower), the potential for short-term noise impact from at-grade construction could extend to approximately 380 feet from the corridor. For elevated structure construction, the distance for noise impact during the daytime could be up to 250 feet for impact pile driving, assuming a usage factor of 20% during the day. If alternative methods of piling are used, the distance to impact could be less. When a specific piling method is determined, a screening distance could be calculated.

Based on the distances above, there would be sensitive receptors within the screening distances for all three OMF South alternatives, including the mainline track design options. Noise impacts perceived by residents and other sensitive receptors would vary depending on the proximity of the construction activity, the type of equipment being used, the time of day, and the overall duration of construction. While the noise levels would be similar for construction of any of the build alternatives, the Hybrid and Full Excavation design options for the Midway Landfill Alternative may be perceived to have a greater impact due to the extended period of time needed for site preparation work.

Table G2.6-14 Typical Construction Scenario, At-Grade Track

Equipment Type	Typical Noise Level at 50 Feet (dBA)	Equipment Utilization Factor (%)	Leq (dBA)
Grader	85	50	82
Backhoe	80	40	76
Compactor	82	20	75
Loader	85	20	78
Roller	74	20	67
Truck	88	40	84
Crane, mobile	83	20	76
Total 8-hour workday Leq at 50 feet:			**88**

6.6 Construction Vibration

Unlike typical LRV operations, there is the potential for damage to nearby structures at close distances due to construction vibration from activities, such as pile driving, hoe rams, vibratory compaction, and loaded trucks. Most limits on construction vibration are based on reducing the potential for damage to nearby structures. Although construction vibrations are only temporary, it is still reasonable to assess the potential for human annoyance and damage.

As a conservative approach, the nonengineered timber and masonry construction category (Category III) has been used to assess the potential for construction vibration impacts. A vibration criterion of 94 VdB has been used to assess potential damage impact, and 72 VdB has been used to assess potential vibration annoyance from construction activities. Vibration source levels at 25 feet and the distances to potential residential annoyance and potential damage are shown in Table G2.6-15. With the exception of impact pile driving, the potential for damage is limited to within 25 feet of construction activities. For impact pile driving, the distance for the potential for damage is up to 55 feet. There are no sensitive receptors within 25 feet of the OMF South site alternatives, but there are several within 55 feet of the mainline track design options in Belmor. However, any potential for impacts would depend on the piling method chosen.

Because the exact location of construction equipment is important in projecting vibration levels, a more detailed assessment of potential vibration damage will be performed during final design when more accurate equipment locations are known.

Table G2.6-15 Summary of Potential Construction Vibration Impacts

Equipment Type	Typical Vibration Level at 25 Feet (VdB)	Distance for Potential Damage (feet)	Distance for Potential Annoyance (feet)
Impact pile driving	104	55	290
Push piling	84	25	125
Hoe ram	87	15	80
Caisson drilling	87	15	80
Loaded trucks	86	15	75
Clam shovel	94	25	135
Vibratory roller	94	25	135

7 CUMULATIVE IMPACTS

Cumulative impacts for the OMF South project would be associated with TDLE. If TDLE is constructed, all 144 LRVs would be needed and stored at OMF South. With the additional vehicles, there would be additional operations within the facility, including additional LRV movements into and out of the facility in the morning and evening, respectively. Additionally, for the South 336th and South 344th Street alternatives, the LRVs leaving and entering would be split between the northern and southern tracks leading to the mainline. Finally, the mainline track connecting the South 336th Street and South 344th Street alternatives would become the operational track, with higher speeds and LRV operations throughout the day.

The additional LRVs from TDLE operating within the OMF South alternative sites would increase some noise levels, but there would still be no FTA noise impacts or WAC exceedances. However, the operation of TDLE along the mainline tracks would cause an increase in the number and magnitude of noise impacts (including severe noise impacts) in Belmor to residences near the mainline tracks for the South 336th Street and South 344th Street alternatives. The additional impacts are due to the number of trains that would be in revenue service along the mainline, as compared with only trains moving to and from the OMF site with the OMF South project only. There would be no cumulative impacts from TDLE for the Midway Landfill Alternative

There would be no vibration impacts associated with OMF South. With the inclusion of the TDLE project, there would be several vibration impacts at residences in Belmor for the South 336th Street and South 344th Street alternatives. These impacts would be due to revenue service operations of the TDLE, including higher speeds on the track. The vibration impacts could be eliminated with the use of highly resilient fasteners on the elevated structures. With the Midway Landfill Alternative, there would be no cumulative vibration impacts from the TDLE project.

Further details regarding TDLE noise and vibration impacts and mitigation are included in the Tacoma Dome Link Extension Draft Environmental Impact Statement, which is expected to be published in 2022.

