



Operations and Maintenance Facility South

Final Environmental Impact Statement
Appendix G2: Noise and Vibration Technical Report



June 2024

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 Final Environmental Impact Statement (EIS).

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 the 55 mph Design Option for the mainline track for the Preferred or South 344th Street alternatives to the Federal Way Downtown Station. All exceedances and impacts could be mitigated through the implementation of noise barriers.

Table of Contents

| | | |
|----------|--|--------------|
| 1 | INTRODUCTION..... | G2-1 |
| 1.1 | Project Description..... | G2-1 |
| 2 | NOISE AND VIBRATION BASICS | G2-8 |
| 2.1 | Noise Basics | G2-8 |
| 2.2 | Vibration Basics | G2-10 |
| 3 | IMPACT ASSESSMENT METHODOLOGY | G2-12 |
| 3.1 | Operational Noise Assessment Methodology | G2-12 |
| 3.1.1 | OMF Site Noise Assessment Methodology..... | G2-12 |
| 3.1.2 | Mainline and Test Track Noise Assessment Methodology | G2-13 |
| 3.1.3 | Noise Measurement Procedures and Equipment Methodology | G2-13 |
| 3.2 | Operational Vibration Assessment Methodology | G2-14 |
| 3.2.1 | Vibration Measurement Procedures Methodology | G2-15 |
| 3.3 | Construction Noise Assessment Methodology | G2-16 |
| 3.4 | Construction Vibration Assessment Methodology | G2-18 |
| 4 | IMPACT CRITERIA..... | G2-19 |
| 4.1 | FTA Operational Noise Impact Criteria..... | G2-19 |
| 4.2 | FTA Operational Vibration Impact Criteria..... | G2-21 |
| 4.3 | FTA Construction Noise Impact Criteria..... | G2-24 |
| 4.4 | FTA Construction Vibration Impact Criteria | G2-25 |
| 4.5 | Traffic Noise Criteria | G2-25 |
| 4.6 | Local Ordinances..... | G2-26 |
| 5 | AFFECTED ENVIRONMENT | G2-27 |
| 5.1 | Noise and Vibration Sensitive Land Use | G2-27 |
| 5.1.1 | Preferred Alternative Site | G2-27 |
| 5.1.2 | South 344th Street Alternative Site..... | G2-27 |
| 5.1.3 | Midway Landfill Alternative | G2-27 |
| 5.1.4 | Mainline Track..... | G2-28 |
| 5.2 | Existing Noise Conditions | G2-28 |
| 5.2.1 | Noise Measurement Results..... | G2-28 |
| 5.3 | Existing Vibration Conditions | G2-34 |
| 6 | IMPACT ASSESSMENT | G2-35 |
| 6.1 | No-Build Alternative | G2-35 |
| 6.2 | Build Alternatives | G2-35 |
| 6.2.1 | Preferred Alternative Site | G2-36 |
| 6.2.2 | South 344th Street Alternative Site..... | G2-37 |

| | | |
|----------|---|--------------|
| 6.2.3 | Midway Landfill Alternative | G2-38 |
| 6.3 | Preferred and South 344th Street Alternatives Mainline and Test Track Noise..... | G2-40 |
| 6.3.1 | Traffic Noise | G2-43 |
| 6.4 | Vibration | G2-45 |
| 6.5 | Construction Noise..... | G2-46 |
| 6.6 | Construction Vibration..... | G2-47 |
| 7 | CUMULATIVE IMPACTS | G2-48 |
| 8 | MITIGATION | G2-50 |
| 8.1 | Operational Noise | G2-50 |
| 8.1.1 | Traffic Noise | G2-51 |
| 8.2 | Operational Vibration | G2-51 |
| 8.3 | Construction..... | G2-53 |
| 9 | REFERENCES..... | G2-54 |

Figures

| | | |
|---------------|---|-------|
| Figure G2.1-1 | Project Vicinity: OMF South Alternatives..... | G2-3 |
| Figure G2.1-2 | Conceptual Layout: Preferred Alternative..... | G2-4 |
| Figure G2.1-3 | Conceptual Layout: South 344th Street Alternative | G2-5 |
| Figure G2.1-4 | Conceptual Layout: Midway Landfill Alternative | G2-6 |
| Figure G2.1-5 | Mainline Track Options | G2-7 |
| Figure G2.2-1 | Typical A-Weighted Sound Levels | G2-9 |
| Figure G2.2-2 | Typical Ldn Noise Exposure Levels | G2-9 |
| Figure G2.2-3 | Typical Levels of Ground-Borne Vibration | G2-11 |
| Figure G2.3-1 | Vehicle Force Density Levels at 25 mph | G2-15 |
| Figure G2.3-2 | Vibration Propagation Measurement Schematic | G2-16 |
| Figure G2.4-1 | FTA Noise Impact Criteria..... | G2-20 |
| Figure G2.4-2 | FTA Cumulative Noise Impact Criteria | G2-21 |
| Figure G2.4-3 | FTA Detailed Vibration Criteria..... | G2-23 |
| Figure G2.5-1 | Measurement Locations for Existing Noise and Vibration: Preferred Alternative | G2-29 |
| Figure G2.5-2 | Measurement Locations for Existing Noise and Vibration: South 344th Street Alternative | G2-31 |
| Figure G2.5-3 | Measurement Locations for Existing Noise: Midway Landfill Alternative..... | G2-33 |
| Figure G2.6-1 | Noise Impact Locations: 55 mph Design Option..... | G2-42 |
| Figure G2.6-2 | Existing and Proposed Highway Noise Walls | G2-44 |
| Figure G2.7-1 | Cumulative Transit and Traffic Noise Impacts | G2-49 |
| Figure G2.8-1 | Noise Barrier Locations: 55 mph Design Option..... | G2-52 |

Tables

| | | |
|---------------|--|-------|
| Table G2.3-1 | Construction Equipment Noise Emission Levels | G2-17 |
| Table G2.3-2 | Construction Equipment Vibration Source Levels..... | G2-18 |
| Table G2.4-1 | Land Use Categories and Metrics for Transit Noise Impact Criteria | G2-19 |
| Table G2.4-2 | Ground-Borne Vibration and Noise Impact Criteria for General Assessment..... | G2-22 |
| Table G2.4-3 | Ground-Borne Vibration and Noise Impact Criteria for Special Buildings..... | G2-22 |
| Table G2.4-4 | Interpretation of Vibration Criteria for Detailed Analysis | G2-24 |
| Table G2.4-5 | FTA Construction Noise Criteria..... | G2-24 |
| Table G2.4-6 | FTA Construction Vibration Damage Criteria | G2-25 |
| Table G2.4-7 | Washington State Noise Control Regulation | G2-26 |
| Table G2.4-8 | Washington State Exemptions for Short-Term Noise Exceedances | G2-26 |
| Table G2.5-1 | Summary of Existing Ambient Noise Measurements Results for Preferred Alternative | G2-28 |
| Table G2.5-2 | Summary of Existing Ambient Noise Measurements Results for South 344th Street Alternative | G2-30 |
| Table G2.5-3 | Summary of Existing Ambient Noise Measurements Results for the Midway Landfill Alternative..... | G2-32 |
| Table G2.5-4 | Summary of Existing Ambient Noise Measurements Results for Mainline Track Options | G2-34 |
| Table G2.6-1 | Summary of FTA Category 2 Noise Impacts for the Preferred Alternative Site | G2-36 |
| Table G2.6-2 | Summary of FTA Category 3 Noise Impacts for the Preferred Alternative Site..... | G2-36 |
| Table G2.6-3 | Summary of WAC Nighttime Noise Exceedances for the Preferred Alternative Site..... | G2-37 |
| Table G2.6-4 | Summary of FTA Category 2 Noise Impacts for the South 344th Street Alternative Site | G2-37 |
| Table G2.6-5 | Summary of FTA Category 3 Noise Impacts for the South 344th Street Alternative Site | G2-38 |
| Table G2.6-6 | Summary of WAC Nighttime Noise Exceedances for the South 344th Street Alternative Site | G2-38 |
| Table G2.6-7 | Summary of FTA Category 2 Noise Impacts for the Midway Landfill Alternative..... | G2-39 |
| Table G2.6-8 | Summary of FTA Category 3 Noise Impacts for the Midway Landfill Alternative..... | G2-39 |
| Table G2.6-9 | Summary of WAC Nighttime Noise Exceedances for the Midway Landfill Alternative..... | G2-39 |
| Table G2.6-10 | Summary of FTA Category 2 Noise Impacts for the 40 mph Alignment Mainline Track..... | G2-40 |
| Table G2.6-11 | Summary of FTA Category 2 Noise Impacts: 55 mph Design Option Mainline Track | G2-41 |

Table G2.6-12 Summary of FTA Category 2 Vibration Impacts for the 40 mph Alignment Mainline Track.....G2-45

Table G2.6-13 Summary of FTA Category 2 Vibration Impacts for the 55 mph Design Option Mainline TrackG2-45

Table G2.6-14 Typical Construction Scenario, At-Grade TrackG2-47

Table G2.6-15 Summary of Potential Construction Vibration Impacts.....G2-47

Table G2.8-1 Summary of Potential Noise Barrier LocationsG2-51

Attachments

Attachment G2-1 Measurement Site Photographs

Attachment G2-2 Noise Measurement Data

Attachment G2-3 Vibration Measurement Data

Acronyms and Abbreviations

| | |
|------------------|---|
| Belmor | Belmor Mobile Home Park |
| 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 |
| GIS | geographic information system |
| Hz | Hertz |
| I-5 | Interstate 5 |
| in/sec | inches per second |
| L _{dn} | day-night sound level |
| Leq | equivalent sound level |
| L _{max} | maximum noise level |
| L _n | sound level exceeded n-percent of the time |
| LRV | light rail vehicle |
| LSTM | line source transfer mobility |
| L _v | vibration level |
| mph | miles per hour |
| NAC | noise abatement criteria |
| OMF | operations and maintenance facility |
| OMF South | Operations and Maintenance Facility South |
| PPV | peak particle velocity |
| RMS | root mean square |
| SEL | sound exposure level |
| Sound Transit | Central Puget Sound Regional Transit Authority |
| Sound Transit 3 | Sound Transit 3: The Regional Transit System Plan for Central Puget Sound |
| TDLE | Tacoma Dome Link Extension |
| U.F. | usage factor |
| V _{dB} | vibration decibel |
| WAC | Washington Administrative Code |
| WSDOT | Washington State Department of Transportation |

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 noise and vibration assessment for the two mainline track options from the Preferred and the South 344th Street alternatives to the Federal Way Downtown Station, 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 approximately 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 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.

Three site alternatives for the proposed project are evaluated in the Final EIS: two in Federal Way and one in Kent (Figure G2.1-1). These alternatives are named the Preferred Alternative (referred to as the South 336th Street Alternative in the 2021 Draft EIS), the South 344th Street Alternative, and the Midway Landfill Alternative, respectively.

OMF South would need to have tracks connecting to a light rail line that will be operating when the facility is planned to open, which in southern King County is the Federal Way Link Extension (FWLE). The length and location of these connecting tracks varies by alternative. The Preferred Alternative would require the construction of approximately 1.4 miles of mainline tracks and the South 344th Street Alternative would require approximately 1.8 miles of mainline tracks. The Midway Landfill Alternative is adjacent to FWLE and would connect by lead tracks directly to the FWLE mainline tracks. The Preferred and South 344th Street alternative mainlines include tail tracks that extend approximately 1,000 feet past the site to allow trains to turn around and access the site from the south if the northern lead tracks were out of service.

The Preferred and South 344th Street alternative would also include a test track to prepare new vehicles for service. The test track would run east of and parallel to the mainline connecting the sites to FWLE. (Figures G2.1-2 and G2.1-3). Figure G2.1-5 shows the mainline track options. The Midway Landfill Alternative would not include a test track because the varying grades of the existing mainline tracks make it infeasible. Due to this, this analysis assumes that LRV testing would occur on the mainline tracks.

In addition to the features identified above, the Preferred Alternative includes the extension of 18th Place S between S 340th Street and S 336th Street to replace the functions of 20th Avenue S, which would be vacated, and the extension of 21st Ave S south to S 344th Street to meet Federal Way code requirements.

