# Noise Report

## Strander Boulevard Extension Project

City of Tukwila, King County

*Prepared for:*

**City of Tukwila**
6200 Southcenter Boulevard
Tukwila, WA 98188

*Prepared by:*

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**March 2018**

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# Acronyms

| | |
|---|---|
| dB(A) | The A-weighted sound level measured in decibels. A-weighted network = a frequency-equalizing function which approximates the sensitivity of human hearing to sounds of moderate SPL. |
| EB | East bound traffic lane |
| EPA | Environmental Protection Agency |
| FHWA | Federal Highway Administration |
| $L_{eq}$(1h) | The equivalent sound level (the logarithmic sum of sound exposure levels) over 1 hour |
| mph | Miles per hour |
| NAC | Noise Abatement Criteria |
| NB | North bound traffic lane |
| SB | South bound traffic lane |
| SEL | Sound Exposure Level |
| SPL | Sound Pressure Level |
| TNM | FHWA traffic noise model – version 2.5 |
| WB | West bound traffic lane |
| WSDOT | Washington State Department of Transportation |

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# Executive Summary

Widener & Associates undertook this study to analyze existing and predicted future traffic noise conditions in the vicinity of the proposed Strander Boulevard Extension Project. The entire project consists of constructing a shoofly, excavating an underpass of vehicular and pedestrian traffic, as well as erecting a two-span bridge for the BNSF railroad. Other utility work by BNSF, BP Oil, ATT, SPU, and SPE are also required during the course of the project. Associated construction activities required for the above description have included or will include excavation, utility relocation, railroad shoofly embankment, grading, dewatering, storm sewer, water line, installation of shoring walls and retaining walls, paving, curb and gutter, illumination, striping, and signing. Cities of Renton and Tukwila, Pierce County, WA within Section 25 of Range 4E and Township 23N. Existing land use along the project corridor is divided light industrial and commercial.

Sound levels for the 'Existing 2017', 'No Build 2040' and 'Build 2040' conditions were derived from the Traffic Noise Model (TNM) 2.5, verified with field measurements, and compared with the Federal Highway Administration (FHWA) and the Washington State Department of Transportation (WSDOT) standards and criteria. Sound level recording and modeling was undertaken in accordance with FHWA guidelines and standards. A total of eight receivers were modeled within the project area. As per WSDOT guidelines, all receivers were modeled for the worst case hourly condition in the project area as a whole (the PM peak hour). Traffic data was collected in 2017 and forecasted for 'No Build 2040', and 'Build 2040' conditions.

This study shows that noise above established thresholds (as defined by FHWA/WSDOT) occurs at three locations along the project corridor. The 2040 Build scenario does not predict a substantial increase over the existing condition at any of the eight receivers. The greatest increase in sound level under the ‘Build 2040’ condition compared to existing conditions is 3 dB at receiver 3. The greatest sound level experienced under the 'Build 2040’ condition is 73 dB(A) at receivers 2 and 7. See table below for modeled results for all conditions.

**Summary of results for the Existing, No Build 2040, and Build 2040 conditions**

| Receivers | | Existing (2017) LAeq1hr | No Build (2040) LAeq1hr | Build (2040) LAeq1hr | Impact Approach Noise Level Criteria | Impact Substantial Increase Criteria |
|---|---|---|---|---|---|---|
| Number | Name/Description | | | | | |
| V-1 | Validation Site 1 | 75 | 76 | 76 | - | - |
| V-2 | Validation Site 2 | 73 | 74 | 74* | - | - |
| 3 | Restaurant | 68 | 70 | 73 | 71 | 10 |
| 4 | Offices 1 | 59 | 60 | 63 | 71 | 10 |
| 5 | Offices 2 | 63 | 64 | 67 | 71 | 10 |
| 6 | Offices 3 | 57 | 58 | 60 | 71 | 10 |
| 7 | Credit Union | 71 | 72 | 73 | 71 | 10 |
| 8 | Interurban Trail | 66 | 67 | 69 | 66 | 10 |

*This location is only used for validation. The noise level in the build condition is only estimated due to proximity to the roadway and is not subject to consideration of abatement measures.

Based on the results of this study, abatement measures were fully evaluated in accordance with Federal Highway Administration and Washington State Department of Transportation noise abatement policy. It was concluded that none of the abatement measures are 'feasible or reasonable' by Federal Highway Administration/Washington State Department of Transportation criteria.

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# 1. Introduction

The purpose of this report is to document and analyze existing traffic noise conditions and predict future traffic noise conditions in the vicinity of the proposed Strander Boulevard Project, in Tukwila, WA. Sound levels for the ‘Existing 2017’, ‘No Build 2040’ and ‘Build 2040’ conditions were compared with the FHWA / WSDOT standards and criteria. Sound levels were derived from the FHWA approved noise model, TNM 2.5. Calculations generated by the model were verified using field measurements in accordance with FHWA and WSDOT requirements. This report was used to determine whether or not noise abatement measures should be warranted as part of the proposed project, and as appropriate, to make recommendations regarding such options.

## *1.1 Noise Characteristics and Measurement*

### 1.1.1 Defining Noise

Noise is defined as unwanted sound (Maekawa and Lord., 1994; Bell *et al*., 1996; Berglund *et al.*, 1996). Noise is recognized as having both a physical and a psychological component. The physical component is set, while the psychological component (the degree of annoyance) depends on the listener and their physiological and psychological state as well as the frequency and time of the varying pattern of the sound. Low frequency (particularly anthropogenic sources) and impulse sounds are thought to result in higher levels of annoyance (Hall *et al.*, 1981; Maekawa and Lord, 1994; Bell *et al*., 1996; Berglund *et al*., 1996).

### 1.1.2 Measuring Noise

When measuring noise, the decibel scale, the A-weighted network, and the descriptor $L_{eq}$ are usually used to describe and quantify the noise levels experienced by a receiver. These descriptors are described in the following paragraphs.

The decibel scale is a logarithmic scale, derived from the Pascal scale and based on sound pressure levels (the physical correlate of loudness). The threshold of human hearing is at 20 micropascals or 0 dB. A change of 20 dB corresponds to a ten-fold increase in micropascals. Thus, 20 dB is equivalent to 200 micropascals. However, the decibel scale provides a better approximation of the perception of loudness than the Pascal scale, 1 dB indicates the same fractional change in sound pressure at all levels. Generally, a 3 dB increase is barely perceptible to human listeners. A 6 dB increase corresponds to a doubling of the sound pressure; however, a 10 dB increase is necessary for the sound to be perceived as being twice as loud (FHWA, 1995; Maekawa *et al.*, 1994; Boeker and Van Grondelle, 1995). Refer to Table 1 for examples of typical sound source levels.

**Table 1:** Sound Pressure Levels of Representative Sounds and Noises

| Source | Decibels | Description |
|---|---|---|
| **Large rocket engine (nearby)** | **180** | |
| **Jet take-off (nearby)** | **150** | |
| **Pneumatic riveter** | **130** | **Pain threshold** |
| **Jet take-off (60 meters)** | **120** | |
| **Construction noise (3 meters)** | **110** | |
| **Subway train** | **100** | |
| **Heavy truck (15 meters) and** | **90** | **Constant exposure** |
| **Niagara Falls** | **80** | **endangers hearing** |
| **Average factory** | **70** | |
| **Normal conversation (1 meter)** | **60** | |
| **Quiet office** | **50** | |
| **Quiet Library** | **40** | |
| **Soft whisper (5 meters)** | **30** | |
| **Rustling leaves** | **20** | |
| **Normal breathing** | **10** | **Very quiet** |
| **Hearing threshold** | **0** | **Barely audible** |

Source: Tipler 1976

The type of weighting curve used in measuring sound is important in determining the accuracy of the result as a measure of the impact of the sound on those hearing it. The frequency of sound determines the ability of the human auditory system to detect it. As the sound of a constant sound pressure level decreases in frequency from about 1 kHz or increases in frequency from about 5 kHz, its perceived loudness decreases. Therefore, in order to measure what is actually being heard by humans, measurement of sound pressure level is adjusted to account for the relative loudness of the frequency through the use of weighting networks (A, B and C) in sound level meters. Networks are based on approximate equal-loudness contours rather than the hearing threshold curve. The A-weighted network is considered to most accurately represent human perception of noise (Maekawa and Lord, 1994; Boeker and Van Grondelle, 1995; Berglund *et al.*, 1996).

The descriptor used to measure traffic-induced sound levels in this study is dB(A) $L_{eq}$(1h), which is defined as the equivalent A-weighted sound level [the logarithmic sum of sound exposure levels (SELs)] over 1 hour.

# 2. Project Description

## 2.1 Location

The proposed project is located in the Cities of Renton and Tukwila, Pierce County, WA. The legal geographic area is Section 25 of Range 4E and Township 23N. Existing land use along the project corridor is divided light industrial and commercial. Refer to Figure 1 for the project vicinity and Figure 2 for land use designations.

## 2.2 Proposed Work

The entire project consists of constructing a shoofly, excavating an underpass of vehicular and pedestrian traffic, as well as erecting a two-span bridge for the BNSF railroad. Other utility work by BNSF, BP Oil, ATT, SPU, and SPE are also required during the course of the project. Associated construction activities required for the above description have included or will include excavation, utility relocation, railroad shoofly embankment, grading, dewatering, storm sewer, water line, installation of shoring walls and retaining walls, paving, curb and gutter, illumination, striping, and signing.