8 MITIGATION

8.1 Operational Noise

The Sound Transit Link Noise Mitigation Policy (Sound Transit 2004) sets source mitigation as the preferred method of mitigation, followed by path mitigation, such as noise barriers, and then receiver mitigation last, which would include sound insulation of properties. There are several methods of noise mitigation available, including:

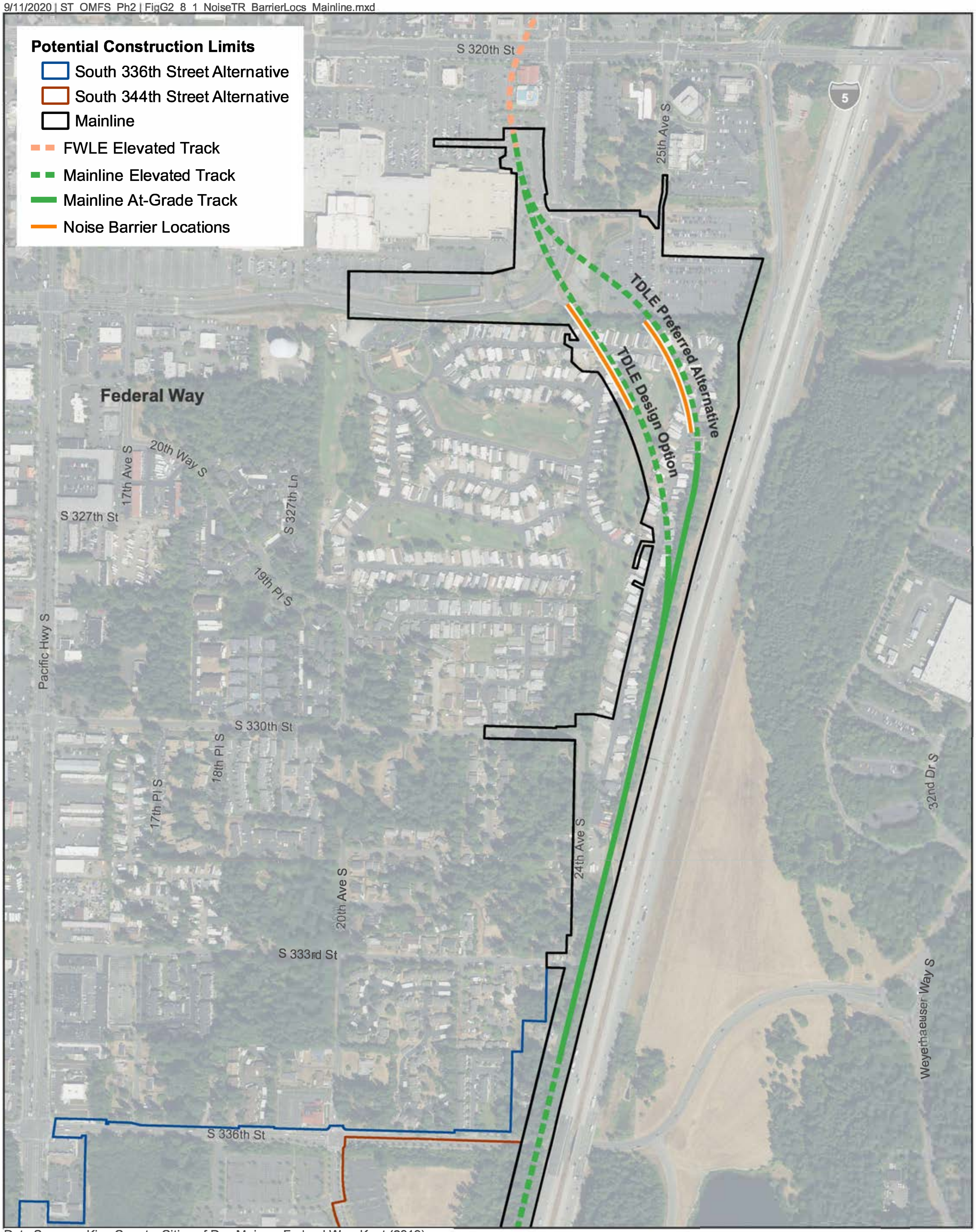
- **Noise Barriers:** Installation of noise barriers beside the tracks is commonly used to reduce noise from surface transportation sources. Depending on the height and location relative to the tracks, noise barriers can achieve between 5 and 15 dB of noise reduction. The primary requirements for an effective noise barrier are that (1) the barrier must be high enough and long enough to break the line of sight between the sound source and the receiver, (2) the barrier must be of an impervious material with a minimum surface density of 4 pounds per square foot, and (3) the barrier must not have any gaps or holes between the panels or at the bottom. Because many materials meet these requirements, the selection of materials for noise barriers is usually dictated by aesthetics, durability, cost, and maintenance considerations. Noise barriers for transit projects typically range from 8 to 12 feet in height along at-grade track and can be as low 4 feet in height on elevated structures.
- **Building Sound Insulation:** Although typically used as a last resort, sound insulation may be necessary when noise barriers are not feasible or desirable and for buildings where indoor sensitivity is of most concern. Substantial improvements in building sound insulation (on the order of 5 to 10 dBA) can often be achieved by adding an extra layer of glazing to the windows, by sealing holes in exterior surfaces that act as sound leaks, and by providing forced ventilation and air-conditioning so that windows do not need to be opened.