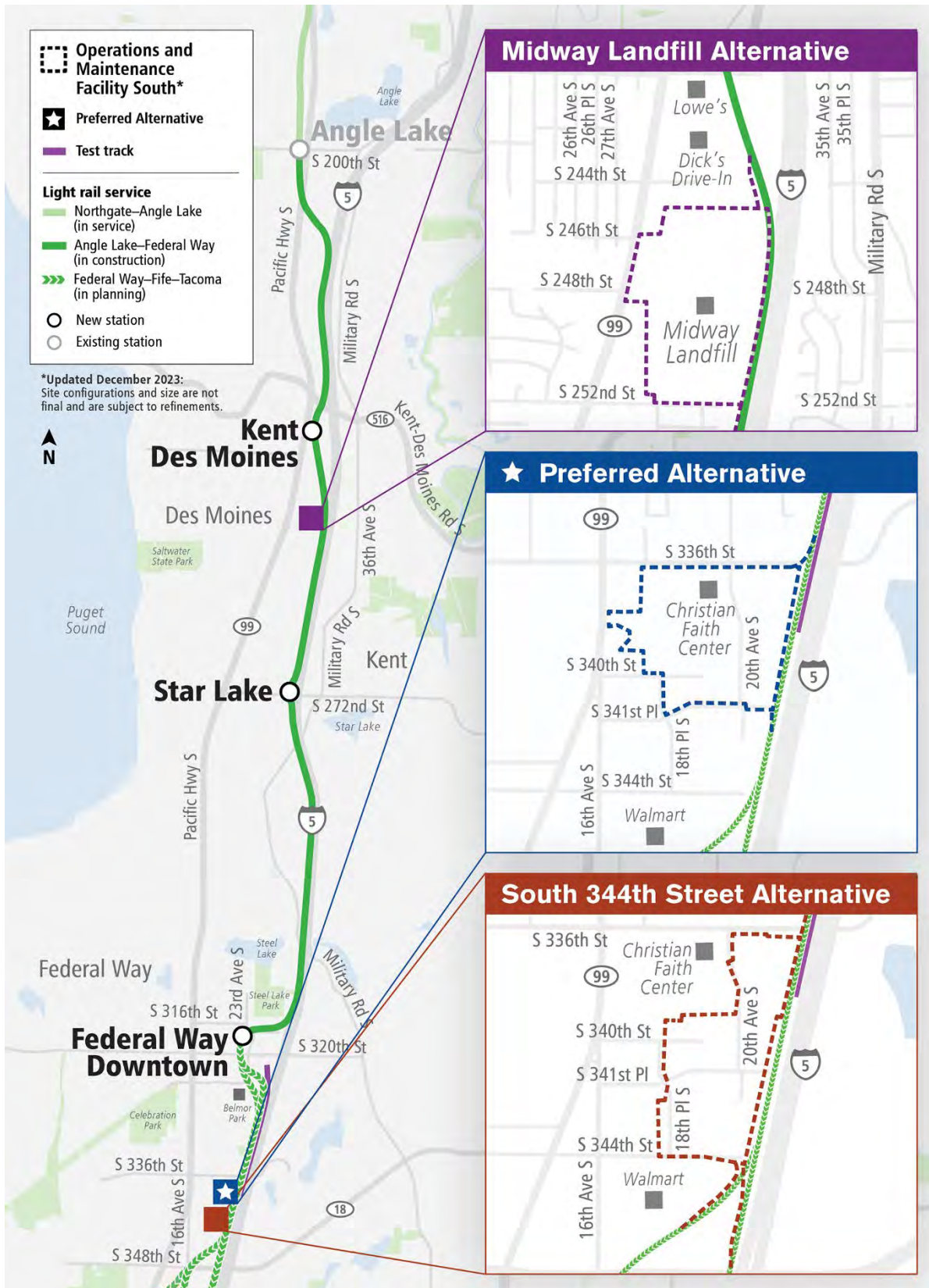
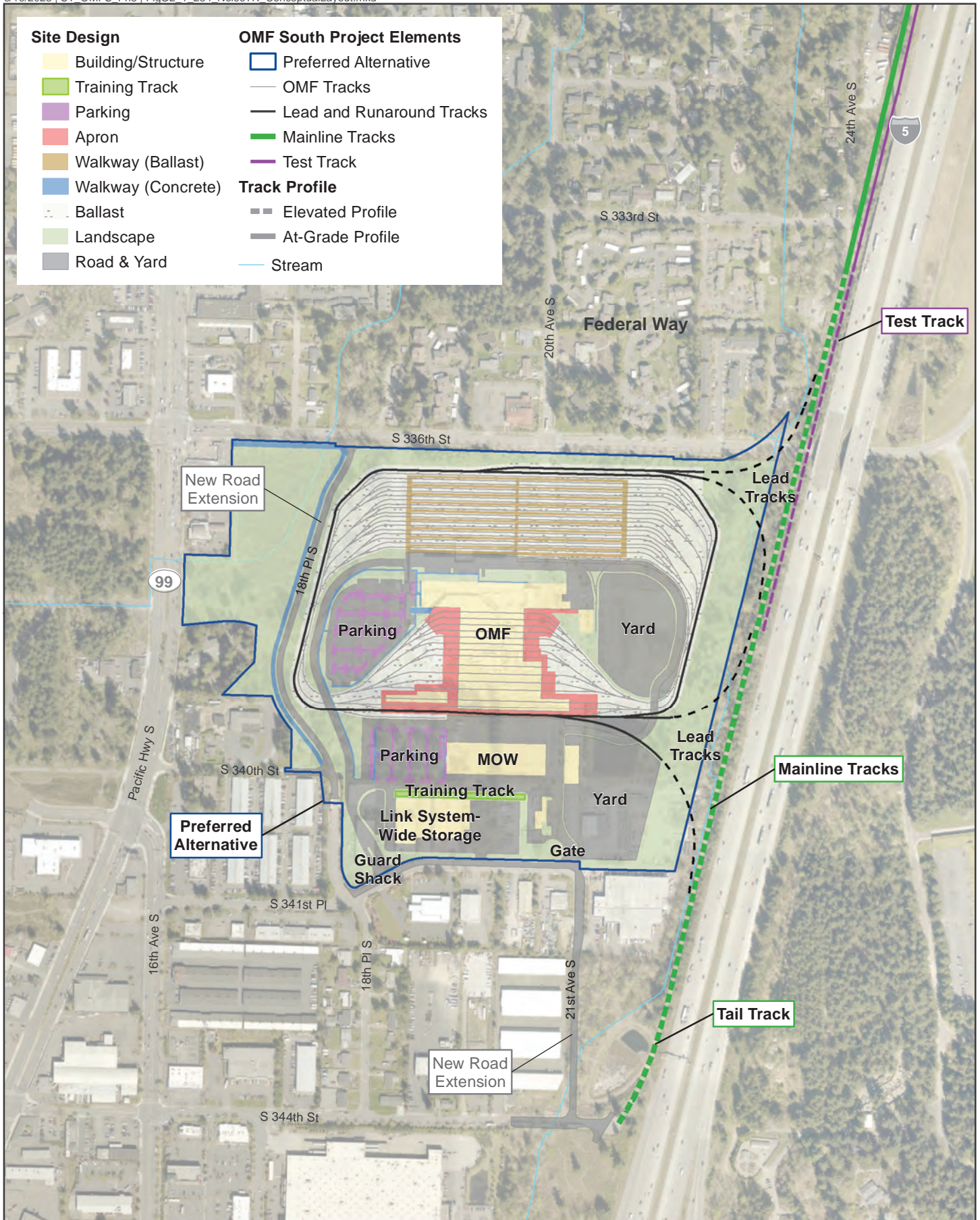


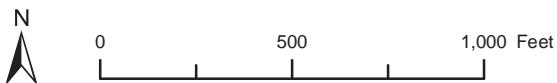
Figure G2.1-1 Project Vicinity: OMF South Alternatives

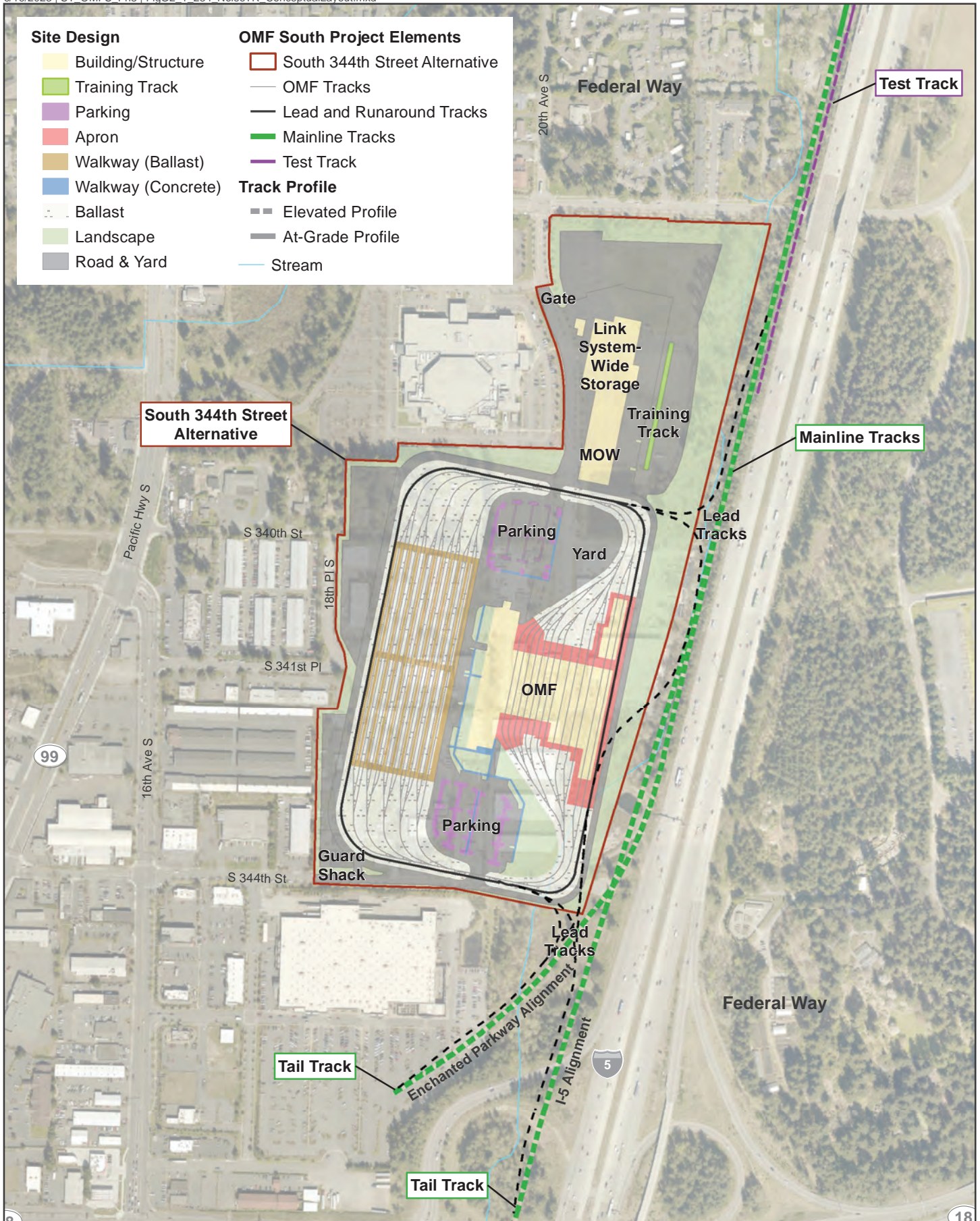


Data Sources: King County; Cities of Des Moines, Federal Way, Kent (2019).

FIGURE G2.1-2
 Conceptual Layout
 Preferred Alternative

OMF South

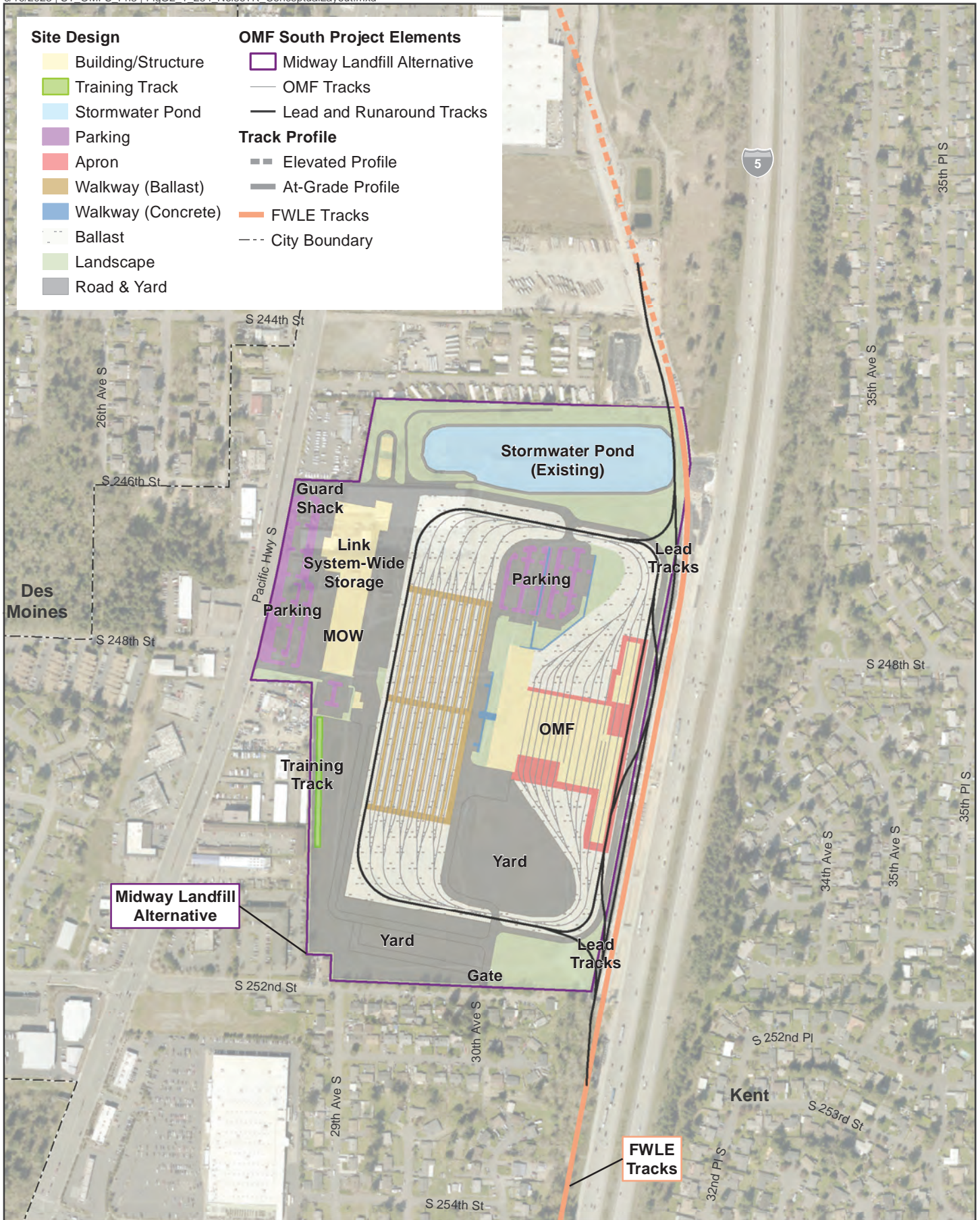




Data Sources: King County; Cities of Des Moines, Federal Way, Kent (2019).