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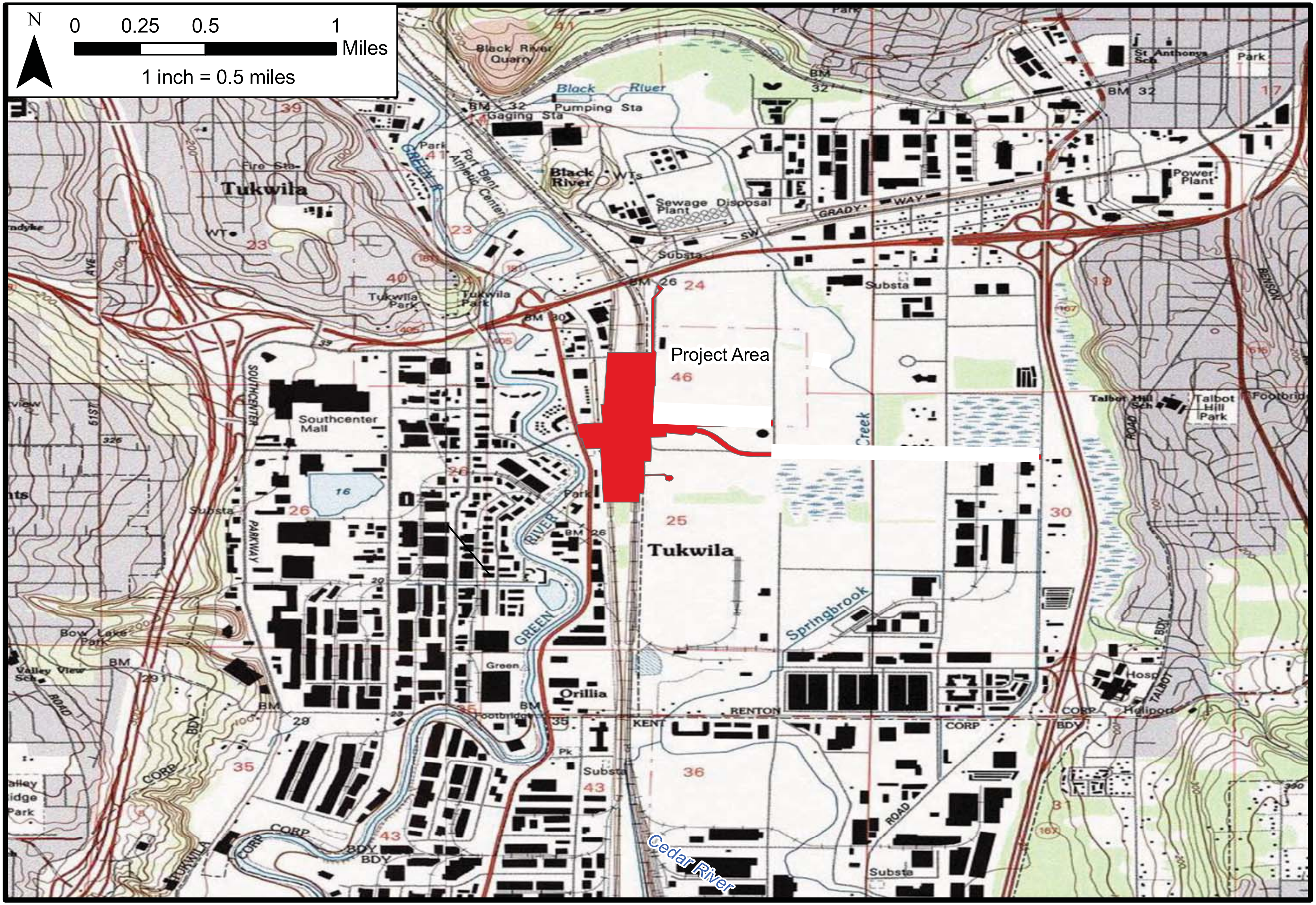



**Figure 1: Vicinity Map**

*Strander Boulevard Extension Project*

**City of Renton**

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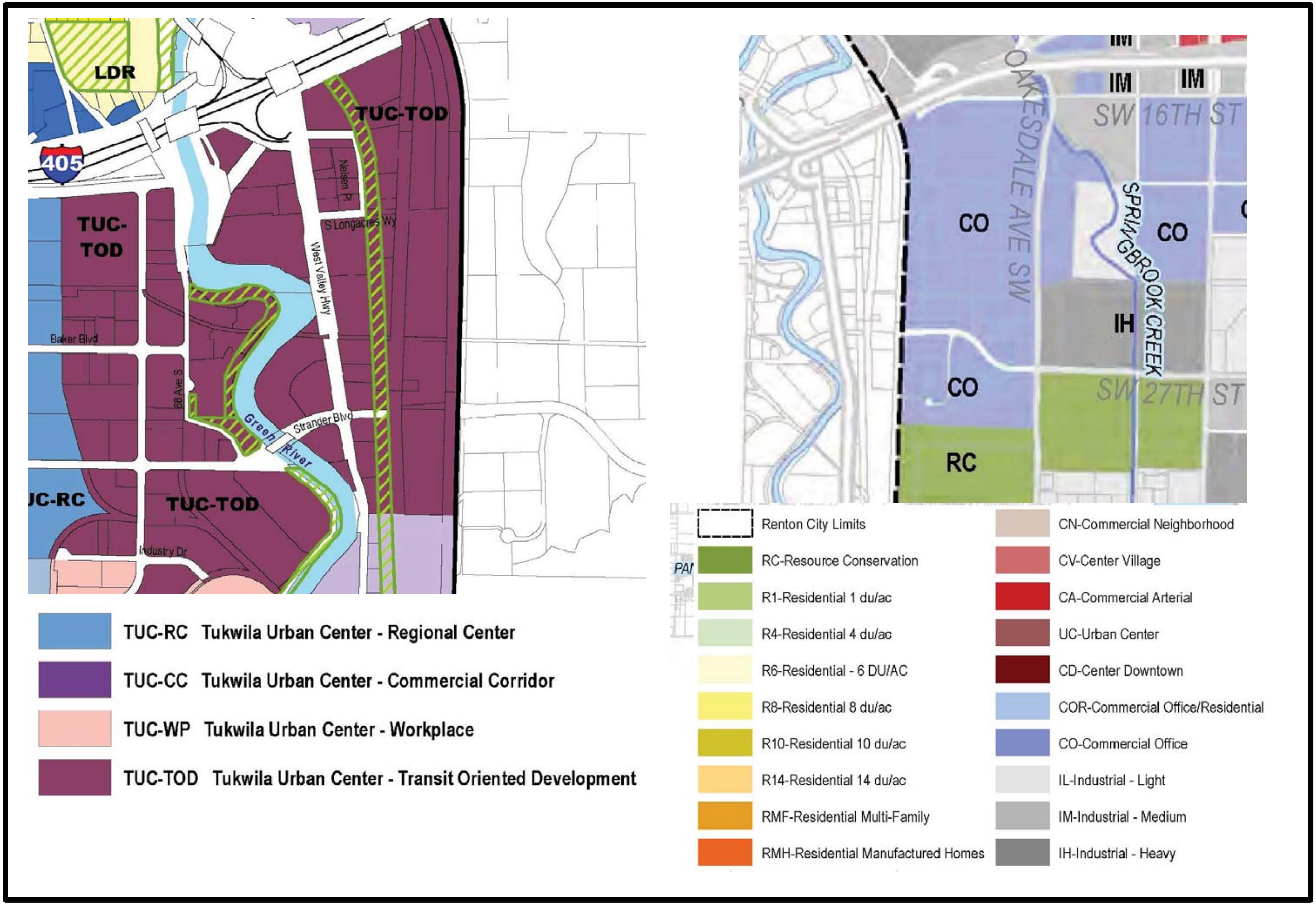


# Figure 2: Land Use Designations

*Strander Boulevard Extension Project*

**City of Renton**

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# 3. Criteria for Determining Impacts

This section discusses applicable noise regulations and agency guidelines that provide the basis for evaluating potential noise impacts and mitigation or abatement for a proposed project. Noise regulations and guidelines for federally funded highway projects in Washington are established by WSDOT and the FHWA. The FHWA (23 C.F.R. §772.5(g)) defines traffic noise impacts to occur either when:

- predicted traffic noise levels approach or exceed the noise abatement criteria;
- predicted traffic noise levels substantially exceed the existing noise levels; or
- predicted traffic noise levels are severe noise levels

WSDOT has defined ‘approach’ to be within 1 dB(A) below the FHWA noise abatement criteria of 67 dB(A) and has defined ‘substantially exceed’ to be a 10 dB(A) increase over existing noise levels. A severe impact is defined as a level greater than 80 dB(A) $L_{eq}$(1h).

Therefore, a noise impact is determined to occur when predicted noise levels ‘approach’ or ‘exceed’ the FHWA noise abatement criteria[1] as given in Table 1 or when predicted noise levels are 10 dB(A) or greater over the existing level. For example, traffic noise impacts for Activity Category B (residences, schools etc.) would occur if predicted noise levels were to be equal or greater than 66 dB(A) $L_{eq}$ (1h).

[1] Noise standards that specify exterior $L_{eq}$(h) noise levels for various land activity categories.

**Table 2: FHWA noise abatement criteria**

| Activity Category | $L_{eq}$(1h) dB(A) | Description of Activity Category |
|---|---|---|
| A | 57 (exterior) | Lands on which serenity and quiet are of extraordinary significance and serve an important public need and where the preservation of those qualities is essential if the area is to continue to serve its intended purpose. |
| B | 67 (exterior) | Residential (single and multi-family units) |
| C | 67 (exterior) | Active sports centers, amphitheaters, auditoriums, campgrounds, cemeteries, day care centers, hospitals, libraries, medical facilities, parks, picnic areas, places of worship, playgrounds, public meeting rooms, public or nonprofit institutional structures, radio studios, recording studios, recreational areas, Section 4(f) sites, schools, television studios, trails, and trail crossings. |
| D | 52 (interior) | Auditoriums, day care centers, hospitals, libraries, medical facilities, places of worship, public meeting rooms, public or nonprofit institutional structures, radio studios, schools, and television studios. |
| E | 72 (exterior) | Hotels, motels, offices, restaurants/bars, and other developed lands, properties or activities not included in A-D or F. Includes undeveloped land permitted for these activities. |
| F | - | Agriculture, airports, bus yards, emergency services, industrial, logging, maintenance facilities, manufacturing, mining, retail facilities, shipyards, utilities (water resources, water treatment, and electrical), and warehousing. |
| G | - | Undeveloped lands that are not permitted |

Source: 23 C.F.R. Part 772

Sound levels generated by any proposed project are primarily compared to the FHWA / WSDOT standards and criteria rather than to the ‘Existing’ condition or to the ‘No Build 2040’ condition. The project proponent is required to consider mitigation options when the proposed project meets or exceeds FHWA / WSDOT standards and criteria in the future build condition. In a case where the criteria are exceeded by a lesser degree as a result of the proposed project than under the ‘Existing’ condition, the project proponent is still required to consider mitigation options.

# 4. Methods

## *4.1 Field Data Collection*

Sound levels were recorded in the field on December 30, 2017. Sound level recordings were made at two sites along the project corridor between 1:45 and 3 pm. Refer to Figure 3 and the data sheets provided in Appendix C. Recordings were made using a Larson and Davis Type 1 Sound Level Meter (model 820) and the following variables:

- Descriptor: $L_{eq}$
- Integration rate: Fast
- Sample rate, 15 minutes
- Weighting, A

The timing and source of other noises perceptible above the traffic noise were also noted. The sound level meter, microphone, and calibrator were within factory calibration. Calibration certificates for the meter, microphone, and calibrator are provided in Appendix A. The microphone was placed 5 feet off the ground and the site chosen was an area of potential outdoor human use (refer to Appendix C).

Traffic data collected in the field was used to validate the model in accordance with FHWA and WSDOT requirements. Traffic data and weather conditions collected in the field at the time of the sound recording were entered into the model. The following traffic data and baseline information was collected during each 15-minute sound recording interval:

- total numbers of each traffic type (automobiles, medium trucks [2 axles and 6 tires] heavy trucks [greater than 2 axles / 6 tires], buses, and motorbikes) directionally separated;
- average speed
- temperature
- humidity

Sound levels calculated by the model were compared with those recorded in the field. The acceptable margin of error between the field recordings and the modeled results were plus or minus 2 dB(A). The difference between the field recordings and modeled results for all sites were within 2 dB(A).

## 4.2 Traffic Noise Model

The FHWA traffic noise model version 2.5 (TNM) was used to model the existing and future ('Build 2040' and 'No Build 2040') road traffic-induced noise environment within the project area.

### 4.2.1 Receivers

A total of eight receivers were modeled. All but one of these receivers are characterized as 'Activity Category E' receivers. For all Category E receivers, the impact criterion is 71 dB(A). One receiver is characterized as a 'Activity Category C' receiver. The impact criterion is 66dB(A).