For the proposed project alternatives, noise barriers are proposed for mitigation along the elevated mainline track for the South 336th Street and South 344th Street alternatives. The approximate locations and lengths of the noise barriers would depend on which mainline design option is chosen and are shown in Table G2.8-1 and shown in Figures G2.8-1 and G2.8-2. The final height and length of the barriers would be determined during final design. However, typical noise barriers are 4 feet in height on elevated structures. Assuming 4-foot barriers on the elevated structure at the locations described below, the barriers would provide approximately 8 dB of noise reduction (with 1 and 3 dB of reduction required to eliminate impacts, respectively), and there would be no residual impacts after mitigation. No mitigation would be necessary for the Midway Landfill Alternative.

The noise mitigation for the cumulative effects of TDLE on sensitive receptors near the mainline and the South 336th Street or South 344th Street alternatives could include one or more of a combination of the methods described above. This will be further detailed in the Tacoma Dome Link Extension Draft Environmental Impact Statement, which is expected to be published in 2022.

Table G2.8-1 Summary of Potential Noise Barrier Locations

Project Alternative	Approximate Location	Noise Barrier Length (feet)
TDLE Preferred Alternative Mainline Track	Southbound side from south of park-and-ride to Oakland Hills Boulevard	600
TDLE Design Option Mainline Track	Southbound side from south of park-and-ride to south of Seminole Lane	600



Data Sources: King County; Cities of Des Moines, Federal Way, Kent (2019).

N

0 500 1,000 Feet

FIGURE G2.8-1
Noise Barrier Locations
Mainline Track Options

OMF South

8.2 Operational Vibration

No operational vibration impacts are projected to occur; therefore, no vibration mitigation is required.

8.3 Construction

Construction activities will be carried out in compliance with Sound Transit specifications and applicable local noise regulations. Construction noise is exempt from the WAC noise limits, except at residential land uses during nighttime hours (10 p.m. to 7 a.m.). If construction is performed during nighttime hours, the contractor must meet the WAC noise level requirements or obtain a noise variance from the governing jurisdiction. Specific construction noise and vibration mitigation measures will be developed during the final design phase of the project when more detailed construction information is available. The following measures could be applied as needed to minimize temporary construction noise and vibration impacts:

- Avoiding nighttime construction in residential neighborhoods
- Locating stationary construction equipment as far as possible from noise-sensitive sites
- Constructing noise barriers, such as temporary walls or piles of excavated material, between noisy activities and noise-sensitive receivers
- Routing construction-related truck traffic to roadways that will cause the least disturbance to residents
- Using alternative construction methods to minimize the use of impact and vibratory equipment (e.g., pile drivers and compactors). If pile driving is necessary it would be limited to daytime hours.

The primary means of mitigating noise and vibration from construction activities is to require the contractors to prepare a detailed Noise and Vibration Control Plan. A noise control engineer or acoustician would work with the contractor to prepare a Noise and Vibration Control Plan in conjunction with the contractor’s specific equipment and methods of construction. Key elements of a plan could include:

- Contractor’s specific equipment types
- Schedule (dates and times of day) and methods of construction
- Maximum noise limits for each piece of equipment with certification testing
- Prohibitions on certain types of equipment and processes during the night or day time hours per local agency coordination and approved variances
- Identification of specific sensitive sites where near construction sites
- Methods for projecting construction noise levels
- Implementation of noise and vibration control measures where appropriate
- Methods for responding to community complaints in compliance with Sound Transit Outreach requirements.

9 REFERENCES

FHWA (Federal Highway Administration). 2006. FHWA Construction Noise Handbook. Final Report FHWA-HEP-06-015. Available at: https://www.fhwa.dot.gov/Environment/noise/construction_noise/handbook/. Accessed 2020.

FTA (Federal Transit Administration). 2018. Transit Noise and Vibration Impact Assessment Manual. FTA Report No. 0123. Federal Transit Administration, John A. Volpe National Transportation System Center and Cross-Spectrum Acoustics Inc. Available at: https://www.transit.dot.gov/sites/fta.dot.gov/files/docs/research-innovation/118131/transit-noise-and-vibration-impact-assessment-manual-fta-report-no-0123_0.pdf. Accessed 2020.

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Sound Transit. 2019. 2019 Reference Noise and Vibration Levels for Link Light Rail Projects.

ATTACHMENT G2-1

Measurement Site Photographs

Figure G2-1.1 Site A Long-Term Noise Measurement: Midway Landfill Alternative

Figure G2-1.2 Site B Long-Term Noise Measurement: Midway Landfill Alternative

Figure G2-1.3 Site C Long-Term Noise Measurement : Midway Landfill Alternative

Figure G2-1.4 Site D Long-Term Noise Measurement: Mainline Track Options to Federal Way Transit Center

Figure G2-1.5 Site E Long-Term Noise Measurement – Mainline Track Options to Federal Way Transit Center

Figure G2-1.6 Site F Long-Term Noise Measurement: South 336th Street and South 344th Street Alternatives

Figure G2-1.7 Site G Long-Term Noise Measurement: South 336th Street/ South 344th Street Alternatives

Figure G2-1.8 Site H Long-Term Noise Measurement: South 336th Street and South 344th Street Alternatives