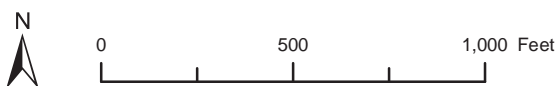
FIGURE G2.1-3
 Conceptual Layout
 South 344th Street Alternative
 OMF South

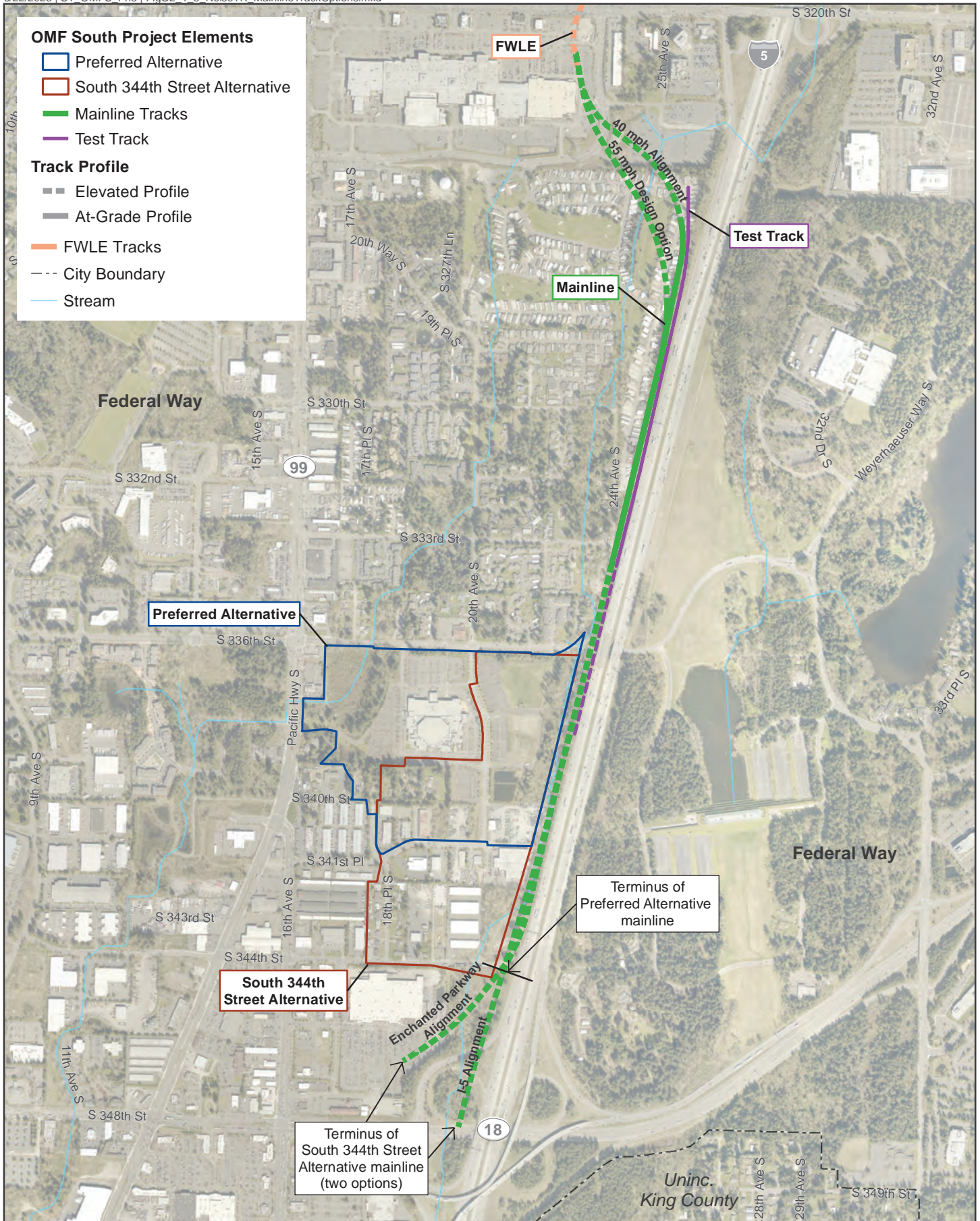




Data Sources: King County; Cities of Des Moines, Federal Way, Kent (2019).

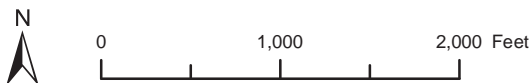
FIGURE G2.1-4
 Conceptual Layout
 Midway Landfill Alternative
 OMF South





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

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



2 NOISE AND VIBRATION BASICS

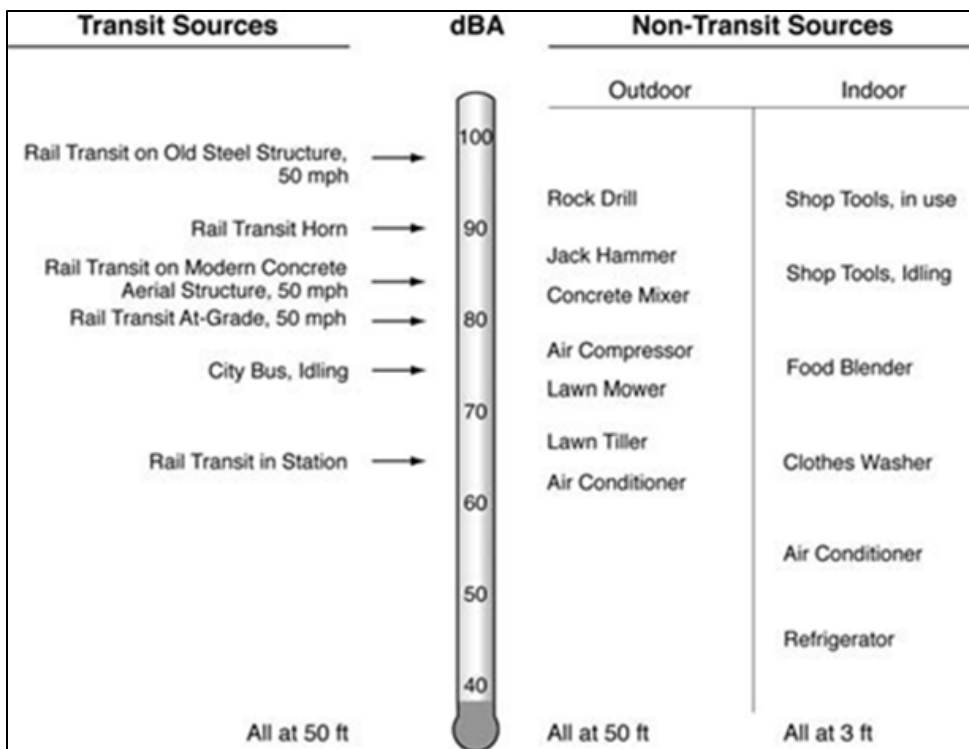
2.1 Noise Basics

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 non-transit 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.

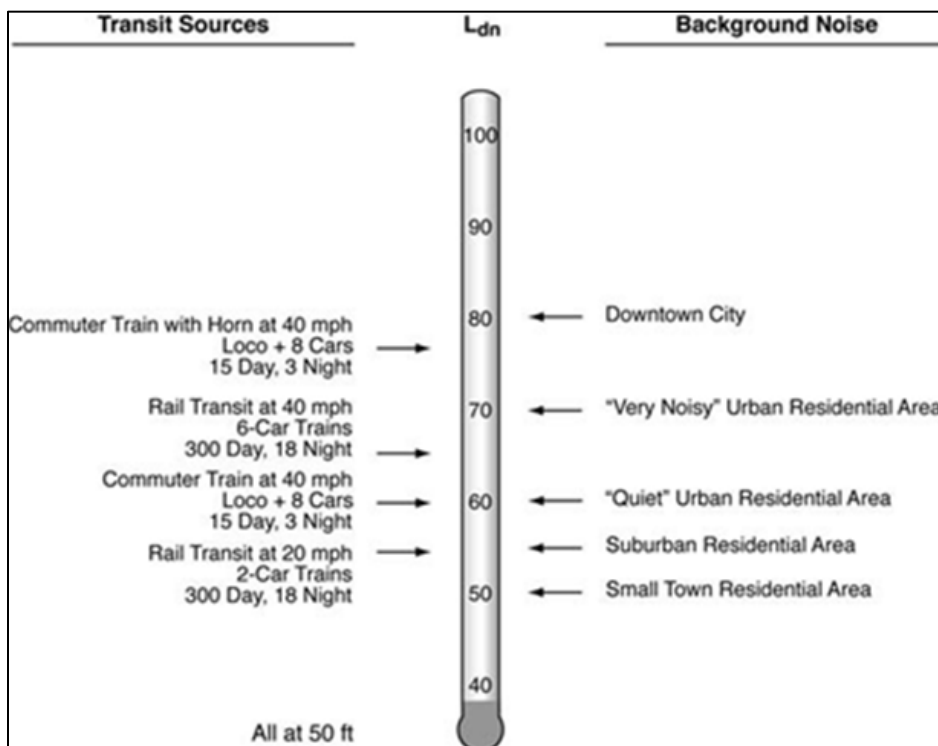
Typical Ldn values for various transit operations and environments are shown on Figure G2.2-2.

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

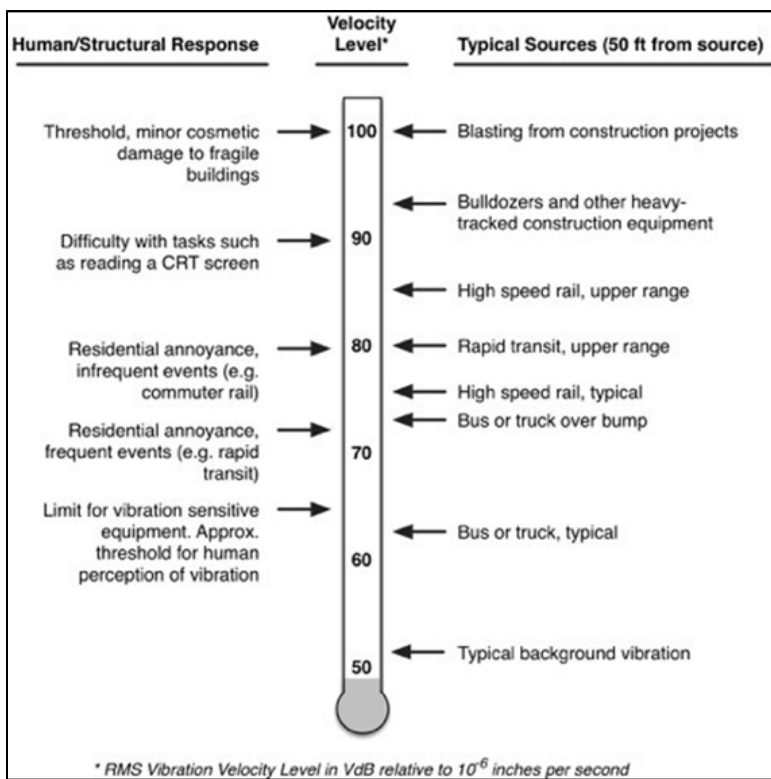
2.2 Vibration Basics

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 1×10^{-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 OMF South facility, vehicle washing and drying, a traction power substation, vehicles moving on the mainline track (for the Preferred Alternative and the 344th Street Alternative) into service in the morning and back to the facility in the late evening, and operations on the test track. The only activity that would generate vibration would be LRVs moving on the mainline and test track options for the Preferred 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 Tacoma Dome Link Extension (TDLE) project, which will be assessed in a separate EIS. 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 Preferred 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 approximately 144; operations would also increase. The results of that assessment are covered in Section 7, Cumulative Impacts.
- 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 approximately 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 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 and Test Track Noise Assessment Methodology

For the Preferred and the South 344th Street alternatives, trains would depart to the north on the mainline track to the Federal Way Downtown Station. 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 Preferred 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.
- For the test track, eight one-car LRVs would make roundtrips per hour for 4 hours during the daytime and 6 hours during the nighttime.
- LRV train speeds will be 25 mph on the mainline track and 55 mph on the test track.
- The sound exposure level (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 one-car LRV trains on at-grade ballast and tie tracks traveling at 55 mph would be 80.1 dBA at 50 feet (Sound Transit 2019).
- The SEL for one- and 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 and test 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 Standard S1.4 for Type 1 (Precision) sound level meters. Calibrations, traceable to the U.S. National Institute of Standards and Technology, 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 Preferred 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 and 55 mph on the test track.
- 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:

$$L_v = \text{FDL} + \text{LSTM}$$

Where:

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

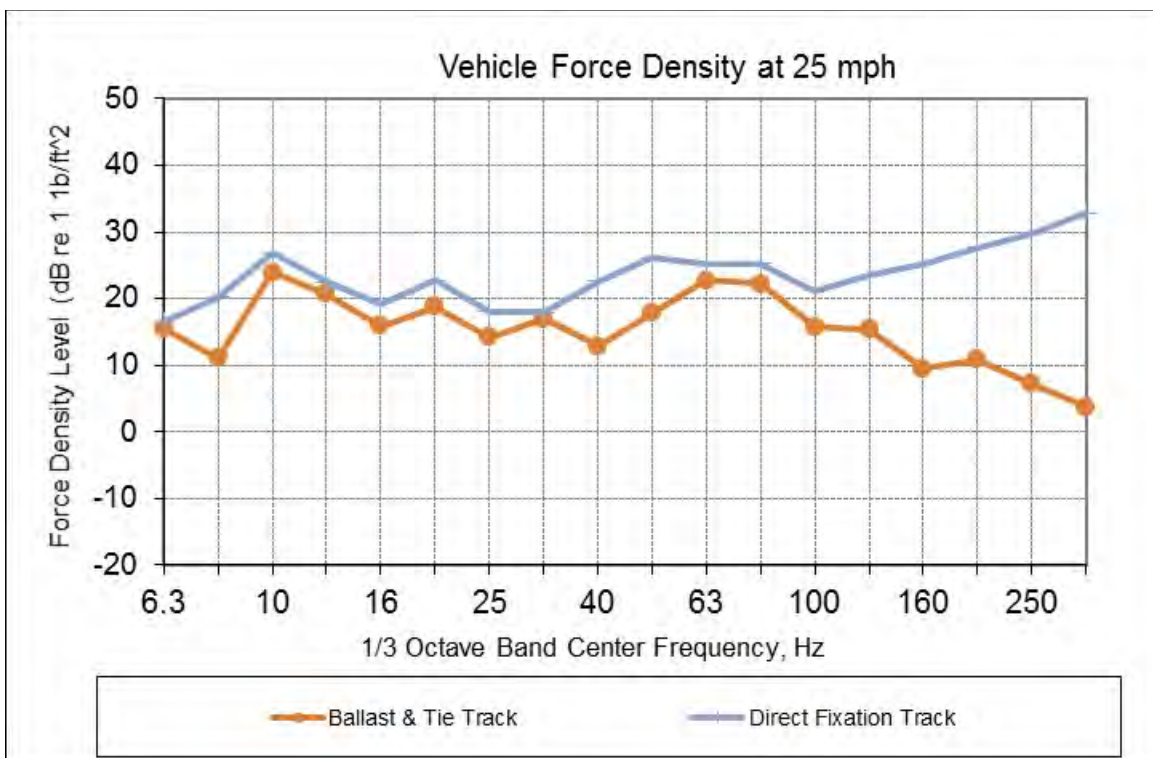


Figure G2.3-1 Vehicle Force Density Levels at 25 mph

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, was calculated using proprietary software in the Cross-Spectrum Acoustics laboratory. The transfer mobility represents the vibration propagation characteristics of the ground at the measurement site and along the mainline track design options.