Receivers were chosen based on the following factors:

1. Proximity to the existing and proposed roadway. Sites most likely to be impacted were favored.
2. Location along the corridor. Receivers were selected along the length of the project corridor and extend out from the road to such a distance to ensure that all traffic noise impacts are included. Modeling limits are extended to reach any location which reaches 65 dB(A) to ensure the full impacted area is captured.
3. Primary areas of outdoor use. Receivers were placed at sites which appeared to have the most foot traffic.
4. Sites which would be removed as a result of the proposed project or which were too close to the roadway to model were not selected.

As per WSDOT guidelines, all receivers were modeled for the worst case condition in the project area as a whole (the PM peak hour) for 2017 and 2040.

### 4.2.2 Traffic Data

**4.2.2.1 Existing Condition**

***Traffic Data***

Traffic data for the PM Peak Hour were provided by Fehr and Peers based on tube counts conducted within the project corridor. Traffic was directionally separated and provided percentages of vehicle type (Refer to Appendix B). Speeds along the corridor were based on posted speed limits.

**4.2.2.2 No Build 2040 Condition**

Traffic numbers on existing roads were used to predict traffic numbers on the new road by Fehr and Peers. Percentages of vehicle types were assumed to be the same as for the 'Existing 2017' condition. Refer to Appendix B for the traffic data and the vehicle percentages used to model the 'No Build 2040' condition. The posted speed for each roadway was used, resulting in the worst hourly noise conditions.

**4.2.2.3 Build 2040 Condition**

Predicted counts were also used to model the 'Build 2040' condition. Percentages of vehicle types were assumed to be the same as for the 'Existing 2012' and 'No Build 2040' conditions. The proposed posted speed for the new roadway. Remaining roadways were assumed to have the same posted speed. Refer to Appendix B for the data used to model the 'Build 2040' condition.

# 5. Results

## 5.1 Existing Noise Environment

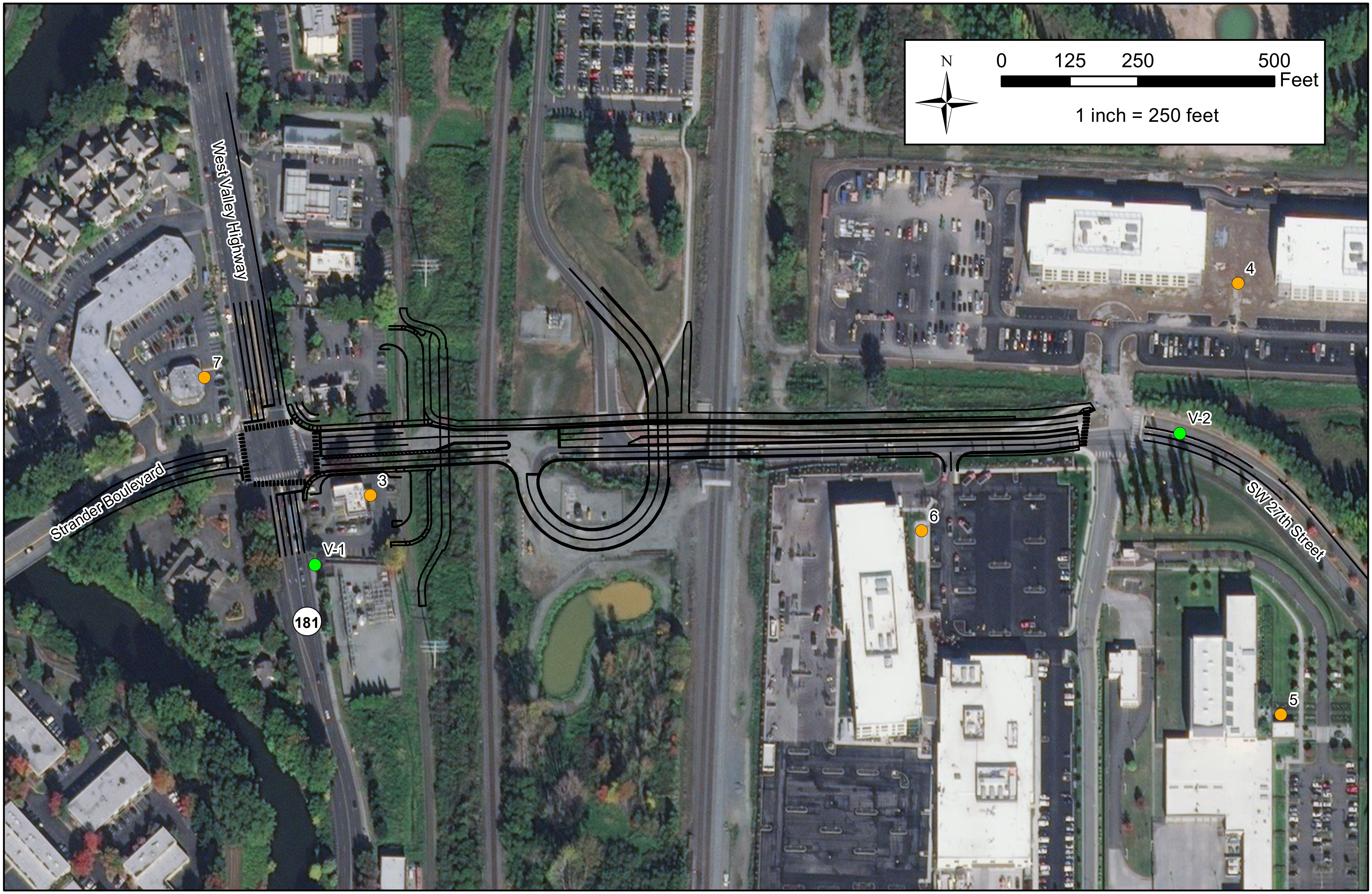
### 5.1.1 Field Measurement

Sound levels were recorded in the field at two sites along the project corridor. Data from the site was compared to the modeled results (based on traffic data collected during the sound level recording) in order to validate the model in accordance with WSDOT requirements. WSDOT requires that the modeled results and the field measurements come within plus or minus 2 dB(A) of one another. Site one (Receiver 1) was located on the sidewalk south of the intersection of W Valley Highway and Strander Boulevard. Site two (Receiver 2) was located on the east side of the project on SW 27th Street near the intersection with Naches Avenue SW. These sites were chosen as they represent the conditions within the project area, however they do not require noise abatement consideration. The $L_{eq}$ levels measured in the field were 71.4 dB(A) for site one. The $L_{eq}$ levels calculated by the model were 70.2 dB(A) for site one. The $L_{eq}$ levels measured in the field were 61.8 dB(A) for site two. The $L_{eq}$ levels calculated by the model were 59.9 dB(A) for site two. Therefore, the result is within the acceptable margin of error and modeling of all receivers under all conditions (Existing, No Build, and Build) could proceed. The meter was correctly calibrated at the time of recording. All field validation sites are depicted in Figure 3.

Environmental conditions recorded during field measurements are as follows:

- Temperature, 49°F;
- Relative Humidity, 65%;

Sound levels at the field recording site was dominated by vehicular traffic. Refer to the data sheets provided in Appendix C.




- Receiver
- Validation
- Proposed Road

# Figure 3: Receiver Locations

*Strander Boulevard Extension Project*

City of Renton

March 2017

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## 5.2 *Future Noise Environment*

Of the eight receivers modeled, three exceeded the FHWA/WSDOT sound level criteria under the build condition. Receivers 7 and 8 exceeded the sound level criteria under all conditions. Refer to Table 3 for the results of existing sound levels modeled at all receivers and to Figure 3 for the locations.

The 2040 Build scenario does not predict a substantial increase over the existing condition at any of the eight receivers. The greatest increase in sound level under the 'Build 2040' condition compared to existing conditions is 5 dB at receiver 3. The greatest sound level experienced under the 'Build 2040' condition is 73 dB(A) at receivers 3 and 7.

**Table 3: Summary of results for the Existing, No Build 2040, and Build 2040 conditions**

| Receivers | | Existing (2017) LAeq1hr | No Build (2040) LAeq1hr | Build (2040) LAeq1hr | Impact Approach Noise Level Criteria | Impact Substantial Increase Criteria |
|---|---|---|---|---|---|---|
| Number | Name/Description | | | | | |
| 1 | Validation Site 1 | 75 | 76 | 76 | - | - |
| 2 | Validation Site 2 | 73 | 74 | 74* | - | - |
| 3 | Restaurant | 68 | 70 | 73 | 71 | 10 |
| 4 | Offices | 59 | 60 | 63 | 71 | 10 |
| 5 | Offices 2 | 63 | 64 | 67 | 71 | 10 |
| 6 | Office 3 | 57 | 58 | 60 | 71 | 10 |
| 7 | Credit Union | 71 | 72 | 73 | 71 | 10 |
| 8 | Interurban Trail | 66 | 67 | 69 | 66 | 10 |

*This location is only used for validation. The noise level in the build condition is only estimated due to proximity to the roadway and is not subject to consideration of abatement measures.

## 5.3 Summary of Modeled Results

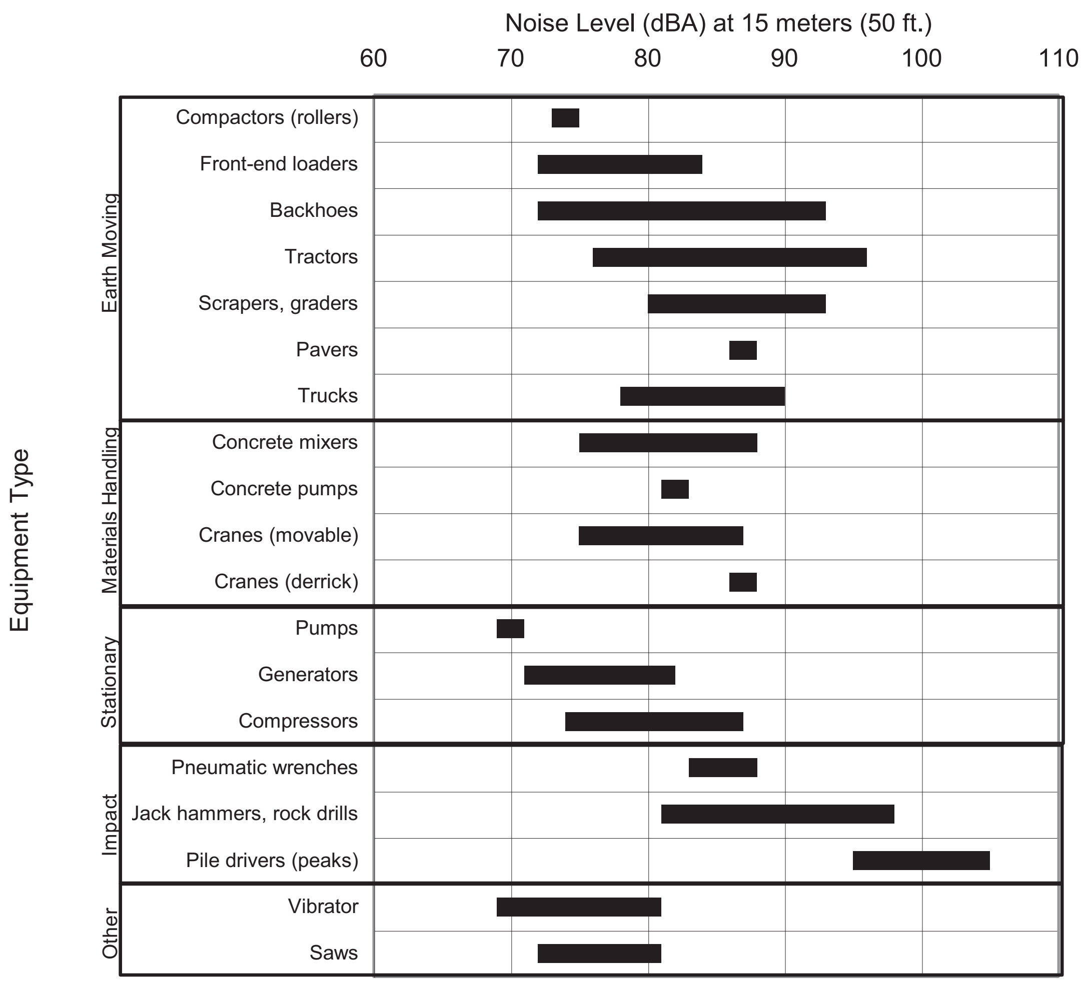
This study shows that noise above established thresholds (as defined by FHWA/WSDOT) occur at three locations along the project corridor. The 2040 Build scenario does not predict a substantial increase over the existing condition at any of the eight receivers. The greatest increase in sound level under the ‘Build 2040’ condition compared to existing conditions is 5 dB at receiver 3. The greatest sound level experienced under the 'Build 2040' condition is 73 dB(A) at receivers 3 and 7.