Figure G2-1.9 Vibration Propagation Measurement: Belmor Mobile Home Park

ATTACHMENT G2-2

Noise Measurement Data

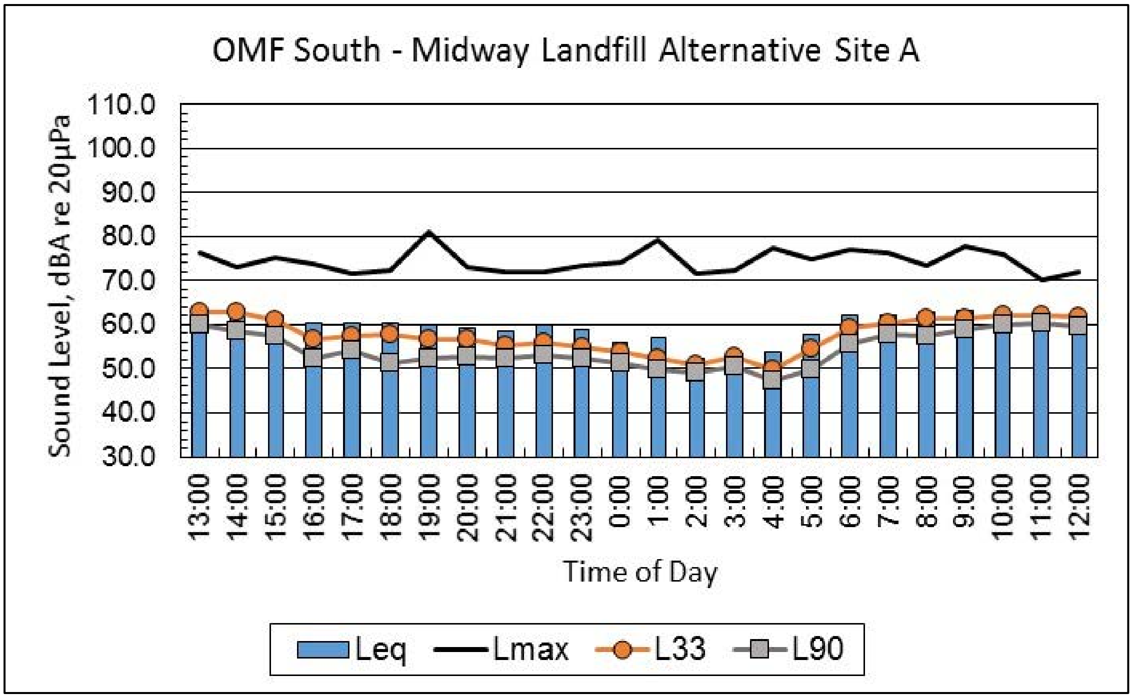

Figure G2-2.1 Site A Long-Term Noise Measurement Data: Midway Landfill Alternative

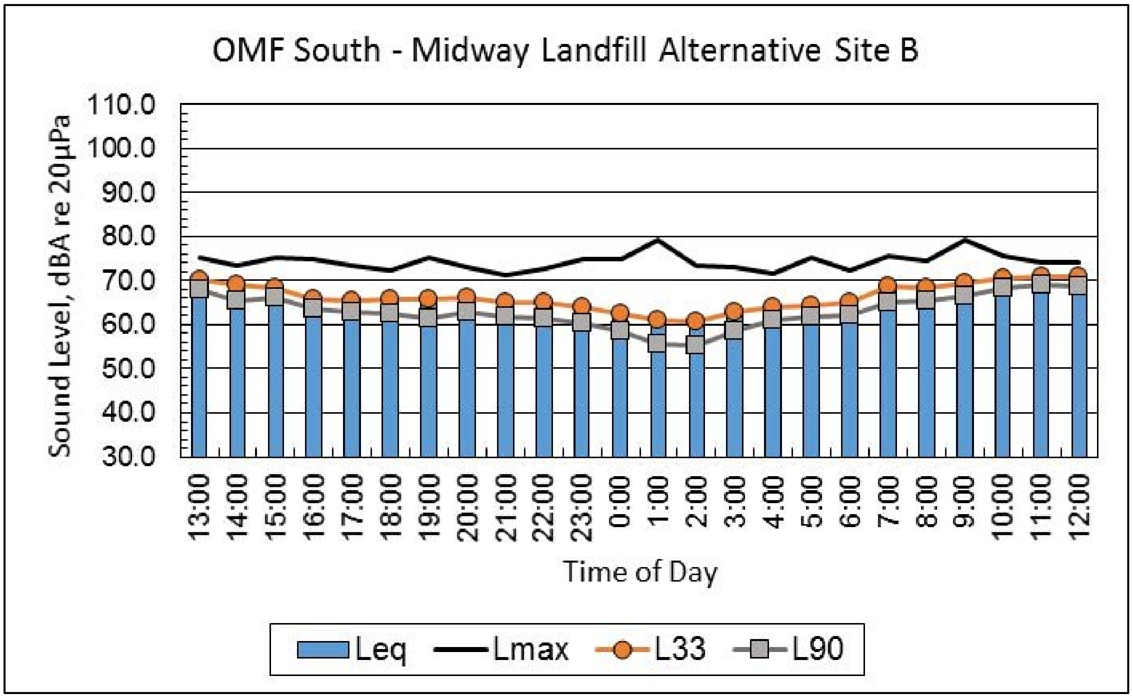

Figure G2-2.2 Site B Long-Term Noise Measurement Data: Midway Landfill Alternative