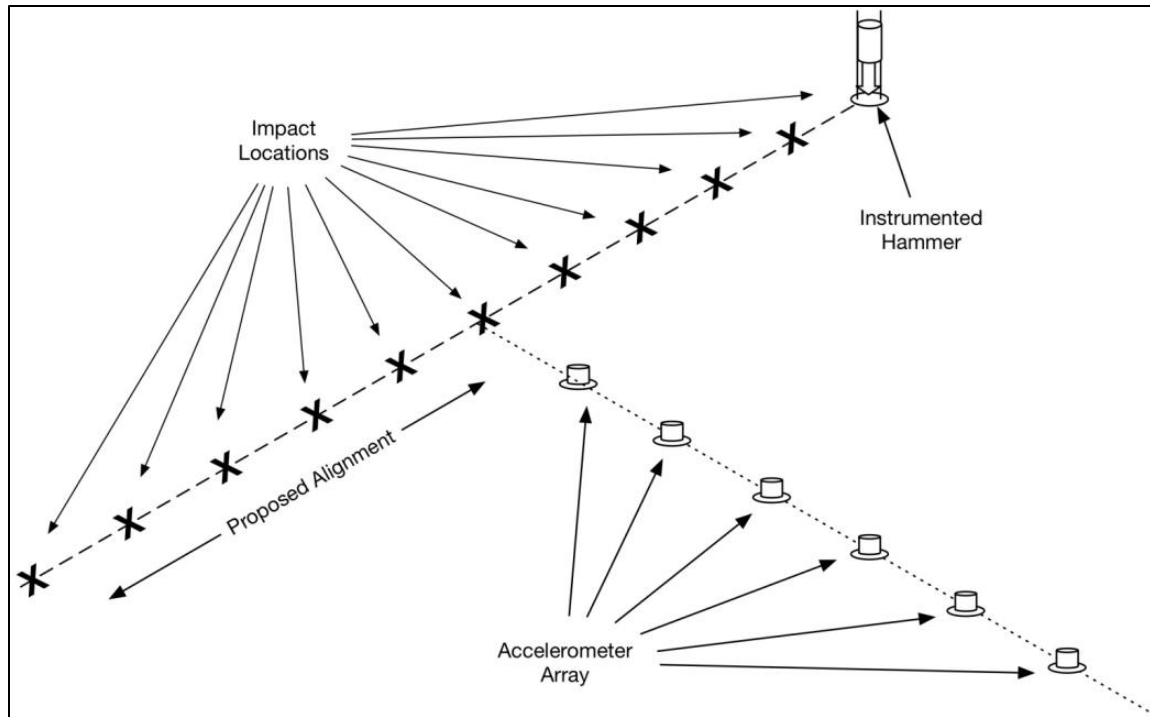


Figure G2.3-2 Vibration Propagation Measurement Schematic

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 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:

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

where:

$Leq(n)$ = noise exposure at a receiver resulting from the operation of a single piece of equipment over n hours,
 L_{max} = 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:

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

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:

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

where:

$Lv(D)$ = RMS vibration level at distance D,
 $Lv(25 \text{ ft})$ = 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. |

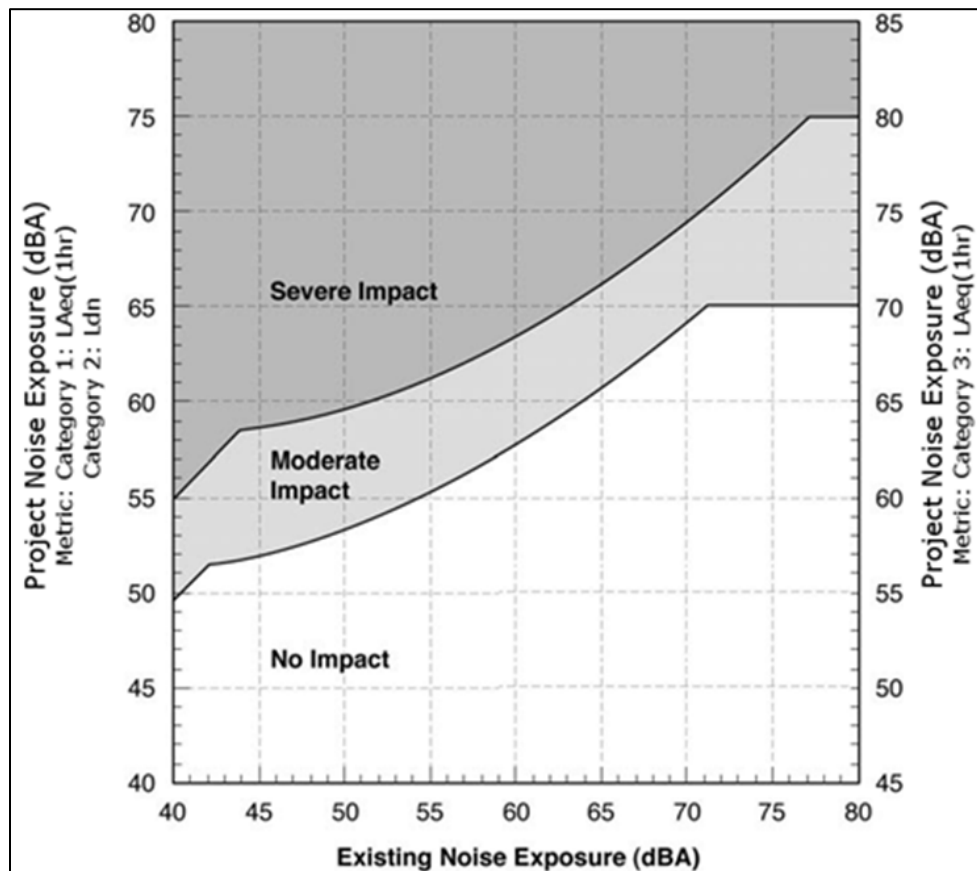
Source: FTA 2018

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:

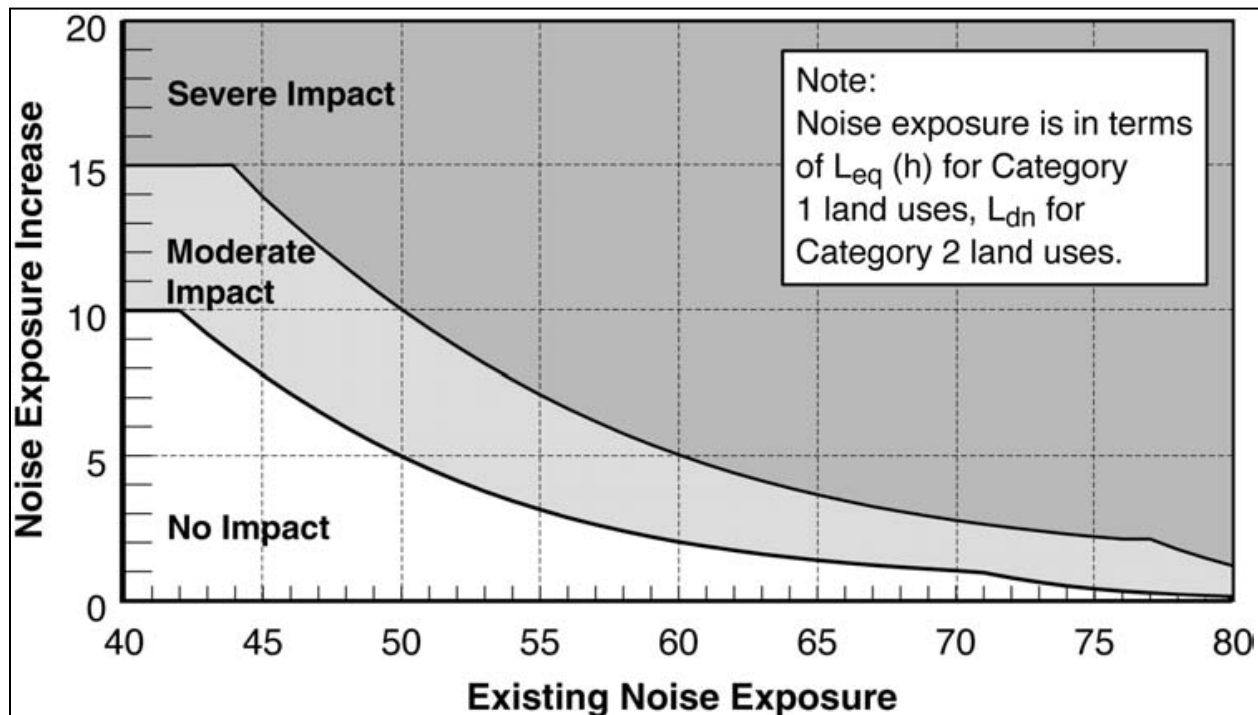
- **No Impact:** In this range, the project is considered to have no impact since, on average, the introduction of the project will result in an insignificant increase in the number of people highly annoyed by the new project noise.
- **Moderate Impact:** Project-generated noise in this range is considered 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 L_{dn} and L_{eq} 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

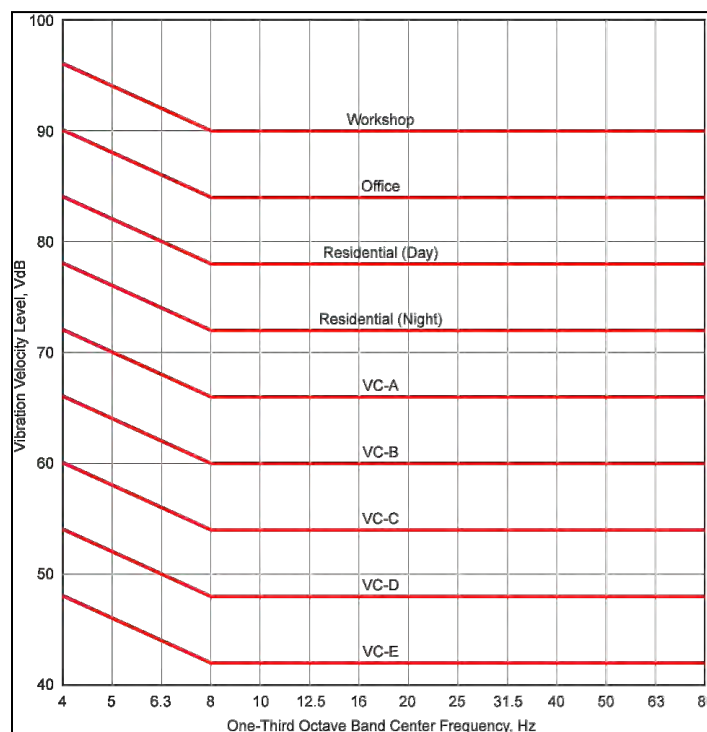
Notes:

- (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 would 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

OMF South does not include any modifications to existing highways that would change the vertical or horizontal alignment or add new lanes. The Preferred Alternative would remove 21st Avenue S between S 336th Street and S 341st Place, extend 18th Avenue S between S 340th Street and S 336th Street, and extend 21st Avenue S south to S 344th Street. However, these new and extended roadways would not be located near sensitive receptors nor have the traffic volumes to increase noise levels to the extent that a noise study would be warranted. Vehicle traffic within the OMF sites was assessed using FTA noise impact criteria, along with other project components.

As required by the FTA, the criteria for determining traffic noise impacts associated with OMF South are taken from the FHWA Procedures for Abatement of Highway Traffic Noise and Construction Noise, Code of Federal Regulations Title 23, § 772 (2010). A traffic noise impact occurs if predicted traffic noise levels approach the criteria levels for specific FHWA land use activity categories or substantially exceed existing noise levels (e.g., a 10-dBA increase). These levels are defined as noise abatement criteria (NAC) and are based on hourly Leq noise levels during the peak traffic noise hour. The land use activity categories of greatest concern in the OMF South study areas are Types B and C, which include residences, playgrounds, active sports areas, parks, schools, churches, libraries, and hospitals. The noise abatement criterion used to determine impacts on this land use is to approach, or exceed, 67 dBA Leq outside of buildings. Under Washington State Department of Transportation (WSDOT) policy, a traffic noise impact occurs if predicted noise levels approach within 1 dB of the NAC. Therefore, an impact on Type B or C land uses would occur at 66 dBA Leq. Some commercial uses, including hotels and motels, have a criterion of 71 dBA under the WSDOT policy. Many other commercial uses, such as general offices and retail businesses, are not normally considered noise-sensitive.

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 | Maximum Allowable Sound Level (Leq, dBA) ¹ | Maximum Allowable Sound Level (Leq, dBA) ¹ |
|-----------------|---|---|---|
| | Residential Receiver | Commercial Receiver | 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 (WAC 173-62).

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 Downtown Station was investigated based on a review of current project and land use information, geographic information system (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 Preferred Alternative Site

The study area around the Preferred 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.

5.1.2 South 344th Street Alternative Site

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.

5.1.3 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 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.

5.1.4 Mainline Track

The noise-sensitive land uses adjacent to the mainline track design options and the test track between the Federal Way Downtown Station and the Preferred and South 344th Street alternatives are a mix of single- and multi-family residences, including the residences within the Belmor Mobile Home Park (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 Preferred Alternative Site

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 Preferred Alternative. The results of the existing noise measurements were used to characterize the existing noise levels at all noise-sensitive locations near the Preferred Alternative.