Based on the results of this study, receivers experience traffic noise impacts as a result of the proposed project and therefore require abatement consideration in accordance with FHWA and WSDOT policy.

## 5.4 Construction Noise

Short-term noise impacts would occur as a result of construction activities. General construction activities (such as grading, laying base, and paving) would take place as part of the proposed project. Based on WSDOT guidance, short-term noise impacts are expected to radiate up to a maximum of one mile from the project area. Based on the data tabulated by the Environmental Protection Agency (EPA) and WSDOT, sound levels generated during construction are not expected to exceed 95 dB(A). Construction equipment sounds (usually point source) decrease about 6 dB(A) with every doubling of distance. Table 4 depicts typical construction equipment sound levels 50 feet from there source. Surrounding areas would temporarily experience higher noise levels as a result of construction.

**Table 4: Typical construction equipment noise levels**




Source: EPA, 1971 and WSDOT, 1991.

The City of Tukwila's noise ordinance, chapter 8.22.110, define the following as exempt during daytime hours:

> *3. Sounds created by construction or the movement of construction-related materials, including but not limited to, striking or cutting sounds from hammers, saws or equipment with electrical or internal combustion engines emanating from temporary construction sites.*

As defined in chapter 8.22.020:

> *"Daytime" means 7AM-10PM, Monday through Friday and 8AM-10PM, Saturday, Sunday and State-recognized holidays.*

None of the areas around the project are zoned for residential use; no potential impacts to residential zones is possible. The construction noise from this project is exempt from the City of Tukwila and Renton's municipal code during daytime hours and is not required to be mitigated. However, there are some simple techniques that can be put into place to reduce the noise impacts for nearby offices or people passing by the construction area:

- Minimize construction noise by turning off engines when not in use.
- Back up alarms can produce some objectionable sound, although they are exempt from the state noise ordinance. It is recommended that vehicles drive forward as much as possible to avoid the use of back-up alarms.
- Substitute hydraulic or electric models for impact tools such as rock drills or jackhammers.

# 6. Mitigation Needs

As discussed in Section 3, the project proponent is required to consider mitigation options when the proposed project meets or exceeds FHWA/ WSDOT criteria/standards regardless of whether or not the criteria/standards were met or exceeded under the 'Existing' condition. As this study identifies noise impacts, mitigation measures need to be fully evaluated in accordance with FHWA and WSDOT noise abatement policy for receivers that would be impacted by the proposed project. FHWA and WSDOT require that construction of noise barriers be evaluated for feasibility and reasonableness.

Feasibility deals primarily with engineering considerations such as whether or not a substantial reduction in sound levels can be achieved and whether or not abatement measures would affect property access. To be feasible, a noise wall must be constructed to achieve a reduction of at least 5 dB(A) for the majority of impacted first row receivers. Reasonableness assesses the practicality of the abatement measure including: cost, the amount of noise reduction, and future traffic levels. To be reasonable, a noise reduction of at least 7 dB(A) at one sensitive receiver must be achieved. The WSDOT noise mitigation cost per residence is given in the following table.

**Table 5: Noise mitigation cost per residence**

| Design Year Traffic Noise Decibel Level | Allowed Cost Per Household * | Equivalent Wall Surface Area Per Household |
|---|---|---|
| 66 dBA | $36,127 | 700 $ft^2$ |
| 67 dBA | $39,636 | 768 $ft^2$ |
| 68 dBA | $43,146 | 836 $ft^2$ |
| 69 dBA | $46,665 | 904 $ft^2$ |
| 70 dBA | $50,165 | 972 $ft^2$ |
| 71 dBA | $53,674 | 1040 $ft^2$ |
| 72 dBA | $57,184 | 1108 $ft^2$ |
| 73 dBA | $60,693 | 1176 $ft^2$ |
| 74 dBA | $64,203 | 1244 $ft^2$ |

*Reevaluated each year. Based on $51.61 per square foot constructed cost (WSDOT, 2011)
Note: the allowed cost per household (or residential equivalent) can be used for the full range of mitigation options including the construction of barriers and the acquisition of property.

There are three receivers which meet or exceed noise level criteria. These receivers are a credit union office, the interurban trail, and fast food restaurant which are designated as Category E receivers. In order to maintain access to these businesses and their parking lots, a noise wall is not feasible. The Interurban Trail runs parallel to the W Valley Highway in this location and will be rerouted at the crossing of Strander Boulevard during project construction. No feasible wall location exists which would reduce noise from W Valley Highway and access across Strander Boulevard must be maintained.

# References

23 C.F.R. Part 772, *Procedures for Abatement of Highway Traffic Noise and Construction Noise*

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# Appendix A: Calibration Certificates

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PCB PIEZOTRONICS
A PCB GROUP COMPANY

# Certificate of Calibration and Conformance

Certificate Number 2017-206082

Instrument Model PRM828, Serial Number 2422, was calibrated on 14 Dec 2017. The instrument meets factory specifications per Procedure D0001.8135.

**Instrument found to be in calibration as received: YES**
**Date Calibrated: 14 Dec 2017**
**Calibration due: 14 Dec 2018**

## Calibration Standards Used

| MANUFACTURER | MODEL | SERIAL NUMBER | INTERVAL | CAL. DUE | TRACEABILITY NO. |
|---|---|---|---|---|---|
| Larson Davis | LDSigGn/2209 | 0617 / 0104 | 12 Months | 19 Dec 2017 | 2016-204448 |
| Agilent Technologies | 34401A | MY41038589 | 12 Months | 6 Sep 2018 | 2017009650 |

Reference Standards are traceable to the National Institute of Standards and Technology (NIST)

## Calibration Environmental Conditions

Temperature: 24 ° Centigrade

Relative Humidity: 23 %

### Affirmations

This Certificate attests that this instrument has been calibrated under the stated conditions with Measurement and Test Equipment (M&TE) Standards traceable to the U.S. National Institute of Standards and Technology (NIST). All of the Measurement Standards have been calibrated to their manufacturers' specified accuracy / uncertainty. Evidence of traceability and accuracy is on file at Provo Engineering & Manufacturing Center. An acceptable accuracy ratio between the Standard(s) and the item calibrated has been maintained. This instrument meets or exceeds the manufacturer's published specification unless noted.

The collective uncertainty of the Measurement Standard used does not exceed 25% of the applicable tolerance for each characteristic calibrated unless otherwise noted.

The results documented in this certificate relate only to the item(s) calibrated or tested. A one year calibration is recommended, however calibration interval assignment and adjustment are the responsibility of the end user. This certificate may not be reproduced, except in full, without the written approval of the issuer.

"As received" data is the same as shipped data.

Signed: [signature]

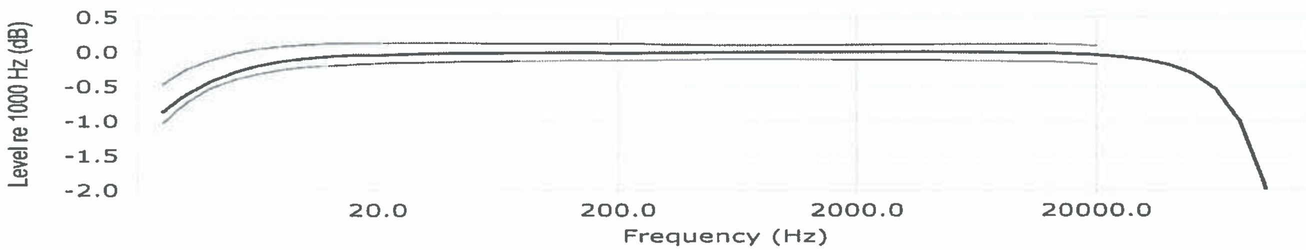
Technician: Sean Childs



Provo Engineering and Manufacturing Center, 1681 West 820 North, Provo, Utah 84601
Toll Free: 888.258.3222 Telephone: 716.926.8243 Fax: 716.926.8215
ISO 9001-2008 Certified

# Preamplifier Model: PRM828 Serial Number: 2422
# Frequency Response Test Report

Frequency response electrically tested at 120.0 dBµV using a 18 pF capacitor to simulate microphone capacitance.