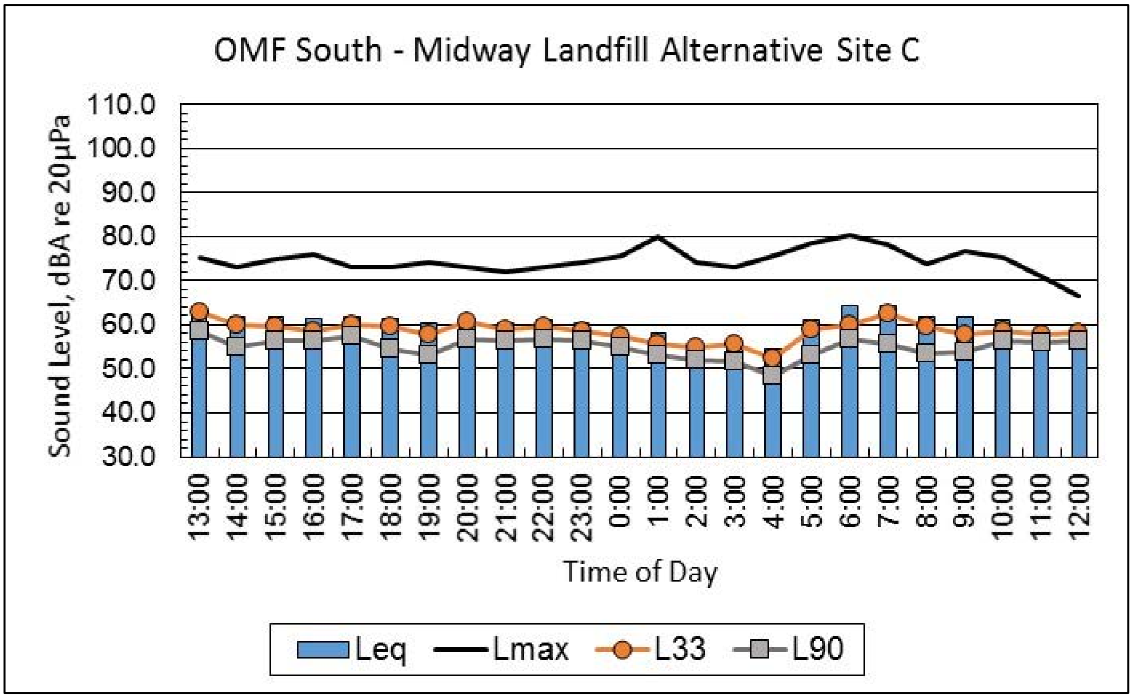

Figure G2-2.3 Site C Long-Term Noise Measurement Data: Midway Landfill Alternative

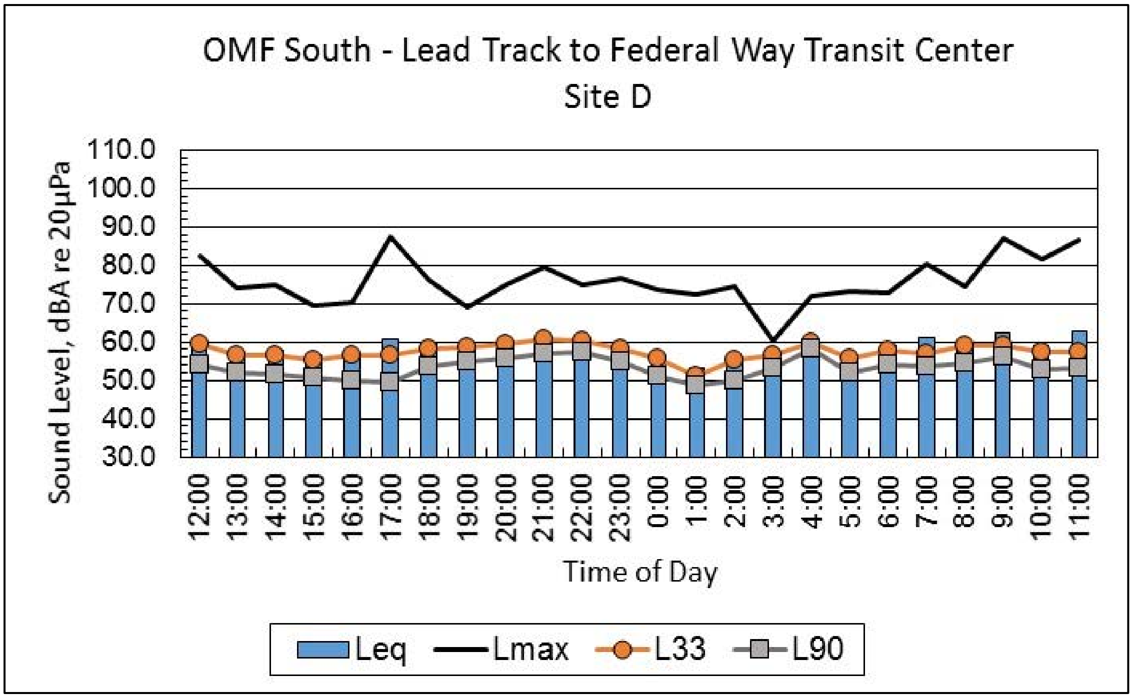

Figure G2-2.4 Site D Long-Term Noise Measurement Data; Mainline Track Options to Federal Way Transit Center