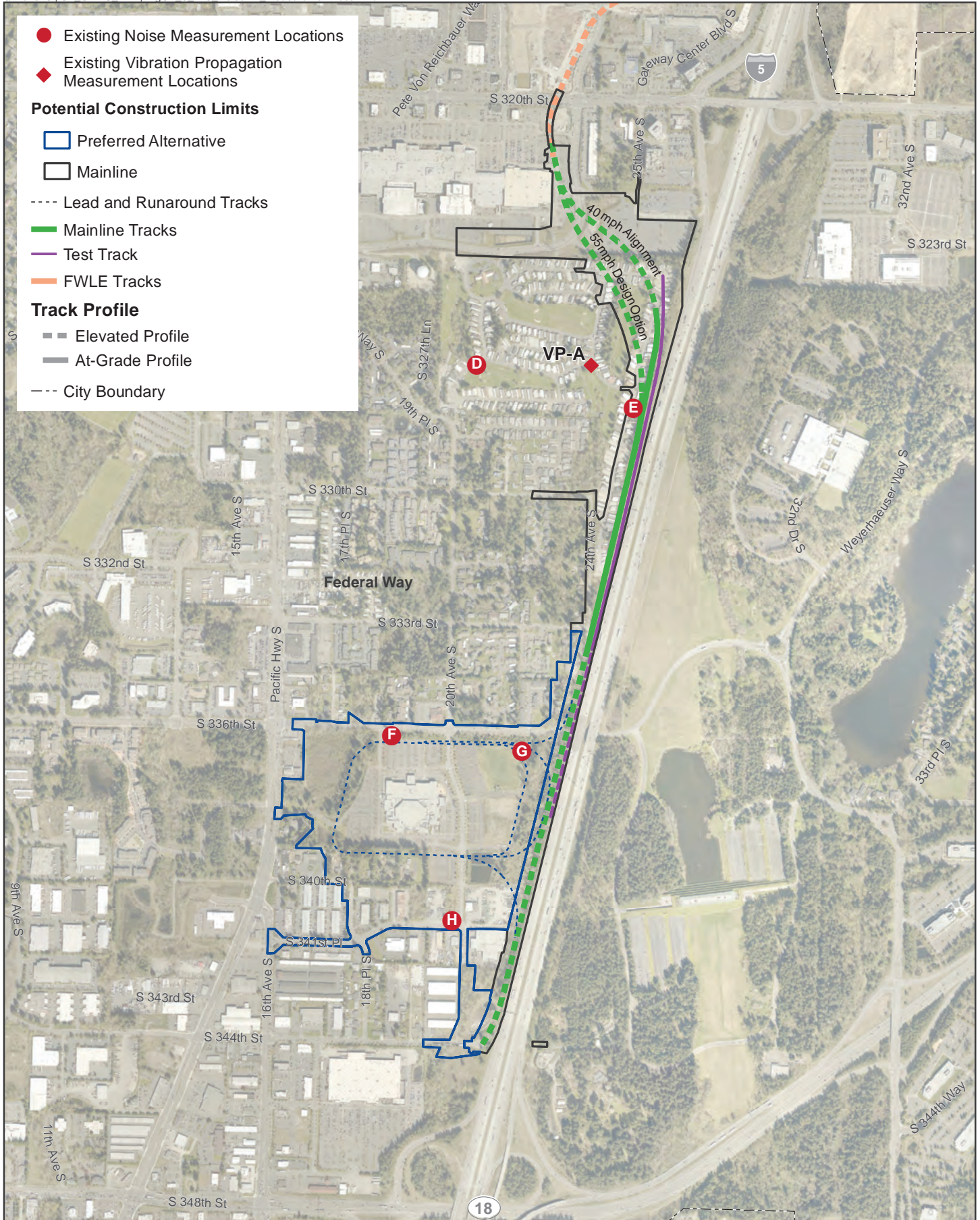
Site F: Christian Faith Center West. The Ldn measured at this location was 67 dBA, and the peak hour Leq was 62 dBA. This location is representative of the residences to the north of the Preferred Alternative away from I-5 and the KAC Baptist Church. The ambient noise levels were dominated by local traffic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

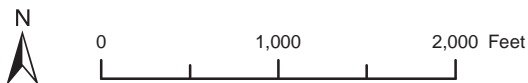
Table G2.5-1 Summary of Existing Ambient Noise Measurements Results for Preferred Alternative

| 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 |



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

FIGURE G2.5-1
Measurement Locations for Existing Ambient Noise and Vibration: Preferred Alternative



5.2.1.2 South 344th Street Alternative Site

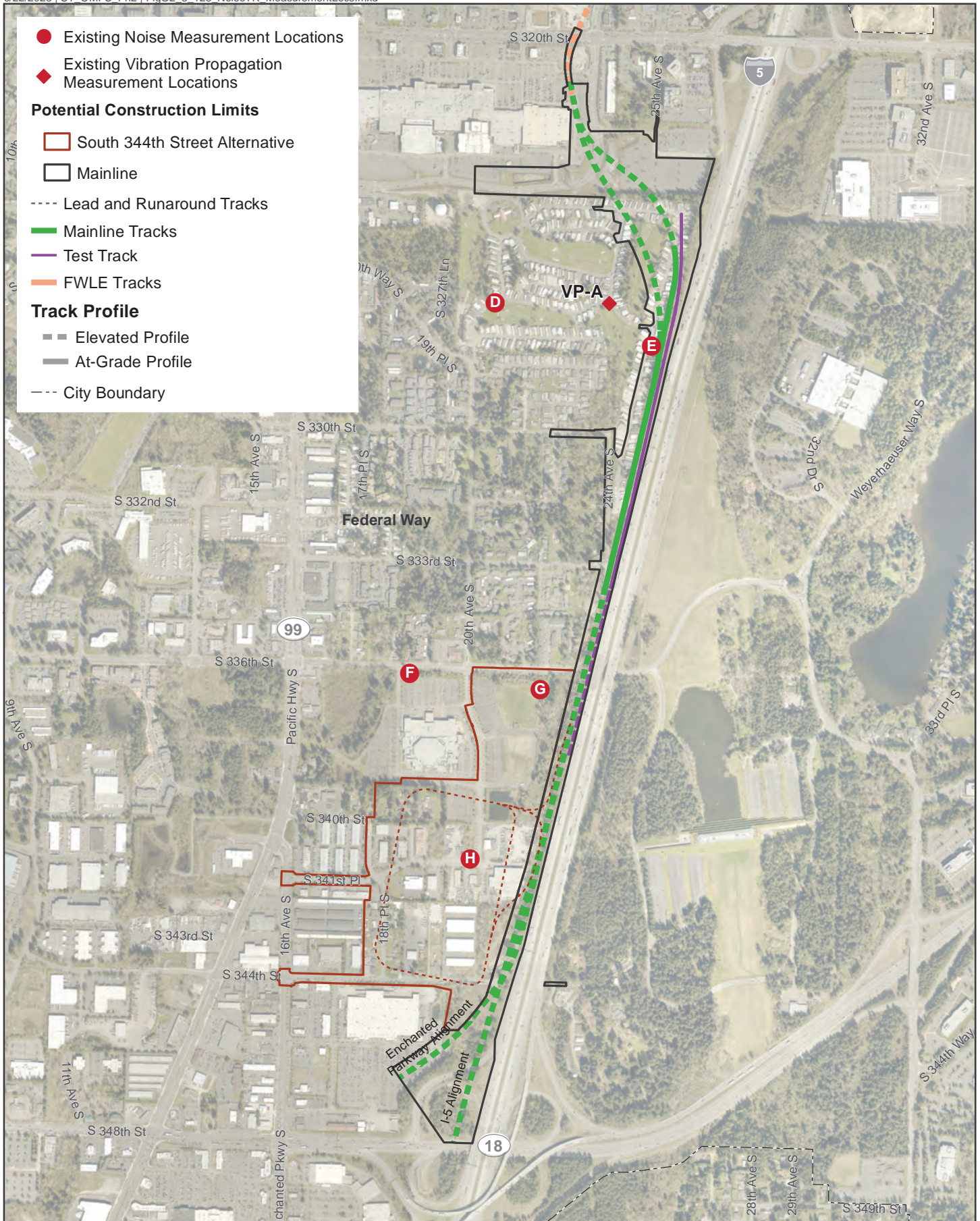
Table G2.5-2 summarizes the results of the existing noise measurement program, and Figure G2.5-2 shows the locations of the two measurements for the South 344th Street Alternative. The results of the existing noise measurements were used to characterize the existing noise levels at all noise-sensitive 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 Preferred 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 Preferred Alternative near I-5. The ambient noise levels were dominated by traffic on I-5.

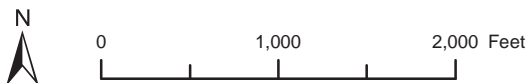
Table G2.5-2 Summary of Existing Ambient Noise Measurements Results for South 344th Street Alternative

| 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 |



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

FIGURE G2.5-2
Measurement Locations for Existing Ambient
Noise and Vibration: South 344th Street



5.2.1.3 Midway Landfill Alternative

Table G2.5-3 summarizes the results of the existing noise measurement program, and Figure G2.5-3 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 G2.5-3 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 |

5.2.1.4 Mainline Track Design Options

Table G2.5-4 summarizes the results of the existing noise measurement program, and Figures G2.5-1 and G2.5-2 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 G2.5-1 and G2.5-2, 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 Final EIS the No-Build Alternative assumes that by the design year 2042, all planned Sound Transit 3 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 constructed noise walls adjacent to the residential areas near the Midway Landfill to mitigate the anticipated noise impacts from that project. No vibration impacts from FWLE are anticipated in the area. The proposed alignment for the TDLE mainline track overlaps with the OMF South Preferred and South 344th Street alternatives. If TDLE is constructed as proposed, the mainline track associated with these alternatives would be built later in time. The noise and vibration effects of TDLE and Federal Way's City Center Access Project on sensitive receptors within the study area for the Preferred and South 344th Street alternatives are discussed in Section 7, Cumulative Impacts. Noise and vibration impacts from TDLE will be further detailed in the TDLE Draft EIS, expected to be published in mid-2024.

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. During final design, all impacts would be reevaluated to verify impact levels and inform the mitigation design.

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, facility operations, and test track 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. 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 Preferred Alternative Site

Comparisons of the existing and future noise levels are presented in Table G2.6-1 and Table G2.6-2 for the Preferred Alternative site. Table G2.6-3 includes the results for FTA Category 2 (residential) receptors with both daytime and nighttime sensitivity to noise, and Table G2.6-4 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 Preferred Alternative site.

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

| Location | Side of OMF | Distance to Nearest Proposed Track (feet) | Existing Noise Level (Ldn, dBA) | Project Noise Level (Ldn, dBA) | Moderate Noise Criteria | Severe Noise Criteria | # of Moderate Impacts | # of Severe Impacts |
|----------------|-------------|---|---------------------------------|--------------------------------|-------------------------|-----------------------|-----------------------|---------------------|
| S 336th Street | North | 176 | 67 | 48 | 62 | 68 | 0 | 0 |
| 18th Place S | South | 933 | 73 | 36 | 65 | 71 | 0 | 0 |
| Total: | | | | | | | 0 | 0 |

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

| Location | Side of OMF | Distance to Nearest Proposed Track (feet) | Existing Noise Level (Ldn, dBA) | Project Noise Level (Ldn, dBA) | Moderate Noise Criteria | Severe Noise Criteria | # of Moderate Impacts | # of Severe Impacts |
|--|-------------|---|---------------------------------|--------------------------------|-------------------------|-----------------------|-----------------------|---------------------|
| Russian-Ukrainian Seventh-Day Adventist Church | North | 180 | 62 | <20 | 64 | 70 | 0 | 0 |
| KAC Baptist Church | West | 295 | 62 | <20 | 64 | 70 | 0 | 0 |
| Restoration Life Church | South | 857 | 67 | <20 | 67 | 72 | 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 Preferred Alternative Site

| Location | Side of OMF | Distance to Nearest Proposed Track (feet) | Project Noise Level (Leq, dBA) | Noise Level for Impact | # of Exceedances |
|----------------|-------------|---|--------------------------------|------------------------|------------------|
| S 336th Street | North | 180 | 42 | 55 | 0 |
| 18th Place S | South | 933 | 30 | 55 | 0 |
| Total: | | | | | 0 |

There are no FTA noise impacts or WAC exceedances for the Preferred Alternative site.

6.2.2 South 344th Street Alternative Site

Comparisons of the existing and future noise levels are presented in Table G2.6-4 and Table G2.6-5 for the South 344th Street Alternative site. Table G2.6-4 includes the results for FTA Category 2 (residential) receptors with both daytime and nighttime sensitivity to noise, and Table G2.6-5 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 site.

Table G2.6-4 Summary of FTA Category 2 Noise Impacts for the South 344th Street Alternative Site

| Location | Side of OMF | Distance to Nearest Proposed Track (feet) | Existing Noise Level (Ldn, dBA) | Project Noise Level (Ldn, dBA) | Moderate Noise Criteria | Severe Noise Criteria | # of Moderate Impacts | # of Severe 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 G2.6-5 Summary of FTA Category 3 Noise Impacts for the South 344th Street Alternative Site

| Location | Side of OMF | Distance to Nearest Proposed Track (feet) | Existing Noise Level (Ldn, dBA) | Project Noise Level (Ldn, dBA) | Moderate Noise Criteria | Severe Noise Criteria | # of Moderate Impacts | # of Severe 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 G2.6-6 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 344th Street Alternative Site

| Location | Side of OMF | Distance to Nearest Proposed 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 site.

6.2.3 Midway Landfill Alternative

Comparisons of the existing and future noise levels with the Midway Landfill Alternative are presented in Table G2.6-7 and Table G2.6-8. 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 Midway Landfill Alternative.

Table G2.6-7 Summary of FTA Category 2 Noise Impacts for the Midway Landfill Alternative

| Location | Side of OMF | Distance to Nearest Track (feet) | Existing Noise Level (Ldn, dBA) | Project Noise Level (Ldn, dBA) | Moderate Noise Criteria | Severe Noise Criteria | # of Moderate Impacts | # of Severe 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 G2.6-8 Summary of FTA Category 3 Noise Impacts for the Midway Landfill Alternative

| Location | Side of OMF | Distance to Nearest Track (feet) | Existing Noise Level (Ldn, dBA) | Project Noise Level (Ldn, dBA) | Moderate Noise Criteria | Severe Noise Criteria | # of Moderate Impacts | # of Severe 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 G2.6-9 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 Midway Landfill Alternative

| Location | Side of OMF | Distance to Nearest 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.

6.3 Preferred and South 344th Street Alternatives Mainline and Test Track Noise

For the Preferred and South 344th Street alternatives mainline track design options and the test track, 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 40 mph Alignment, and Table G2.6-11 includes the results for FTA Category 2 receptors for the 55 mph 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.

There would be no FTA noise impacts for the 40 mph Alignment and four FTA moderate impacts for the 55 mph Design Option. 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 55 mph Design Option, and the projected noise impacts are described below.

Table G2.6-10 Summary of FTA Category 2 Noise Impacts for the 40 mph Alignment Mainline Track

| Location | Side of Track | Distance to Nearest Proposed Track (feet) | Existing Noise Level (Ldn, dBA) | Project Noise Level (Ldn, dBA) | Moderate Noise Criteria | Severe Noise Criteria | # of Moderate Impacts | # of Severe Impacts |
|--|-----------------|---|---------------------------------|--------------------------------|-------------------------|-----------------------|--------------------------|--------------------------|
| S 324th Street to Burning Tree Boulevard | SB ¹ | 80 | 70 | 62 | 64 | 69 | 0 | 0 |
| Burning Tree Boulevard to S 330th Street | SB | 111 | 70 | 56 | 64 | 69 | 0 | 0 |
| S 330th Street to S 333rd Street | SB | 81 | 72 | 58 | 65 | 71 | 0 | 0 |
| S 333rd Street to S 336th Street | SB | 197 | 72 | 64(58) ² | 65 | 71 | 0 (0) ² | 0 (0) ² |
| Total: | | | | | | | 0 (0)² | 0 (0)² |

Note:

- (1) SB = southbound.
- (2) The Preferred Alternative is shown first, followed by the South 344th Street Alternative in parenthesis. The lead tracks and crossovers from the OMF would be further south for the South 344th Street Alternative in comparison to the Preferred Alternative.