| Frequency (Hz) | Relative Level (dB) | Uncertainty (dB) | Limits (dB) | Frequency (Hz) | Relative Level (dB) | Uncertainty (dB) | Limits (dB) |
|---|---|---|---|---|---|---|---|
| 2.5 | -0.86 | 0.08 | -0.46,-1.02 | 631.0 | -0.00 | 0.02 | 0.10,-0.10 |
| 3.2 | -0.60 | 0.06 | -0.25,-0.73 | 794.3 | -0.00 | 0.02 | 0.10,-0.10 |
| 4.0 | -0.42 | 0.06 | -0.12,-0.52 | 1000.0 | 0.00 | 0.02 | 0.10,-0.10 |
| 5.0 | -0.29 | 0.04 | -0.02,-0.40 | 1258.9 | 0.00 | 0.02 | 0.10,-0.10 |
| 6.3 | -0.19 | 0.04 | 0.05,-0.31 | 1584.9 | 0.00 | 0.02 | 0.10,-0.10 |
| 7.9 | -0.13 | 0.04 | 0.08,-0.26 | 1995.3 | 0.00 | 0.02 | 0.11,-0.11 |
| 10.0 | -0.09 | 0.02 | 0.11,-0.22 | 2511.9 | 0.00 | 0.02 | 0.11,-0.11 |
| 12.6 | -0.06 | 0.02 | 0.13,-0.20 | 3162.3 | 0.00 | 0.02 | 0.11,-0.11 |
| 15.8 | -0.04 | 0.02 | 0.13,-0.18 | 3981.1 | 0.00 | 0.02 | 0.11,-0.11 |
| 20.0 | -0.04 | 0.02 | 0.13,-0.16 | 5011.9 | -0.00 | 0.02 | 0.12,-0.12 |
| 25.1 | -0.03 | 0.02 | 0.13,-0.15 | 6309.6 | -0.00 | 0.02 | 0.12,-0.12 |
| 31.6 | -0.02 | 0.02 | 0.14,-0.14 | 7943.3 | -0.01 | 0.02 | 0.12,-0.13 |
| 39.8 | -0.02 | 0.02 | 0.14,-0.14 | 10000.0 | -0.01 | 0.02 | 0.12,-0.13 |
| 50.1 | -0.01 | 0.02 | 0.13,-0.14 | 12589.3 | -0.01 | 0.02 | 0.12,-0.14 |
| 63.1 | -0.01 | 0.02 | 0.13,-0.13 | 15848.9 | -0.02 | 0.02 | 0.11,-0.15 |
| 79.4 | -0.01 | 0.02 | 0.13,-0.13 | 19952.6 | -0.04 | 0.02 | 0.09,-0.17 |
| 100.0 | -0.01 | 0.02 | 0.12,-0.12 | 25118.9 | -0.07 | 0.02 | inf ,-inf |
| 125.9 | -0.01 | 0.02 | 0.12,-0.12 | 31622.8 | -0.11 | 0.02 | inf ,-inf |
| 158.5 | -0.00 | 0.02 | 0.12,-0.12 | 39810.7 | -0.18 | 0.02 | inf ,-inf |
| 199.5 | -0.02 | 0.02 | 0.12,-0.12 | 50118.7 | -0.30 | 0.02 | inf ,-inf |
| 251.2 | -0.01 | 0.02 | 0.12,-0.12 | 63095.7 | -0.53 | 0.05 | inf ,-inf |
| 316.2 | -0.01 | 0.02 | 0.11,-0.11 | 79432.8 | -0.99 | 0.05 | inf ,-inf |
| 398.1 | -0.01 | 0.02 | 0.11,-0.11 | 100000.0 | -1.87 | 0.05 | inf ,-inf |
| 501.2 | -0.00 | 0.02 | 0.10,-0.10 | 125892.5 | -3.11 | 0.06 | inf ,-inf |

1000 Hz measured level: 118.644 dBµV, -1.356 dB re input (0.033 dB uncertainty; -1.533 dB to -0.567 dB limit)
1 kHz (1/3 Octave) Noise Floor : 0.32 µV, -9.80 dBµV (0.47 dB uncertainty; -3.00 dB limit)
Flat (20 Hz - 20 kHz) Noise Floor : 3.39 µV, 10.61 dBµV (0.47 dB uncertainty; 17.00 dB limit)
A-weight Noise Floor : 1.72 µV, 4.72 dBµV (0.46 dB uncertainty; 13.00 dB limit)
Environmental conditions: 23.9 °C, 24.0 %RH (0.3 °C, 3 %RH uncertainty)
Uncertainties are given as expanded uncertainty at ~95 percent confidence level (k = 2).
Test Procedure: D0001.8135 with PRM828 (SMD).xml
This frequency response is in compliance with manufacturers specification for the item tested.
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Technician: Sean Childs    Test Date: 14 Dec 2017 11:07:41

Test Location: Larson Davis, a division of PCB Piezotronics, Inc.
1681 West 820 North, Provo, Utah 84601
Tel: 716 684-0001 www.LarsonDavis.com

PCB PIEZOTRONICS
A PCB GROUP COMPANY

# Certificate of Calibration and Conformance

Certificate Number 2017-206083

Instrument Model 820, Serial Number 1518, was calibrated on 14 Dec 2017. The instrument meets factory specifications per Procedure D0001.8160, ANSI S1.4 1983, IEC 651-Type 1 1979, and IEC 804-Type 1 1985.

**Instrument found to be in calibration as received: YES**
**Date Calibrated: 14 Dec 2017**
**Calibration due: 14 Dec 2018**

## Calibration Standards Used

| MANUFACTURER | MODEL | SERIAL NUMBER | INTERVAL | CAL. DUE | TRACEABILITY NO. |
|---|---|---|---|---|---|
| Larson Davis | LDSigGn/2209 | 0617 / 0104 | 12 Months | 19 Dec 2017 | 2016-204448 |

Reference Standards are traceable to the National Institute of Standards and Technology (NIST)

## Calibration Environmental Conditions

Temperature: 24 ° Centigrade

Relative Humidity: 23 %

### Affirmations

This Certificate attests that this instrument has been calibrated under the stated conditions with Measurement and Test Equipment (M&TE) Standards traceable to the U.S. National Institute of Standards and Technology (NIST). All of the Measurement Standards have been calibrated to their manufacturers' specified accuracy / uncertainty. Evidence of traceability and accuracy is on file at Provo Engineering & Manufacturing Center. An acceptable accuracy ratio between the Standard(s) and the item calibrated has been maintained. This instrument meets or exceeds the manufacturer's published specification unless noted.

The collective uncertainty of the Measurement Standard used does not exceed 25% of the applicable tolerance for each characteristic calibrated unless otherwise noted.

The results documented in this certificate relate only to the item(s) calibrated or tested. A one year calibration is recommended, however calibration interval assignment and adjustment are the responsibility of the end user. This certificate may not be reproduced, except in full, without the written approval of the issuer.

"As received" data is the same as shipped data.
Tested with PRM828 S/N 2422

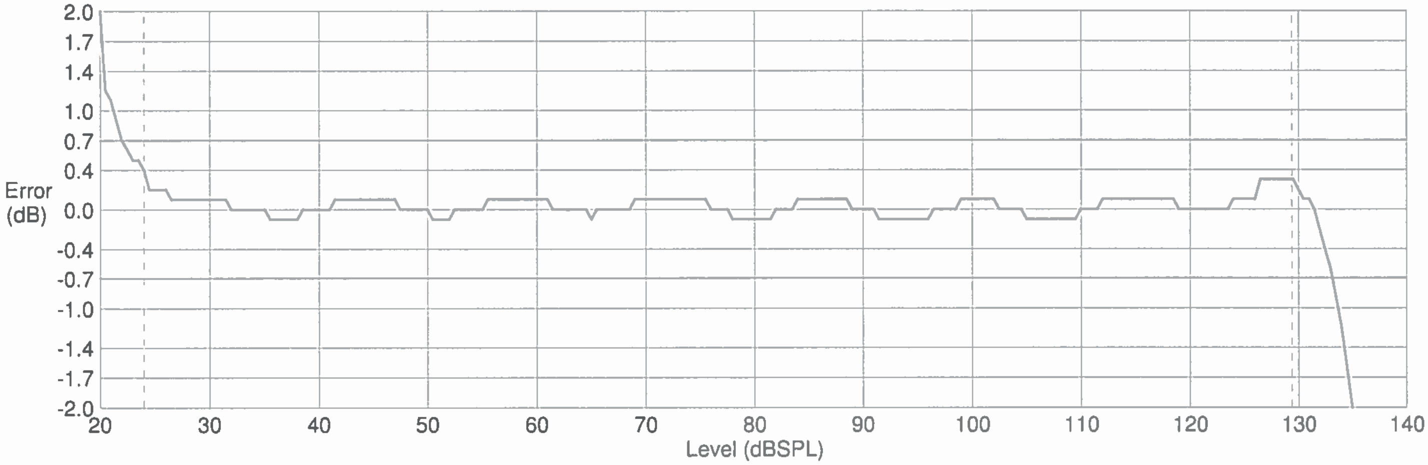
Signed: Sean Childs
Technician: Sean Childs



Provo Engineering and Manufacturing Center, 1681 West 820 North, Provo, Utah 84601
Toll Free: 888.258.3222 Telephone: 716.926.8243 Fax: 716.926.8215
ISO 9001-2008 Certified

## Sound Level Meter Model: 820A Serial Number: A1518
## Log Linearity, Differential Linearity and Range Data

This Type 1 Sound Level Meter (including attached PRM828 preamplifier and ADP005 18 pF input adapter) was calibrated with a reference 1kHz sine wave at a level of 114.0 dBSPL. The instrument's Log Linearity A-weighted slow response was then electrically tested using a 1kHz sine wave from 18.0 dBSPL to 138.0 dBSPL in 0.5 dB increments.




| Levl dBSPL | Meas dBSPL | Err dB |
|---|---|---|
| **18.0** | **20.5** | **2.5** |
| **18.5** | **20.7** | **2.2** |
| **19.0** | **20.9** | **1.9** |
| **19.5** | **21.1** | **1.6** |
| **20.0** | **21.5** | **1.5** |
| **20.5** | **21.7** | **1.2** |
| **21.0** | **22.1** | **1.1** |
| **21.5** | **22.4** | **0.9** |
| **22.0** | **22.7** | **0.7** |
| **22.5** | **23.1** | **0.6** |
| **23.0** | **23.5** | **0.5** |
| **23.5** | **24.0** | **0.5** |
| 24.0 | 24.4 | 0.4 |
| 24.5 | 24.7 | 0.2 |
| 25.0 | 25.2 | 0.2 |
| 25.5 | 25.7 | 0.2 |
| 26.0 | 26.2 | 0.2 |
| 26.5 | 26.6 | 0.1 |
| 27.0 | 27.1 | 0.1 |
| 27.5 | 27.6 | 0.1 |
| 28.0 | 28.1 | 0.1 |
| 28.5 | 28.6 | 0.1 |
| 29.0 | 29.1 | 0.1 |
| 29.5 | 29.6 | 0.1 |
| 30.0 | 30.1 | 0.1 |
| 30.5 | 30.6 | 0.1 |
| 31.0 | 31.1 | 0.1 |
| 31.5 | 31.6 | 0.1 |
| 32.0 | 32.0 | 0.0 |
| 32.5 | 32.5 | 0.0 |
| 33.0 | 33.0 | 0.0 |
| 33.5 | 33.5 | 0.0 |
| 34.0 | 34.0 | 0.0 |
| 34.5 | 34.5 | 0.0 |
| 35.0 | 35.0 | 0.0 |
| 35.5 | 35.4 | -0.1 |
| 36.0 | 35.9 | -0.1 |
| 36.5 | 36.4 | -0.1 |
| 37.0 | 36.9 | -0.1 |
| 37.5 | 37.4 | -0.1 |
| 38.0 | 37.9 | -0.1 |