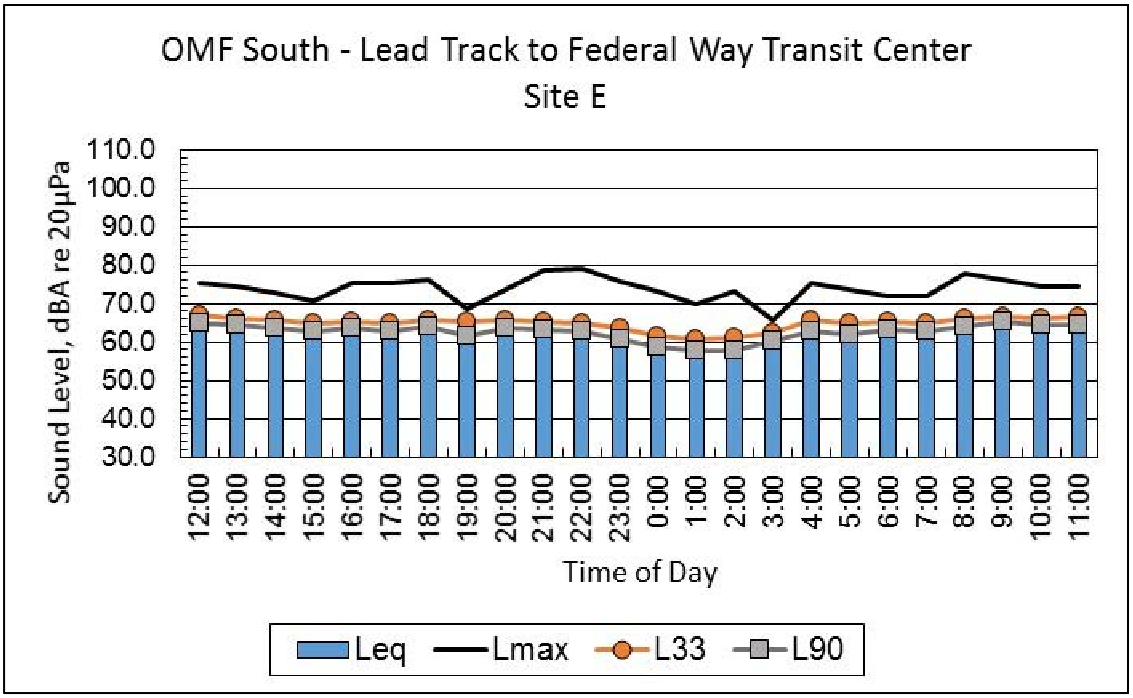

Figure G2-2.5 Site E Long-Term Noise Measurement Data: MainlineTrack Options to Federal Way Transit Center