Table G2.6-11 Summary of FTA Category 2 Noise Impacts: 55 mph Design Option Mainline Track

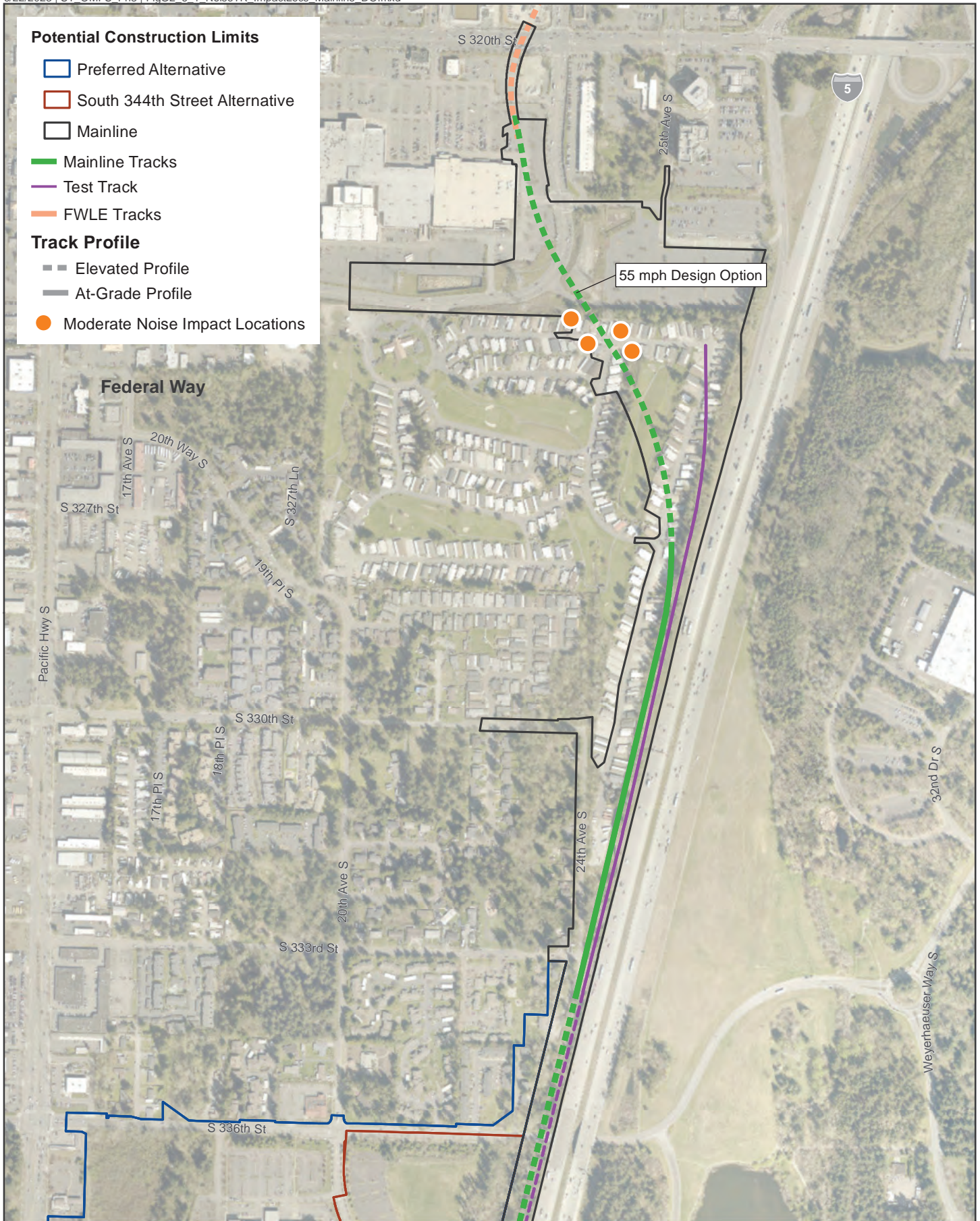
| Location | Side of Track | Distance to Nearest Proposed Track (feet) | Existing Noise Level (Ldn, dBA) | Project Noise Level (Ldn, dBA) | Moderate Noise Criteria | Severe Noise Criteria | # of Moderate Impacts | # of Severe Impacts |
|--|-----------------|---|---------------------------------|--------------------------------|-------------------------|-----------------------|--------------------------|--------------------------|
| S 324th Street to Burning Tree Boulevard | NB ¹ | 76 | 65 | 61 | 64 | 69 | 2 | 0 |
| S 324th Street to Burning Tree Boulevard | SB ¹ | 57 | 65 | 64 | 61 | 66 | 2 | 0 |
| Burning Tree Boulevard to S 330th Street | SB | 85 | 70 | 57 | 64 | 69 | 0 | 0 |
| S 330th Street to S 333rd Street | SB | 81 | 72 | 58 | 65 | 71 | 0 | 0 |
| S 333rd Street to S 336th Street | SB | 197 | 72 | 64 (58) ² | 65 | 71 | 0 (0) ² | 0 (0) ² |
| Total: | | | | | | | 4 (4)² | 0 (0)² |

Note:

- (1) NB = northbound, SB = southbound.
- (2) The Preferred Alternative is shown first, followed by the South 344th Street Alternative in parenthesis. The lead tracks and crossovers from the OMF would be further south for the South 344th Street Alternative in comparison to the Preferred Alternative.

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

S 324th Street to Burning Tree Boulevard (SB): Two 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.



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

FIGURE G2.6-1
Noise Impact Locations
55 mph Design Option

OMF South

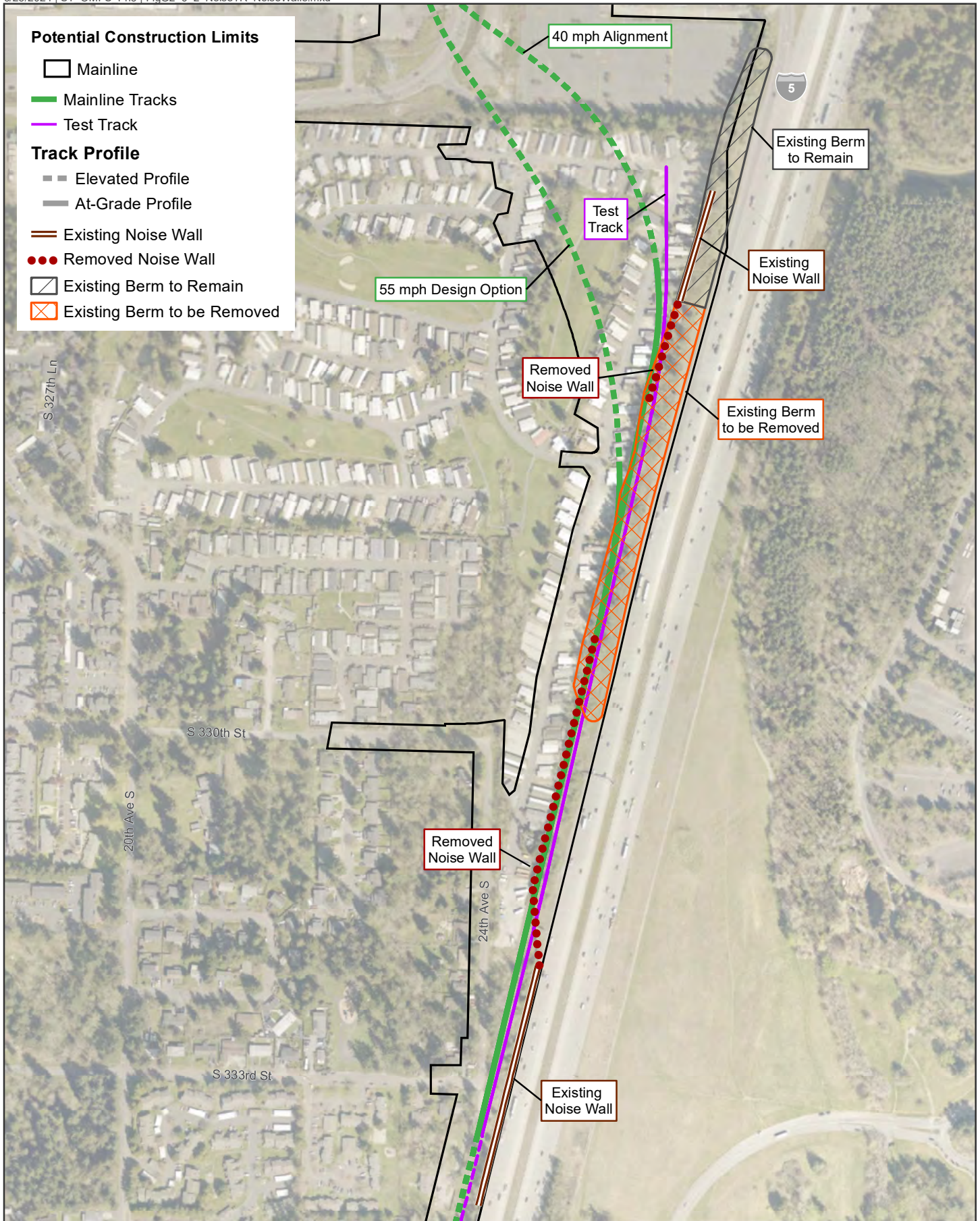


6.3.1 Traffic Noise

Construction of either mainline alignment would modify a portion of an existing berm and remove noise walls adjacent to I-5 that screen residences from traffic noise between S 320th Street and S 336th Street. The berm and noise walls were anticipated to be removed by the City of Federal Way's City Center Access Project, which would construct a new interchange with roundabouts and a new bridge over I-5 at S 324th Street. However, the City Center Access Project is now anticipated to be constructed after OMF South. As a result, Sound Transit would modify the existing berm and remove approximately 1,390 linear feet of noise walls as part of the OMF South project.

While the retained fill structure to support the mainline would serve as a barrier to traffic noise from I-5, the modification of the existing berm and noise walls is anticipated to result in traffic noise impacts for about one to three residences (Sound Transit 2023a). In final design, Sound Transit would conduct additional noise analysis in coordination with Federal Way and WSDOT to verify the findings of the noise analysis, determine whether replacement of noise walls would be necessary, and ensure that the location of any new noise walls would be consistent with the plans for the City Center Access Project.

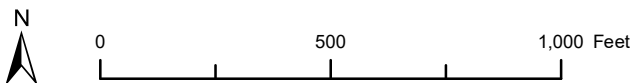
Figure G2.6-2, Proposed Modifications to Highway Noise Walls, shows the location of the existing noise wall and berm and the areas that would be modified to accommodate the construction of the mainline tracks for OMF South under the Preferred or South 344th Street alternatives.



Data Sources: King County; City of Federal Way.

FIGURE G2.6-2
Proposed Modifications to
Highway Noise Walls

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 and test tracks between the Preferred and the South 344th Street alternatives and the Federal Way Downtown Station.

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 40 mph Alignment, and Table G2.6-13 includes the results for FTA Category 2 receptors for the 55 mph 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 40 mph Alignment 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 | 80 | 48 | 72 | 0 |
| Burning Tree Boulevard to S 330th Street | SB | 111 | 46 | 72 | 0 |
| S 330th Street to S 333rd Street | SB | 81 | 47 | 72 | 0 |
| S 333rd Street to S 336th Street | SB | 197 | 46 | 72 | 0 |
| Total: | | | | | 0 |

Note: SB = southbound.

Table G2.6-13 Summary of FTA Category 2 Vibration Impacts for the 55 mph 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 | 76 | 48 | 72 | 0 |
| S 324th Street to Burning Tree Boulevard | SB | 57 | 48 | 72 | 0 |
| Burning Tree Boulevard to S 330th Street | SB | 85 | 46 | 72 | 0 |
| S 330th Street to S 333rd Street | SB | 81 | 44 | 72 | 0 |
| S 333rd Street to S 336th Street | SB | 197 | 43 | 72 | 0 |
| Total: | | | | | 0 |

Note: NB = northbound, SB = southbound.

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. 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. 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 percent during the day. If alternative methods of piling are used, the distance to impact could be less. When a specific piling method has been 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 would 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 and Federal Way's proposed City Center Access Project for the Preferred and South 344th Street alternatives. Please see Figure G2.7-1, Cumulative Transit and Traffic Noise Impacts. There would be no cumulative noise impacts associated with the Midway Landfill Alternative.

If TDLE is constructed, approximately 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 Preferred and South 344th Street alternatives, the LRVs leaving and entering would be split between the northern and southern tracks leading to the mainline tracks. The additional LRVs from TDLE operating from within the OMF South alternative sites would increase some noise levels, but they would not be loud enough to cause FTA noise impacts or WAC exceedances.

As described previously, the mainline tracks connecting the Preferred and South 344th Street alternatives would become the operational track for TDLE. With TDLE, additional trains would use the mainline tracks, and they would operate at higher speeds. As a result, the operation of TDLE is anticipated to cause additional noise impacts to residences along the mainline tracks in Belmor from either the 40 mph Alignment or the 55 mph Design Option. Impacts would also occur where the mainline curves south of S 324th Street and near the mainline north of S 336th Street. There would be no cumulative noise impacts from TDLE for the Midway Landfill Alternative because the mainline tracks adjacent to the site would already be built as part of FWLE and operating as revenue-generating tracks.

There would be no vibration impacts associated with OMF South. With the inclusion of the TDLE project, there would be an increase in vibration levels due to the higher speed of the trains, but no cumulative vibration impacts are anticipated. With the Midway Landfill Alternative, there would be no cumulative vibration impacts from the FWLE project.

Further details regarding TDLE noise and vibration impacts and mitigation will be included in the TDLE Draft EIS, which is expected to be published in mid-2024. The Draft EIS will include recommended mitigation measures, such as noise barriers, for any noise impacts on sensitive receptors near the mainline tracks, which would address the cumulative effects of TDLE for the Preferred or South 344th Street alternatives. To improve efficiency and eliminate the impacts of two construction activities in the same location, the OMF South project is anticipated to construct noise mitigation required for TDLE if the Preferred Alternative or South 344th Street Alternative is selected as the project to be built.

The City Center Access Project, together with OMF South and TDLE, could result in cumulative noise impacts to a small number of receptors south of S 324th Street. The City Center Access Project proposes to extend S 324th Street across I-5 to the east, which may increase motor vehicle traffic noise that would require mitigation.



Data Sources: King and Pierce County, Cities of Federal Way, Fife, Milton, Tacoma (2023).

FIGURE G2.7-1
Cumulative Transit and Traffic Noise Impacts



8 MITIGATION

8.1 Operational Noise

The Sound Transit Link Light Rail Noise and Vibration Policy (Sound Transit 2023b) 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 Preferred and South 344th Street alternatives, the mainline 40 mph Alignment curves north of S 324th Street and from S 324th Street to Oakland Hills Boulevard would have a radius between 600 and 1,000 feet and would be prepared for wayside lubricators.

Noise barriers are proposed for mitigation along the elevated 55 mph Design Option mainline track for the Preferred and South 344th Street alternatives. The approximate locations and lengths of the noise barriers are shown in Table G2.8-1 and shown in Figure G2.8-1. The final height and length of the barriers would be determined based on additional analysis of potential noise impacts 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 Preferred 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 TDLE Draft EIS, which is expected to be published in mid-2024.