| Levl dBSPL | Meas dBSPL | Err dB |
|---|---|---|
| 38.5 | 38.5 | 0.0 |
| 39.0 | 39.0 | 0.0 |
| 39.5 | 39.5 | 0.0 |
| 40.0 | 40.0 | 0.0 |
| 40.5 | 40.5 | 0.0 |
| 41.0 | 41.0 | 0.0 |
| 41.5 | 41.6 | 0.1 |
| 42.0 | 42.1 | 0.1 |
| 42.5 | 42.6 | 0.1 |
| 43.0 | 43.1 | 0.1 |
| 43.5 | 43.6 | 0.1 |
| 44.0 | 44.1 | 0.1 |
| 44.5 | 44.6 | 0.1 |
| 45.0 | 45.1 | 0.1 |
| 45.5 | 45.6 | 0.1 |
| 46.0 | 46.1 | 0.1 |
| 46.5 | 46.6 | 0.1 |
| 47.0 | 47.1 | 0.1 |
| 47.5 | 47.5 | 0.0 |
| 48.0 | 48.0 | 0.0 |
| 48.5 | 48.5 | 0.0 |
| 49.0 | 49.0 | 0.0 |
| 49.5 | 49.5 | 0.0 |
| 50.0 | 50.0 | 0.0 |
| 50.5 | 50.4 | -0.1 |
| 51.0 | 50.9 | -0.1 |
| 51.5 | 51.4 | -0.1 |
| 52.0 | 51.9 | -0.1 |
| 52.5 | 52.5 | 0.0 |
| 53.0 | 53.0 | 0.0 |
| 53.5 | 53.5 | 0.0 |
| 54.0 | 54.0 | 0.0 |
| 54.5 | 54.5 | 0.0 |
| 55.0 | 55.0 | 0.0 |
| 55.5 | 55.6 | 0.1 |
| 56.0 | 56.1 | 0.1 |
| 56.5 | 56.6 | 0.1 |
| 57.0 | 57.1 | 0.1 |
| 57.5 | 57.6 | 0.1 |
| 58.0 | 58.1 | 0.1 |
| 58.5 | 58.6 | 0.1 |

| Levl dBSPL | Meas dBSPL | Err dB |
|---|---|---|
| 59.0 | 59.1 | 0.1 |
| 59.5 | 59.6 | 0.1 |
| 60.0 | 60.1 | 0.1 |
| 60.5 | 60.6 | 0.1 |
| 61.0 | 61.1 | 0.1 |
| 61.5 | 61.5 | 0.0 |
| 62.0 | 62.0 | 0.0 |
| 62.5 | 62.5 | 0.0 |
| 63.0 | 63.0 | 0.0 |
| 63.5 | 63.5 | 0.0 |
| 64.0 | 64.0 | 0.0 |
| 64.5 | 64.5 | 0.0 |
| 65.0 | 64.9 | -0.1 |
| 65.5 | 65.5 | 0.0 |
| 66.0 | 66.0 | 0.0 |
| 66.5 | 66.5 | 0.0 |
| 67.0 | 67.0 | 0.0 |
| 67.5 | 67.5 | 0.0 |
| 68.0 | 68.0 | 0.0 |
| 68.5 | 68.5 | 0.0 |
| 69.0 | 69.1 | 0.1 |
| 69.5 | 69.6 | 0.1 |
| 70.0 | 70.1 | 0.1 |
| 70.5 | 70.6 | 0.1 |
| 71.0 | 71.1 | 0.1 |
| 71.5 | 71.6 | 0.1 |
| 72.0 | 72.1 | 0.1 |
| 72.5 | 72.6 | 0.1 |
| 73.0 | 73.1 | 0.1 |
| 73.5 | 73.6 | 0.1 |
| 74.0 | 74.1 | 0.1 |
| 74.5 | 74.6 | 0.1 |
| 75.0 | 75.1 | 0.1 |
| 75.5 | 75.6 | 0.1 |
| 76.0 | 76.0 | 0.0 |
| 76.5 | 76.5 | 0.0 |
| 77.0 | 77.0 | 0.0 |
| 77.5 | 77.5 | 0.0 |
| 78.0 | 77.9 | -0.1 |
| 78.5 | 78.4 | -0.1 |
| 79.0 | 78.9 | -0.1 |

| Levl dBSPL | Meas dBSPL | Err dB |
|---|---|---|
| 79.5 | 79.4 | -0.1 |
| 80.0 | 79.9 | -0.1 |
| 80.5 | 80.4 | -0.1 |
| 81.0 | 80.9 | -0.1 |
| 81.5 | 81.4 | -0.1 |
| 82.0 | 82.0 | 0.0 |
| 82.5 | 82.5 | 0.0 |
| 83.0 | 83.0 | 0.0 |
| 83.5 | 83.5 | 0.0 |
| 84.0 | 84.1 | 0.1 |
| 84.5 | 84.6 | 0.1 |
| 85.0 | 85.1 | 0.1 |
| 85.5 | 85.6 | 0.1 |
| 86.0 | 86.1 | 0.1 |
| 86.5 | 86.6 | 0.1 |
| 87.0 | 87.1 | 0.1 |
| 87.5 | 87.6 | 0.1 |
| 88.0 | 88.1 | 0.1 |
| 88.5 | 88.6 | 0.1 |
| 89.0 | 89.0 | 0.0 |
| 89.5 | 89.5 | 0.0 |
| 90.0 | 90.0 | 0.0 |
| 90.5 | 90.5 | 0.0 |
| 91.0 | 91.0 | 0.0 |
| 91.5 | 91.4 | -0.1 |
| 92.0 | 91.9 | -0.1 |
| 92.5 | 92.4 | -0.1 |
| 93.0 | 92.9 | -0.1 |
| 93.5 | 93.4 | -0.1 |
| 94.0 | 93.9 | -0.1 |
| 94.5 | 94.4 | -0.1 |
| 95.0 | 94.9 | -0.1 |
| 95.5 | 95.4 | -0.1 |
| 96.0 | 95.9 | -0.1 |
| 96.5 | 96.5 | 0.0 |
| 97.0 | 97.0 | 0.0 |
| 97.5 | 97.5 | 0.0 |
| 98.0 | 98.0 | 0.0 |
| 98.5 | 98.5 | 0.0 |
| 99.0 | 99.1 | 0.1 |
| 99.5 | 99.6 | 0.1 |

| Levl dBSPL | Meas dBSPL | Err dB |
|---|---|---|
| 100.0 | 100.1 | 0.1 |
| 100.5 | 100.6 | 0.1 |
| 101.0 | 101.1 | 0.1 |
| 101.5 | 101.6 | 0.1 |
| 102.0 | 102.1 | 0.1 |
| 102.5 | 102.5 | 0.0 |
| 103.0 | 103.0 | 0.0 |
| 103.5 | 103.5 | 0.0 |
| 104.0 | 104.0 | 0.0 |
| 104.5 | 104.5 | 0.0 |
| 105.0 | 104.9 | -0.1 |
| 105.5 | 105.4 | -0.1 |
| 106.0 | 105.9 | -0.1 |
| 106.5 | 106.4 | -0.1 |
| 107.0 | 106.9 | -0.1 |
| 107.5 | 107.4 | -0.1 |
| 108.0 | 107.9 | -0.1 |
| 108.5 | 108.4 | -0.1 |
| 109.0 | 108.9 | -0.1 |
| 109.5 | 109.4 | -0.1 |
| 110.0 | 110.0 | 0.0 |
| 110.5 | 110.5 | 0.0 |
| 111.0 | 111.0 | 0.0 |
| 111.5 | 111.5 | 0.0 |
| 112.0 | 112.1 | 0.1 |
| 112.5 | 112.6 | 0.1 |
| 113.0 | 113.1 | 0.1 |
| 113.5 | 113.6 | 0.1 |
| 114.0 | 114.1 | 0.1 |
| 114.5 | 114.6 | 0.1 |
| 115.0 | 115.1 | 0.1 |
| 115.5 | 115.6 | 0.1 |
| 116.0 | 116.1 | 0.1 |
| 116.5 | 116.6 | 0.1 |
| 117.0 | 117.1 | 0.1 |
| 117.5 | 117.6 | 0.1 |
| 118.0 | 118.1 | 0.1 |
| 118.5 | 118.6 | 0.1 |
| 119.0 | 119.0 | 0.0 |
| 119.5 | 119.5 | 0.0 |
| 120.0 | 120.0 | 0.0 |

| Levl dBSPL | Meas dBSPL | Err dB |
|---|---|---|
| 120.5 | 120.5 | 0.0 |
| 121.0 | 121.0 | 0.0 |
| 121.5 | 121.5 | 0.0 |
| 122.0 | 122.0 | 0.0 |
| 122.5 | 122.5 | 0.0 |
| 123.0 | 123.0 | 0.0 |
| 123.5 | 123.5 | 0.0 |
| 124.0 | 124.1 | 0.1 |
| 124.5 | 124.6 | 0.1 |
| 125.0 | 125.1 | 0.1 |
| 125.5 | 125.6 | 0.1 |
| 126.0 | 126.1 | 0.1 |
| 126.5 | 126.8 | 0.3 |
| 127.0 | 127.3 | 0.3 |
| 127.5 | 127.8 | 0.3 |
| 128.0 | 128.3 | 0.3 |
| 128.5 | 128.8 | 0.3 |
| 129.0 | 129.3 | 0.3 |
| **129.5** | **129.8** | **0.3** |
| **130.0** | **130.2** | **0.2** |
| **130.5** | **130.6** | **0.1** |
| **131.0** | **131.1** | **0.1** |
| **131.5** | **131.5** | **0.0** |
| **132.0** | **131.8** | **-0.2** |
| **132.5** | **132.1** | **-0.4** |
| **133.0** | **132.4** | **-0.6** |
| **133.5** | **132.6** | **-0.9** |
| **134.0** | **132.8** | **-1.2** |
| **134.5** | **132.9** | **-1.6** |
| **135.0** | **132.9** | **-2.1** |
| **135.5** | **132.9** | **-2.6** |
| **136.0** | **132.9** | **-3.1** |
| **136.5** | **132.8** | **-3.7** |
| **137.0** | **132.8** | **-4.2** |
| **137.5** | **132.8** | **-4.7** |
| **138.0** | **132.9** | **-5.1** |

Plotted per typical sensitivity of a 2541 microphone; 44.5 mV/Pa & 17.1 pF.