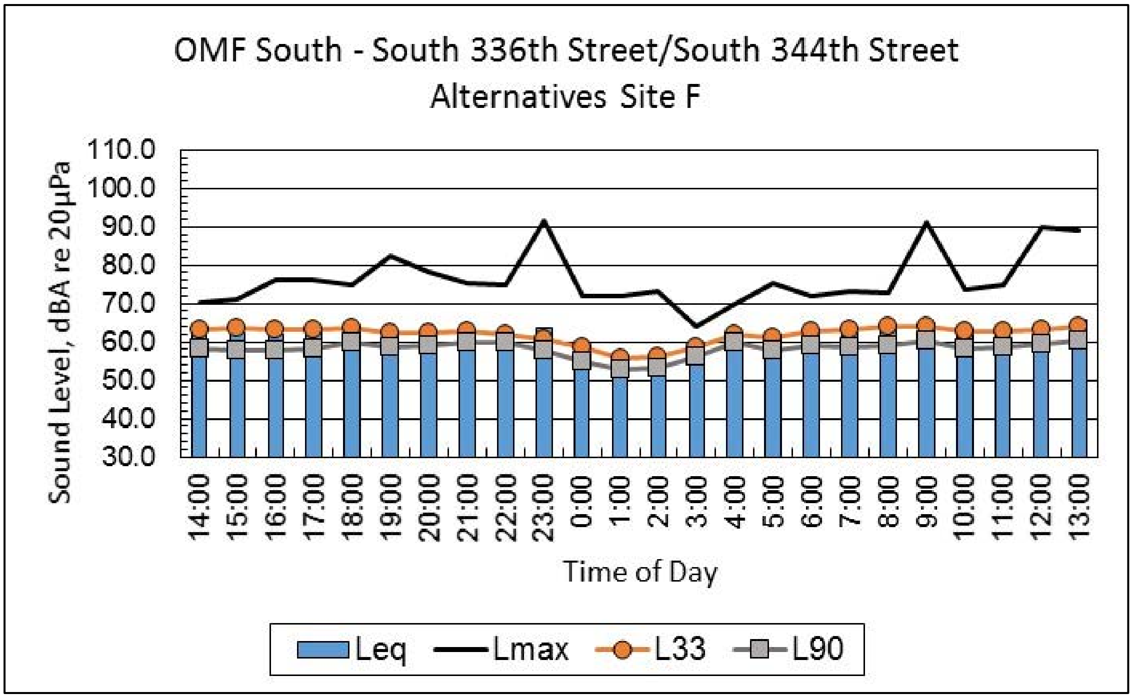

Figure G2-2.6 Site F Long-Term Noise Measurement Data: South 336th Street and South 344th Street Alternatives

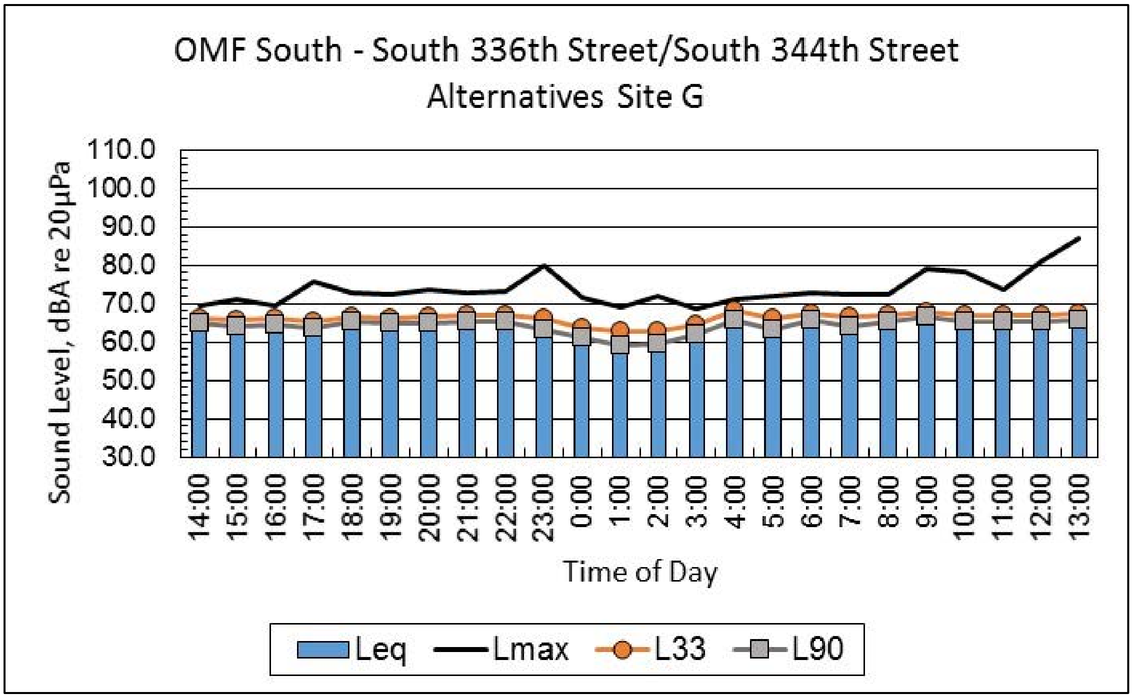

Figure G2-2.7 Site G Long-Term Noise Measurement Data: South 336th Street and South 344th Street Alternatives