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

| Project Alternative | Approximate Location | Noise Barrier Length (feet) |
|----------------------|--|-----------------------------|
| 55 mph Design Option | Northbound side from south of park-and-ride to south of Burning Tree Boulevard | 360 |
| 55 mph Design Option | Southbound side from south of park-and-ride to south of Burning Tree Boulevard | 325 |

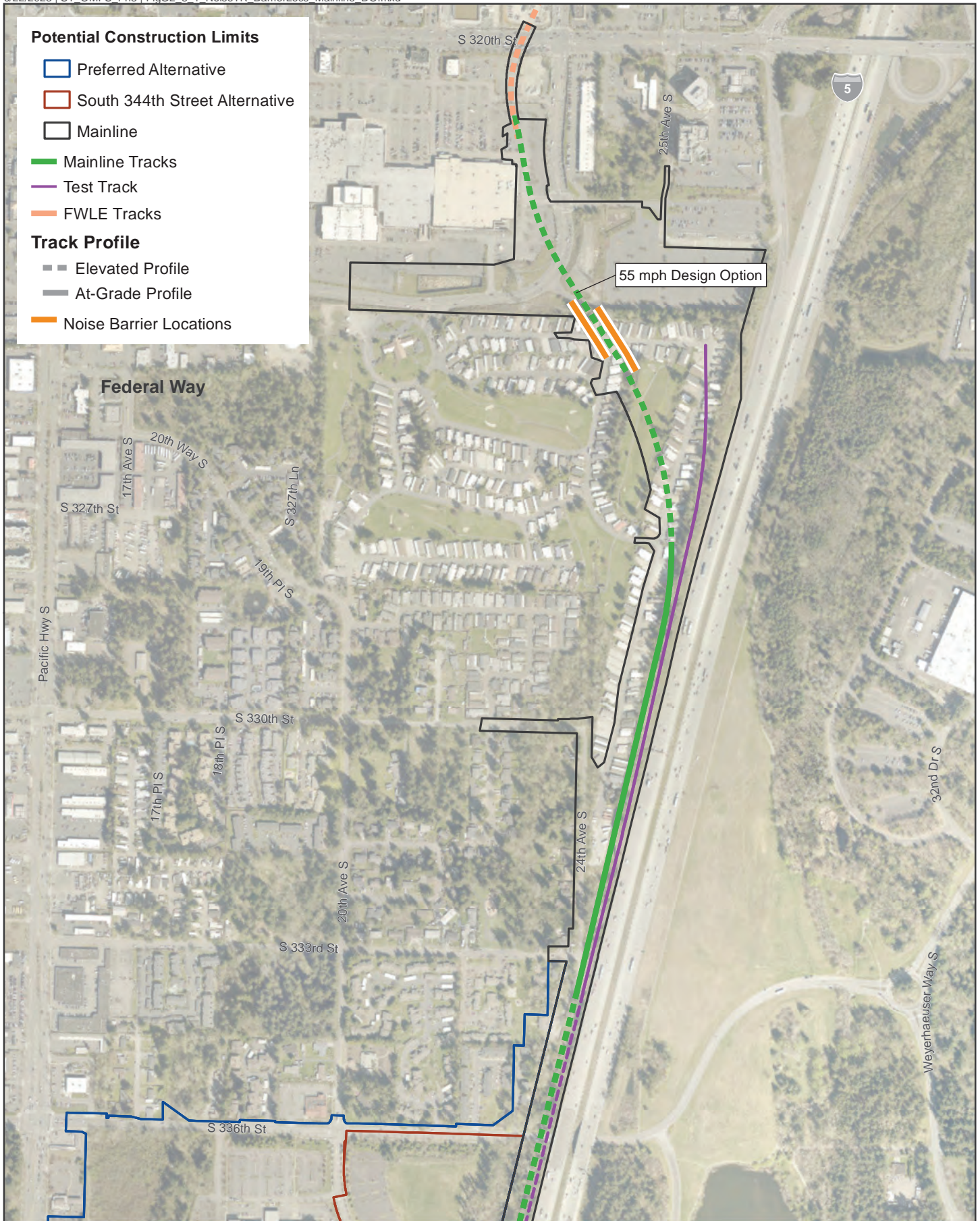
8.1.1 Traffic Noise

Mitigation for traffic noise impacts caused by a project is designed to ensure that, whenever possible, there would be no residences in the study area with project-related traffic noise levels at or above the WSDOT NAC of 66 dBA. In circumstances where existing WSDOT noise barriers (such as walls or berms constructed for the purpose of traffic noise abatement) would be removed or altered by a project, mitigation would be designed to ensure that, whenever possible, there would be no residences with traffic noise levels above the predicted 2042 No-Build levels.

For the Preferred and South 344th Street alternatives, Sound Transit would provide traffic noise mitigation measures where traffic noise levels are predicted to be above the 2042 No-Build levels from removal of the existing WSDOT berm and noise wall. Mitigation would be designed to maintain 2042 No-Build noise levels and could include replacement of noise walls and berms. Sound Transit would conduct additional noise analysis during final design in coordination with WSDOT to confirm whether noise mitigation is needed.

8.2 Operational Vibration

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



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

FIGURE G2.8-1
Noise Barrier Locations
55 mph Design Option

OMF South



8.3 Construction

Construction activities would 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 would 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 when possible
- 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 the following:

- 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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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

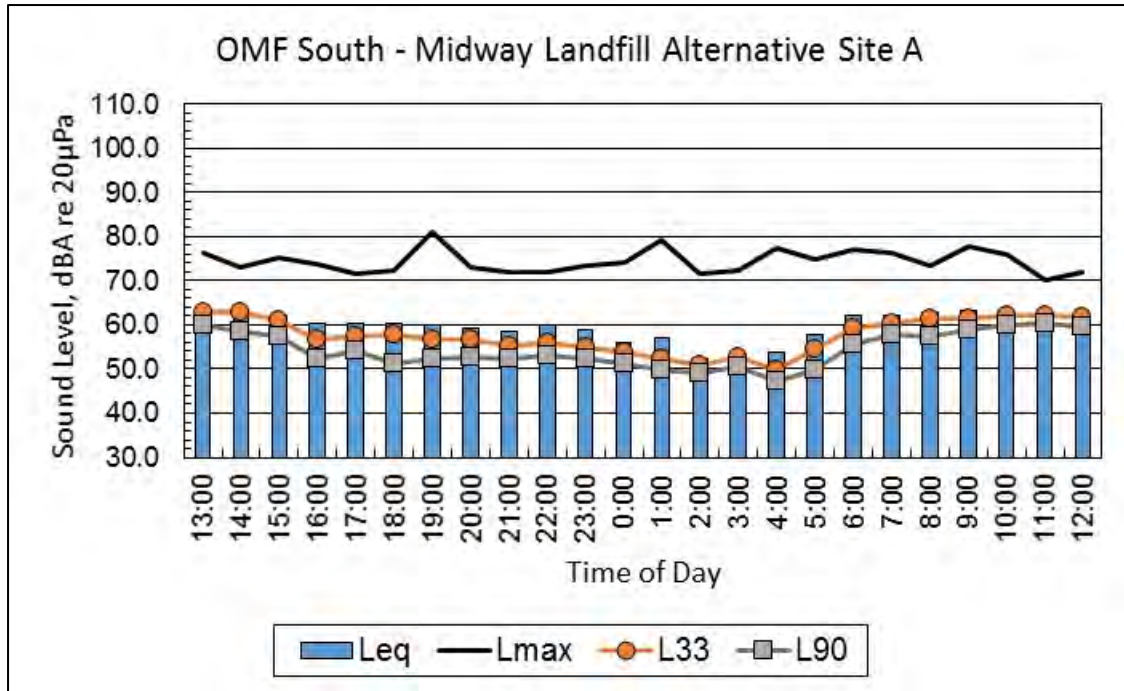


Figure G2-1.9 Vibration Propagation Measurement: Belmor Mobile Home Park



ATTACHMENT G2-2

Noise Measurement Data



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

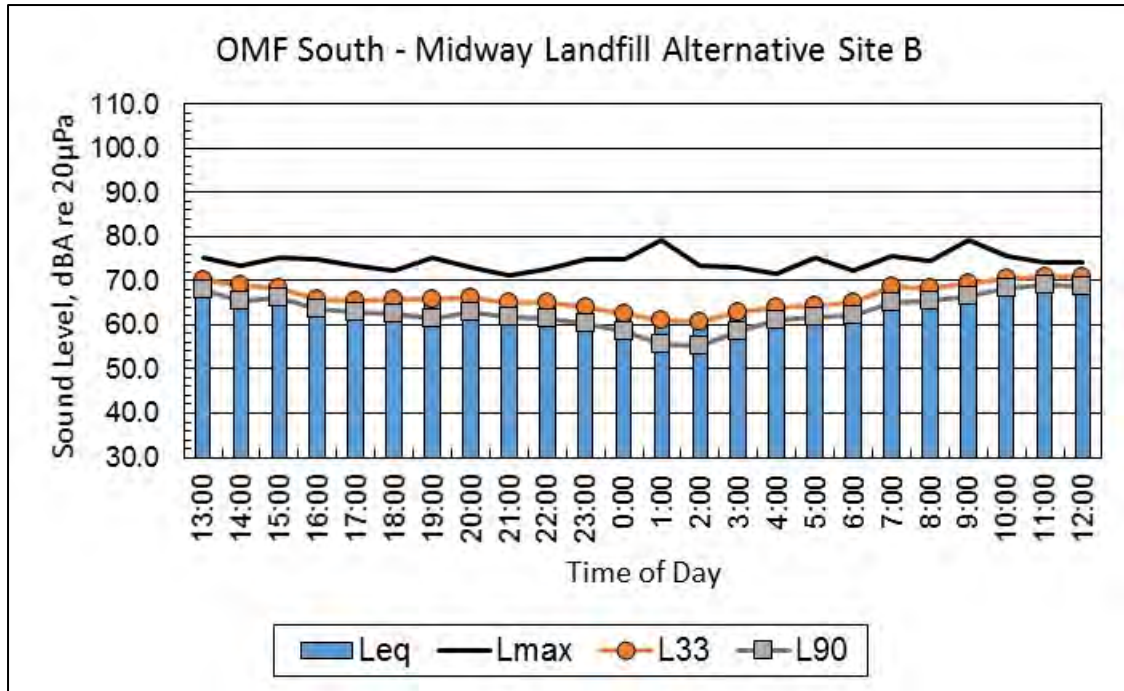


Figure G2-2.2 Site B Long-Term Noise Measurement Data: Midway Landfill Alternative

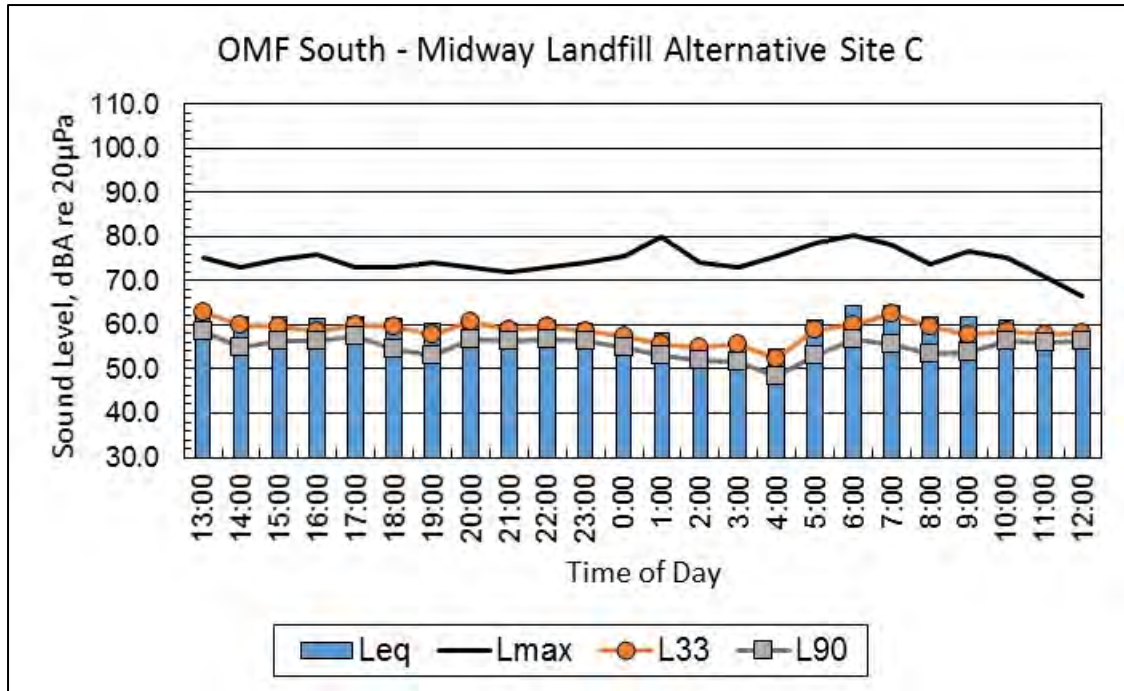


Figure G2-2.3 Site C Long-Term Noise Measurement Data: Midway Landfill Alternative

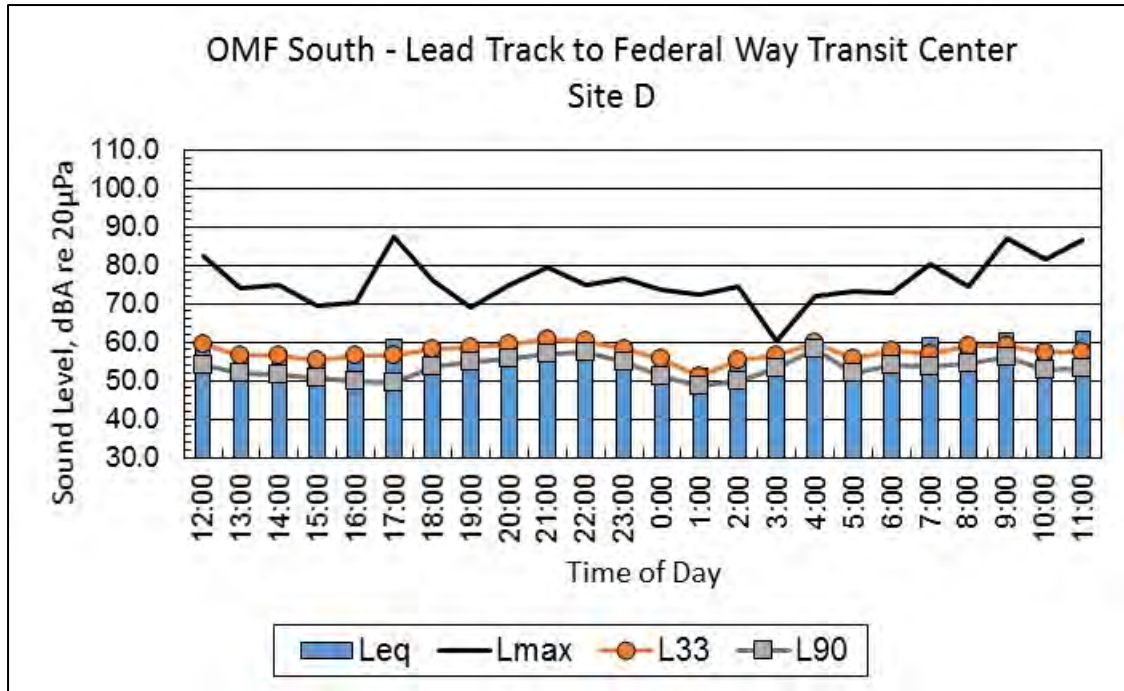


Figure G2-2.4 Site D Long-Term Noise Measurement Data; Mainline Track Options to Federal Way Transit Center