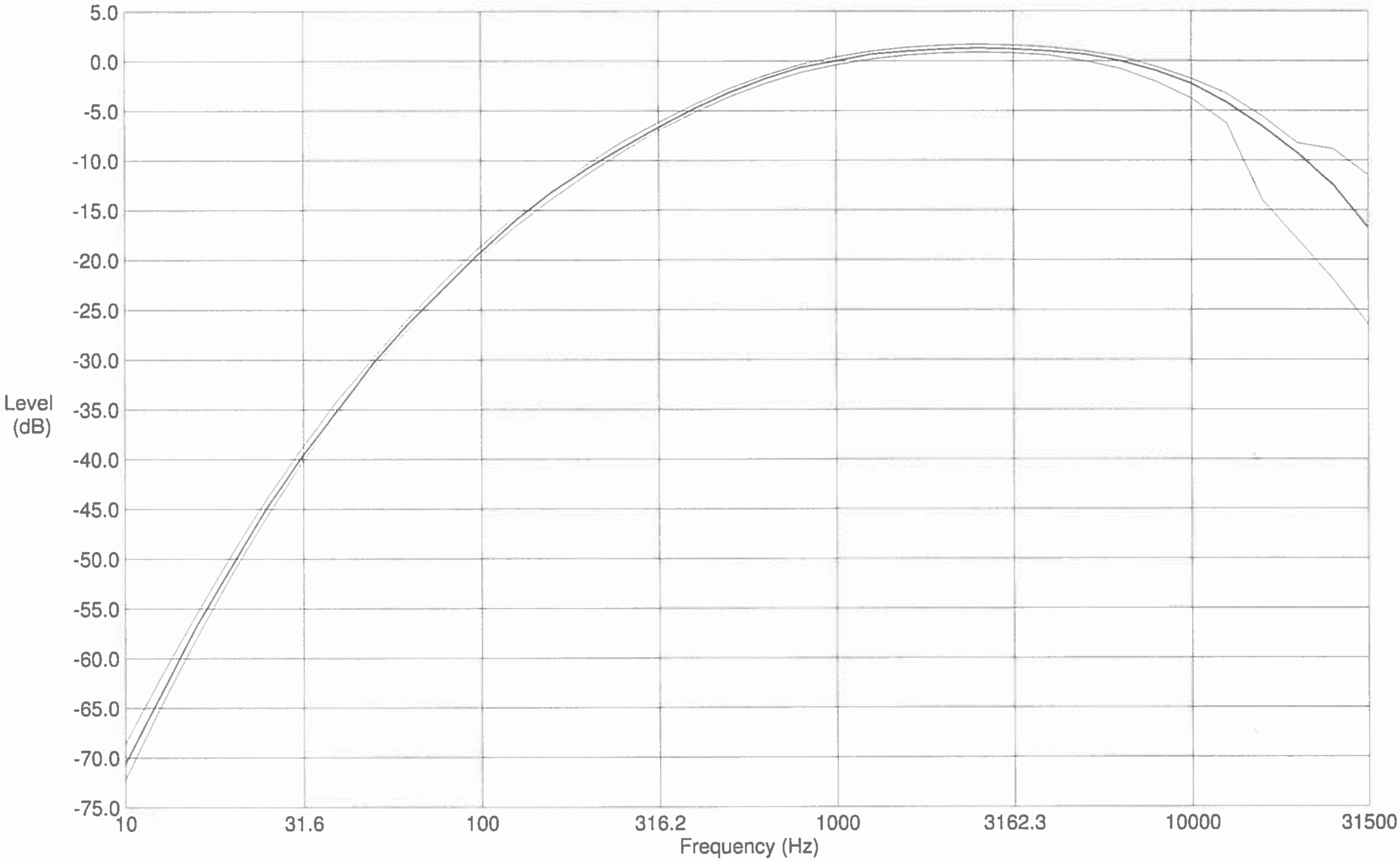
Overload occurs at 129.5 dBSPL.
Primary indicator range: 105.4 dB (lower limit: 24.0 dBSPL to upper limit: 129.4 dBSPL).
Dynamic range: 111.6 dB (noise floor: 17.8 dBSPL to upper limit: 129.4 dBSPL).

This instrument is in compliance with IEC 60651 (2001-10) 7.9 and 7.10, ANSI S1.4-1983 3.2 and IEC 60804 (2001-10) 9.2.1 for Type 1 sound level meters when used with a Larson Davis Type 1 microphone.

Technician: Sean Childs     Test Date: 14DEC2017

# Sound Level Meter Model: 820A Serial Number: A1518
# Certificate of A-Weight Electrical Conformance

This Type 1 Sound Level Meter (including attached PRM828 preamplifier and ADP005 18 pF input adapter) was calibrated with a reference 1kHz sine wave at a level of 114.0 dBSPL. The instrument's A-weighted response was then electrically tested using a 1.9 Vrms sinewave at exact frequencies as specified in IEC 60651 (2001-10) and ANSI S1.4-1983.




| Freq (Hz) | Theor | Measured | Error | Tolerance |
|---|---|---|---|---|
| 10.00 | -70.4 | -70.60 | -0.20 | +1.8, -1.8 |
| 12.59 | -63.4 | -63.70 | -0.30 | +1.5, -1.5 |
| 15.85 | -56.7 | -56.70 | 0.00 | +1.2, -1.2 |
| 19.95 | -50.5 | -50.70 | -0.20 | +1.0, -1.0 |
| 25.12 | -44.7 | -44.70 | 0.00 | +0.9, -0.9 |
| 31.62 | -39.4 | -39.60 | -0.20 | +0.7, -0.7 |
| 39.81 | -34.6 | -34.90 | -0.30 | +0.7, -0.7 |
| 50.12 | -30.2 | -30.20 | 0.00 | +0.5, -0.5 |
| 63.10 | -26.2 | -26.20 | 0.00 | +0.5, -0.5 |
| 79.43 | -22.5 | -22.70 | -0.20 | +0.5, -0.5 |
| 100.00 | -19.1 | -19.20 | -0.10 | +0.5, -0.5 |
| 125.89 | -16.1 | -16.00 | 0.10 | +0.5, -0.5 |
| 158.49 | -13.4 | -13.20 | 0.20 | +0.5, -0.5 |
| 199.53 | -10.9 | -10.80 | 0.10 | +0.5, -0.5 |
| 251.19 | -8.6 | -8.70 | -0.10 | +0.5, -0.5 |
| 316.23 | -6.6 | -6.70 | -0.10 | +0.4, -0.4 |
| 398.11 | -4.8 | -4.80 | 0.00 | +0.4, -0.4 |
| 501.19 | -3.2 | -3.20 | 0.00 | +0.4, -0.4 |

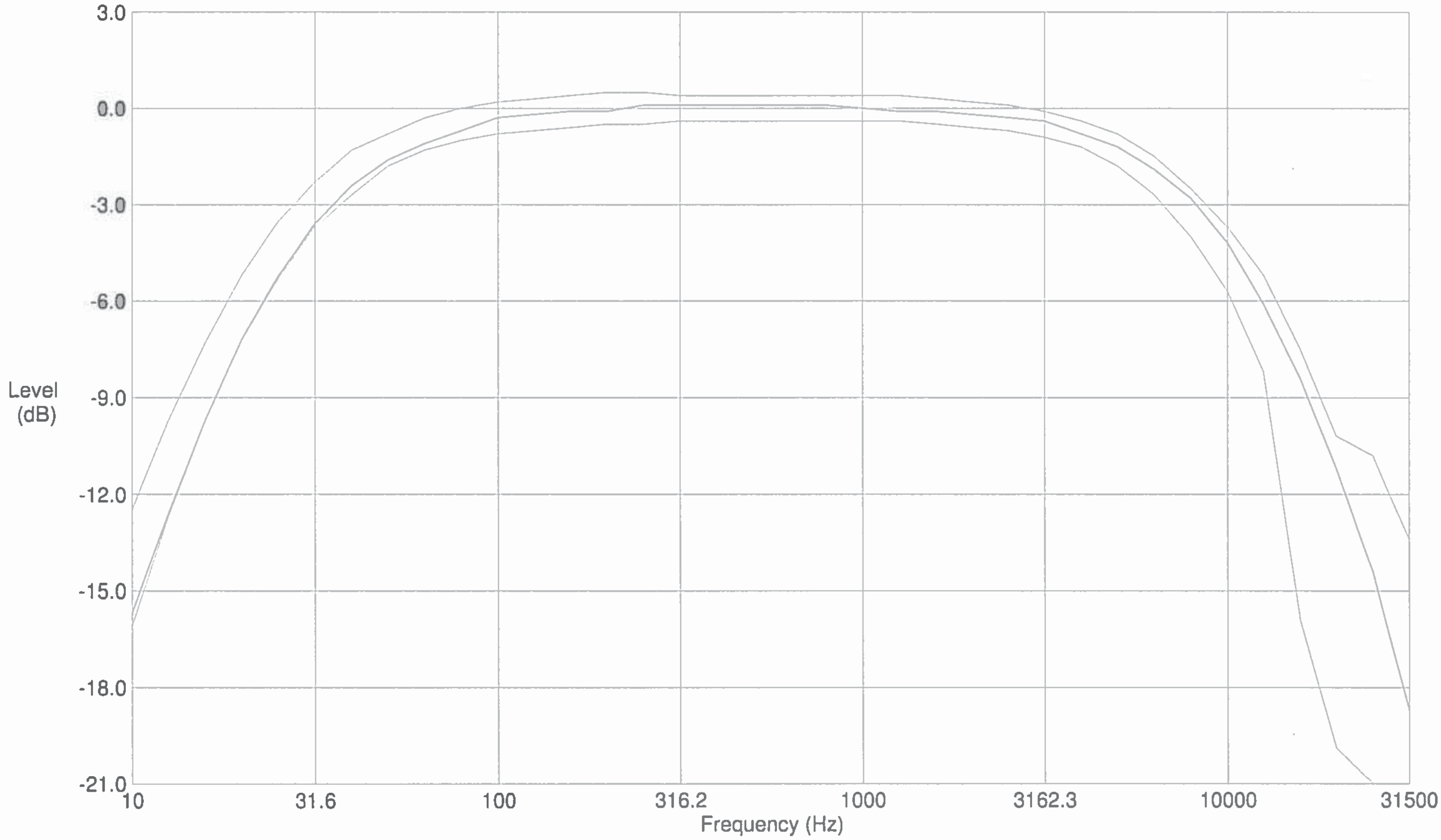
| Freq (Hz) | Theor | Measured | Error | Tolerance |
|---|---|---|---|---|
| 630.96 | -1.9 | -1.80 | 0.10 | +0.4, -0.4 |
| 794.33 | -0.8 | -0.70 | 0.10 | +0.4, -0.4 |
| 1000.00 | 0.0 | 0.00 | 0.00 | +0.4, -0.4 |
| 1258.90 | 0.6 | 0.70 | 0.10 | +0.4, -0.4 |
| 1584.90 | 1.0 | 1.00 | 0.00 | +0.4, -0.4 |
| 1995.30 | 1.2 | 1.20 | 0.00 | +0.4, -0.4 |
| 2511.90 | 1.3 | 1.30 | 0.00 | +0.4, -0.4 |
| 3162.30 | 1.2 | 1.20 | 0.00 | +0.4, -0.4 |
| 3981.10 | 1.0 | 1.00 | 0.00 | +0.4, -0.4 |
| 5011.90 | 0.5 | 0.70 | 0.20 | +0.5, -0.5 |
| 6309.60 | -0.1 | 0.00 | 0.10 | +0.5, -0.7 |
| 7943.30 | -1.1 | -1.00 | 0.10 | +0.5, -1.0 |
| 10000.00 | -2.5 | -2.30 | 0.20 | +0.7, -1.3 |
| 12589.00 | -4.3 | -4.20 | 0.10 | +1.0, -2.0 |
| 15849.00 | -6.6 | -6.60 | 0.00 | +1.0, -7.4 |
| 19953.00 | -9.3 | -9.30 | 0.00 | +1.0, -8.7 |
| 25119.00 | -12.4 | -12.50 | -0.10 | +3.5, -9.6 |
| 31623.00 | -15.8 | -16.80 | -1.00 | +4.3, -10.7 |

This instrument is in compliance with IEC 60651 (2001-10) 6.1 and 9.2.2, ANSI S1.4-1983 5.1 and 8.2.1, and IEC 60804 (2001-10) 5.1 for Type 1 sound level meters when used with a Larson Davis Type 1 microphone.