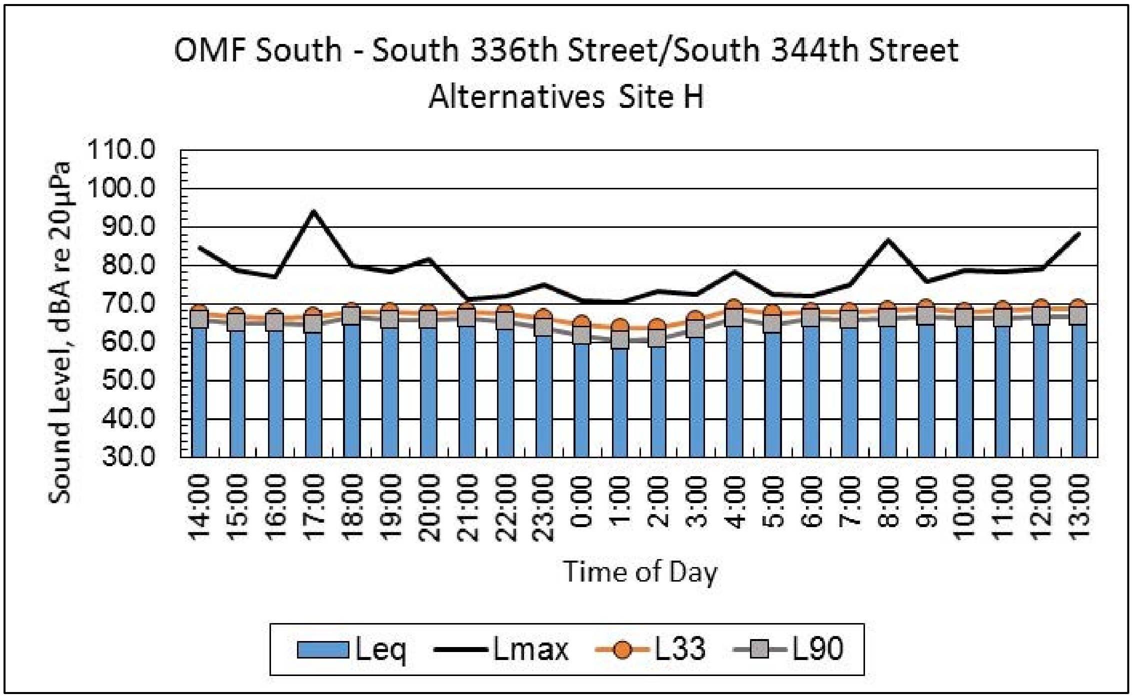

Figure G2-2.8 Site H Long-Term Noise Measurement Data: South 336th Street and South 344th Street Alternatives

ATTACHMENT G2-3

Vibration Measurement Data

Table G2-3.1 Site VP-A Belmor Mobile Home Park 1/3-Octave Band Transfer Mobility Coefficients

Coefficients	6.3 Hz	8 Hz	10 Hz	12.5 Hz	16 Hz	20 Hz	25 Hz	31.5 Hz	40 Hz	50 Hz	63 Hz	80 Hz	100 Hz	125 Hz	160 Hz	200 Hz
A	24.0	30.8	28.2	32.2	42.6	54.2	59.2	71.7	83.0	100.5	101.8	110.5	126.9	151.2	-91.1	-164.6
B	-5.9	-9.1	-7.0	-6.3	-11.3	-16.1	-17.2	-23.9	-31.1	-41.1	-42.8	-49.4	-60.7	-76.3	195.9	282.0
C	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-76.4	-101.6

TM=A+B*log(dist)+C*log(dist)^2

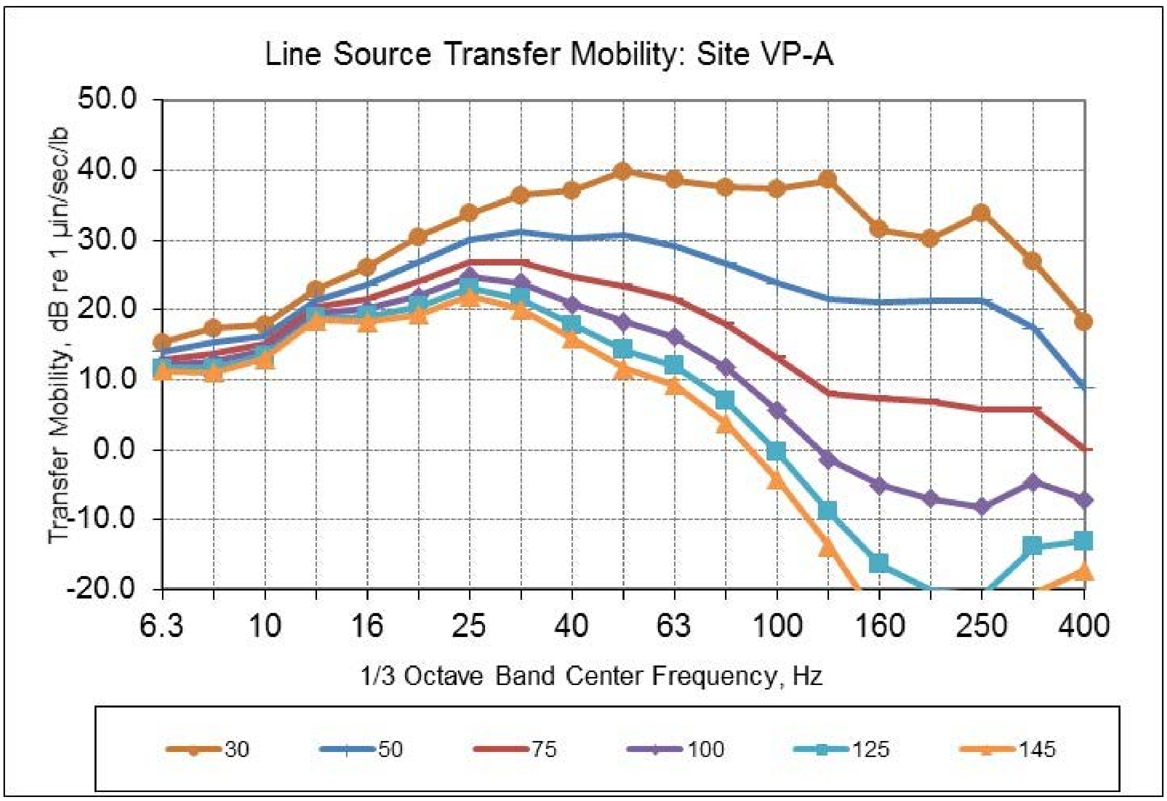

Figure G2-3.1 Line Source Transfer Mobility Site VP-A Belmor Mobile Home Park

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