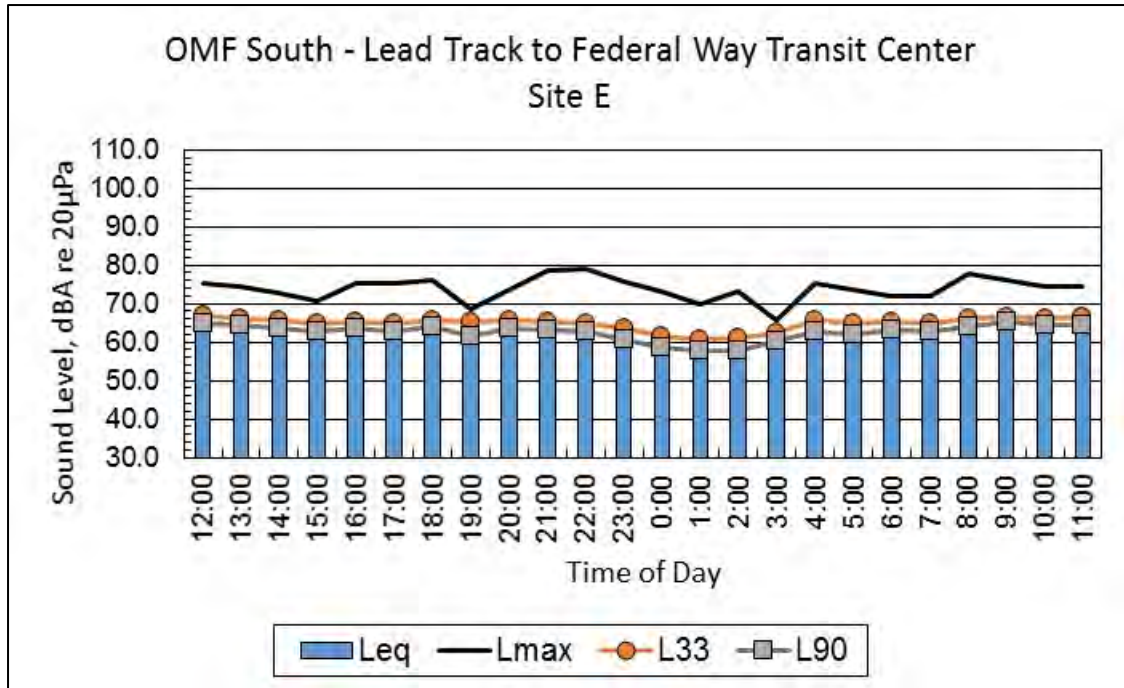


Figure G2-2.5 Site E Long-Term Noise Measurement Data: MainlineTrack Options to Federal Way Transit Center

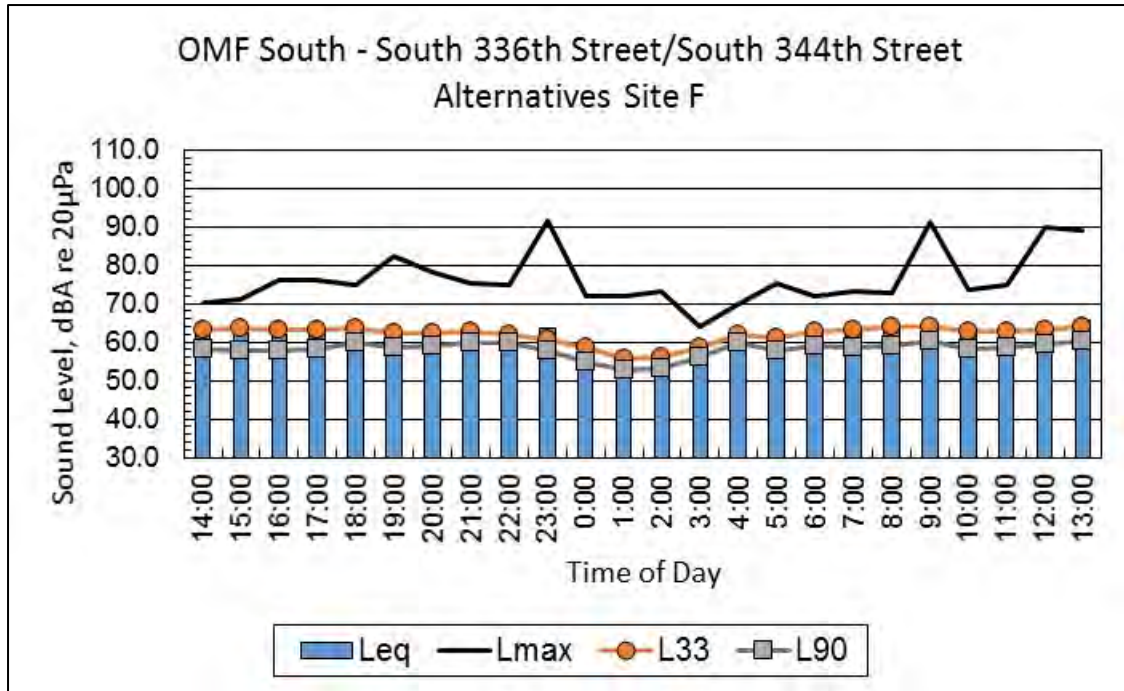


Figure G2-2.6 Site F Long-Term Noise Measurement Data: South 336th Street and South 344th Street Alternatives

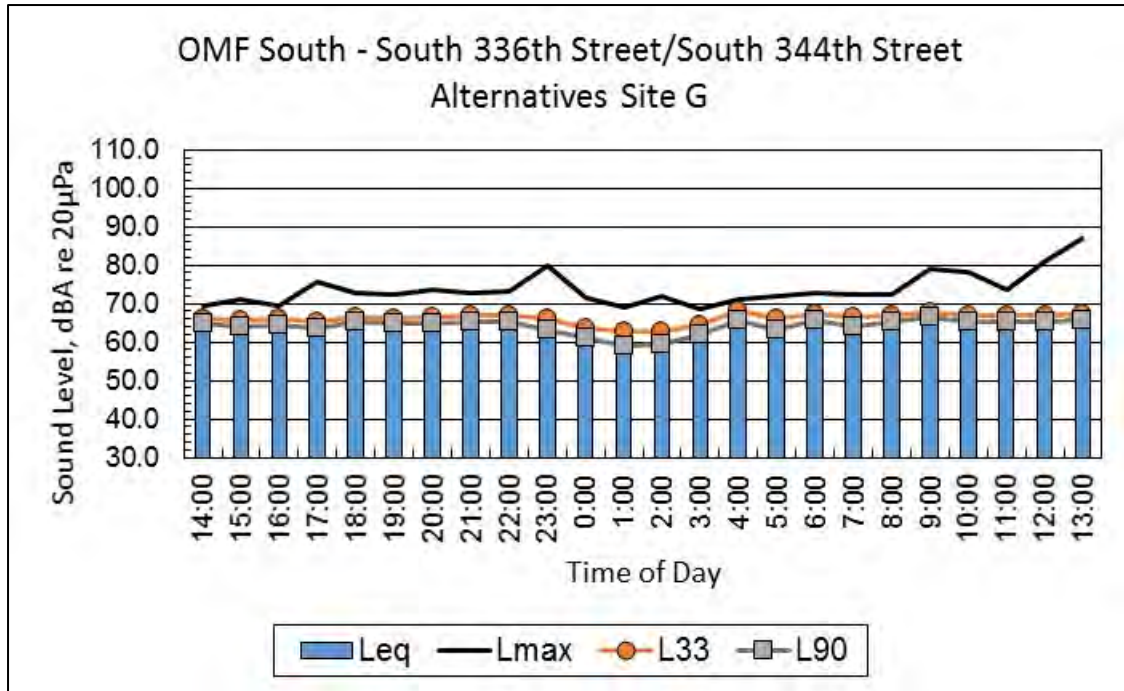


Figure G2-2.7 Site G Long-Term Noise Measurement Data: South 336th Street and South 344th Street Alternatives

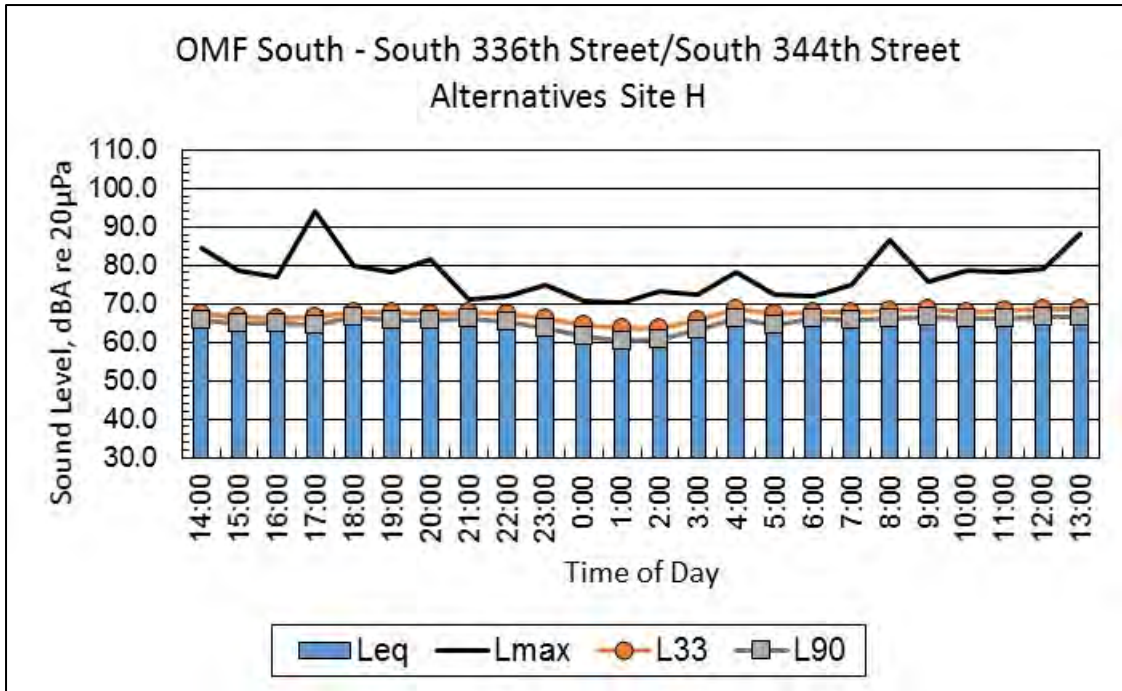


Figure G2-2.8 Site H Long-Term Noise Measurement Data: South 336th Street and South 344th Street Alternatives



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 |

$$TM=A+B*\log(\text{dist})+C*\log(\text{dist})^2$$

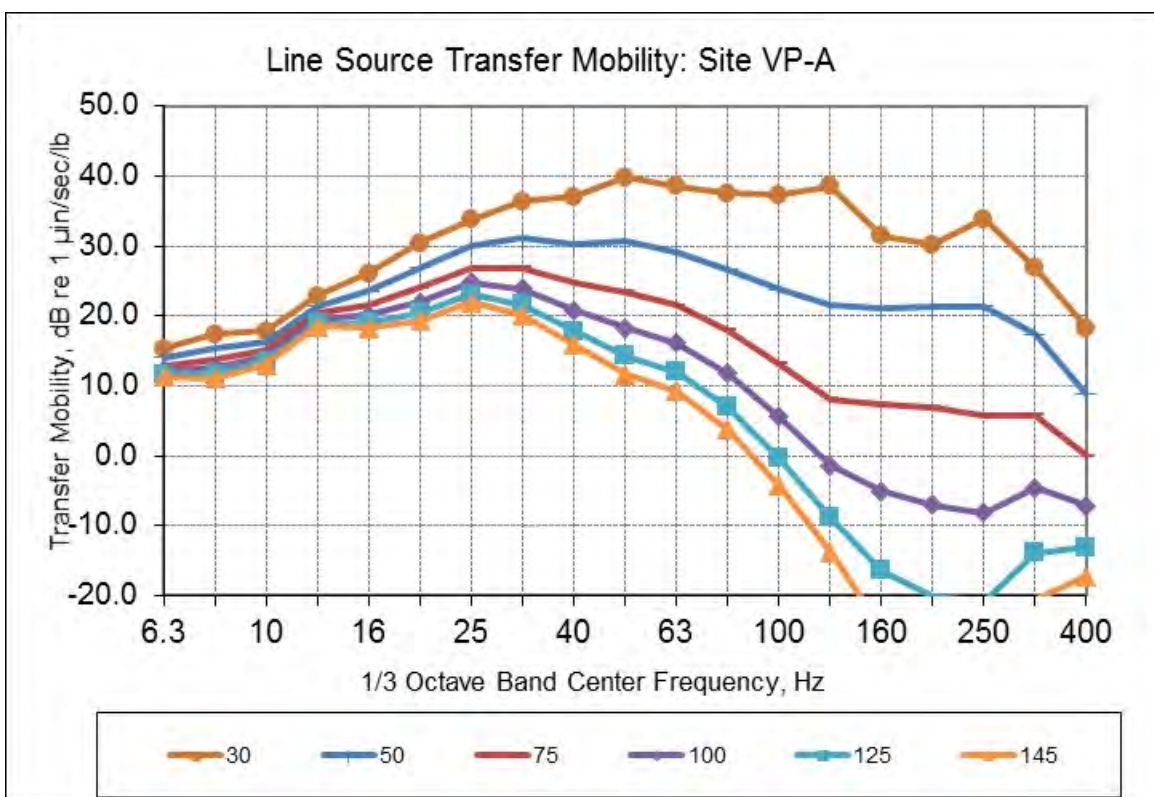


Figure G2-3.1 Line Source Transfer Mobility Site VP-A Belmor Mobile Home Park