Technician: Sean Childs Test Date: 14DEC2017

# Sound Level Meter Model: 820A Serial Number: A1518
# Certificate of C-Weight Electrical Conformance

This Type 1 Sound Level Meter (including attached PRM828 preamplifier and ADP005 18 pF input adapter) was calibrated with a reference 1kHz sine wave at a level of 114.0 dBSPL. The instrument's C-weighted response was then electrically tested using a 1.9 Vrms sinewave at exact frequencies as specified in IEC 60651 (2001-10) and ANSI S1.4-1983.




| Freq (Hz) | Theor | Measured | Error | Tolerance |
|---|---|---|---|---|
| 10.00 | -14.3 | -15.70 | -1.40 | +1.8, -1.8 |
| 12.59 | -11.2 | -12.60 | -1.40 | +1.5, -1.5 |
| 15.85 | -8.5 | -9.70 | -1.20 | +1.2, -1.2 |
| 19.95 | -6.2 | -7.20 | -1.00 | +1.0, -1.0 |
| 25.12 | -4.4 | -5.20 | -0.80 | +0.9, -0.9 |
| 31.62 | -3.0 | -3.60 | -0.60 | +0.7, -0.7 |
| 39.81 | -2.0 | -2.40 | -0.40 | +0.7, -0.7 |
| 50.12 | -1.3 | -1.60 | -0.30 | +0.5, -0.5 |
| 63.10 | -0.8 | -1.10 | -0.30 | +0.5, -0.5 |
| 79.43 | -0.5 | -0.70 | -0.20 | +0.5, -0.5 |
| 100.00 | -0.3 | -0.30 | 0.00 | +0.5, -0.5 |
| 125.89 | -0.2 | -0.20 | 0.00 | +0.5, -0.5 |
| 158.49 | -0.1 | -0.10 | 0.00 | +0.5, -0.5 |
| 199.53 | 0.0 | -0.10 | -0.10 | +0.5, -0.5 |
| 251.19 | 0.0 | 0.10 | 0.10 | +0.5, -0.5 |
| 316.23 | 0.0 | 0.10 | 0.10 | +0.4, -0.4 |
| 398.11 | 0.0 | 0.10 | 0.10 | +0.4, -0.4 |
| 501.19 | 0.0 | 0.10 | 0.10 | +0.4, -0.4 |

| Freq (Hz) | Theor | Measured | Error | Tolerance |
|---|---|---|---|---|
| 630.96 | 0.0 | 0.10 | 0.10 | +0.4, -0.4 |
| 794.33 | 0.0 | 0.10 | 0.10 | +0.4, -0.4 |
| 1000.00 | 0.0 | 0.00 | 0.00 | +0.4, -0.4 |
| 1258.90 | 0.0 | -0.10 | -0.10 | +0.4, -0.4 |
| 1584.90 | -0.1 | -0.10 | 0.00 | +0.4, -0.4 |
| 1995.30 | -0.2 | -0.20 | 0.00 | +0.4, -0.4 |
| 2511.90 | -0.3 | -0.30 | 0.00 | +0.4, -0.4 |
| 3162.30 | -0.5 | -0.40 | 0.10 | +0.4, -0.4 |
| 3981.10 | -0.8 | -0.80 | 0.00 | +0.4, -0.4 |
| 5011.90 | -1.3 | -1.20 | 0.10 | +0.5, -0.5 |
| 6309.60 | -2.0 | -1.90 | 0.10 | +0.5, -0.7 |
| 7943.30 | -3.0 | -2.80 | 0.20 | +0.5, -1.0 |
| 10000.00 | -4.4 | -4.20 | 0.20 | +0.7, -1.3 |
| 12589.00 | -6.2 | -6.10 | 0.10 | +1.0, -2.0 |
| 15849.00 | -8.5 | -8.40 | 0.10 | +1.0, -7.4 |
| 19953.00 | -11.2 | -11.20 | 0.00 | +1.0, -8.7 |
| 25119.00 | -14.3 | -14.40 | -0.10 | +3.5, -9.6 |
| 31623.00 | -17.7 | -18.70 | -1.00 | +4.3, -10.7 |

This instrument is in compliance with IEC 60651 (2001-10) 6.1 and 9.2.2, ANSI S1.4-1983 5.1 and 8.2.1, and IEC 60804 (2001-10) 5.1 for Type 1 sound level meters when used with a Larson Davis Type 1 microphone.

Technician: Sean Childs     Test Date: 14DEC2017

# Calibration Certificate

***Certificate Number 2017013075***

***Customer:***

**Widener & Associates**
**1902 120th Place SouthEast**
**Suite 202**
**Everett, WA 98208, United States**

| | | | | | | |
|---|---|---|---|---|---|---|
| ***Model Number*** | CAL200 | ***Procedure Number*** | D0001.8386 | | |
| ***Serial Number*** | 4920 | ***Technician*** | Scott Montgomery | | |
| ***Test Results*** | **Pass** | ***Calibration Date*** | 14 Dec 2017 | | |
| ***Initial Condition*** | Adjusted | ***Calibration Due*** | 14 Dec 2018 | | |
| | | ***Temperature*** | 23 | °C | ± 0.3 °C |
| ***Description*** | Larson Davis CAL200 Acoustic Calibrator | ***Humidity*** | 34 | %RH | ± 3 %RH |
| | | ***Static Pressure*** | 101.3 | kPa | ± 1 kPa |

***Evaluation Method*** The data is aquired by the insert voltage calibration method using the reference microphone's open circuit sensitivity. Data reported in dB re 20 μPa.

***Compliance Standards*** Compliant to Manufacturer Specifications per D0001.8190 and the following standards:
IEC 60942:2003 ANSI S1.40-2006

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

The quality system is registered to ISO 9001:2008.

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

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

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**Standards Used**

| Description | Cal Date | Cal Due | Cal Standard |
|---|---|---|---|
| Agilent 34401A DMM | 09/06/2017 | 09/06/2018 | 001021 |
| Larson Davis Model 2900 Real Time Analyzer | 04/10/2017 | 04/10/2018 | 001051 |
| Microphone Calibration System | 08/08/2017 | 08/08/2018 | 005446 |
| 1/2" Preamplifier | 10/05/2017 | 10/05/2018 | 006506 |
| Larson Davis 1/2" Preamplifier 7-pin LEMO | 08/08/2017 | 08/08/2018 | 006507 |
| 1/2 inch Microphone - RI - 200V | 04/24/2017 | 04/24/2018 | 006510 |
| Pressure Transducer | 06/01/2017 | 06/01/2018 | 007310 |

## Output Level

| Nominal Level [dB] | Pressure [kPa] | Test Result [dB] | Lower limit [dB] | Upper limit [dB] | Expanded Uncertainty [dB] | Result |
|---|---|---|---|---|---|---|
| 114 | 100.9 | 114.00 | 113.80 | 114.20 | 0.13 | Pass |
| 94 | 101.3 | 94.02 | 93.80 | 94.20 | 0.14 | Pass |

-- End of measurement results--

## Frequency

| Nominal Level [dB] | Pressure [kPa] | Test Result [Hz] | Lower limit [Hz] | Upper limit [Hz] | Expanded Uncertainty [Hz] | Result |
|---|---|---|---|---|---|---|
| 94 | 101.3 | 1,000.16 | 990.00 | 1,010.00 | 0.20 | Pass |
| 114 | 100.9 | 1,000.14 | 990.00 | 1,010.00 | 0.20 | Pass |

-- End of measurement results--

## Total Harmonic Distortion + Noise (THD+N)

| Nominal Level [dB] | Pressure [kPa] | Test Result [%] | Lower limit [%] | Upper limit [%] | Expanded Uncertainty [%] | Result |
|---|---|---|---|---|---|---|
| 94 | 101.3 | 0.52 | 0.00 | 2.00 | 0.25 | Pass |
| 114 | 100.9 | 0.53 | 0.00 | 2.00 | 0.25 | Pass |

-- End of measurement results--

## Level Change Over Pressure

Tested at: 114 dB, 22 °C, 35 %RH

| Nominal Pressure [kPa] | Pressure [kPa] | Test Result [dB] | Lower limit [dB] | Upper limit [dB] | Expanded Uncertainty [dB] | Result |
|---|---|---|---|---|---|---|
| 101.3 | 101.0 | 0.00 | -0.30 | 0.30 | 0.04 ‡ | Pass |
| 108.0 | 107.6 | 0.02 | -0.30 | 0.30 | 0.04 ‡ | Pass |
| 92.0 | 92.0 | -0.03 | -0.30 | 0.30 | 0.04 ‡ | Pass |
| 83.0 | 82.9 | -0.05 | -0.30 | 0.30 | 0.04 ‡ | Pass |
| 74.0 | 74.1 | -0.05 | -0.30 | 0.30 | 0.04 ‡ | Pass |
| 65.0 | 65.0 | -0.02 | -0.30 | 0.30 | 0.04 ‡ | Pass |

-- End of measurement results--

## Frequency Change Over Pressure

Tested at: 114 dB, 22 °C, 35 %RH

| Nominal Pressure [kPa] | Pressure [kPa] | Test Result [Hz] | Lower limit [Hz] | Upper limit [Hz] | Expanded Uncertainty [Hz] | Result |
|---|---|---|---|---|---|---|
| 101.3 | 101.0 | 0.00 | -10.00 | 10.00 | 0.20 ‡ | Pass |
| 92.0 | 92.0 | 0.00 | -10.00 | 10.00 | 0.20 ‡ | Pass |
| 108.0 | 107.6 | 0.01 | -10.00 | 10.00 | 0.20 ‡ | Pass |
| 83.0 | 82.9 | 0.00 | -10.00 | 10.00 | 0.20 ‡ | Pass |
| 74.0 | 74.1 | -0.01 | -10.00 | 10.00 | 0.20 ‡ | Pass |
| 65.0 | 65.0 | -0.01 | -10.00 | 10.00 | 0.20 ‡ | Pass |

-- End of measurement results--

## Total Harmonic Distortion + Noise (THD+N) Over Pressure

Tested at: 114 dB, 22 °C, 35 %RH

| Nominal Pressure [kPa] | Pressure [kPa] | Test Result [%] | Lower limit [%] | Upper limit [%] | Expanded Uncertainty [%] | Result |
|---|---|---|---|---|---|---|
| 74.0 | 74.1 | 0.50 | 0.00 | 2.00 | 0.25 ‡ | Pass |
| 65.0 | 65.0 | 0.50 | 0.00 | 2.00 | 0.25 ‡ | Pass |
| 108.0 | 107.6 | 0.54 | 0.00 | 2.00 | 0.25 ‡ | Pass |
| 101.3 | 101.0 | 0.53 | 0.00 | 2.00 | 0.25 ‡ | Pass |
| 92.0 | 92.0 | 0.52 | 0.00 | 2.00 | 0.25 ‡ | Pass |
| 83.0 | 82.9 | 0.51 | 0.00 | 2.00 | 0.25 ‡ | Pass |

-- End of measurement results--

Signatory: *Scott Montgomery*

# Initial Assessment

***Certificate Number 2017013074***

***Customer:***
**Widener & Associates**
**1902 120th Place SouthEast**
**Suite 202**
**Everett, WA 98208, United States**

| | | | | | |
|---|---|---|---|---|---|
| ***Model Number*** | CAL200 | ***Procedure Number*** | D0001.8386 | | |
| ***Serial Number*** | 4920 | ***Technician*** | Scott Montgomery | | |
| ***Test Results*** | **Pass** | ***Calibration Date*** | 14 Dec 2017 | | |
| ***Initial Condition*** | As Received | ***Calibration Due*** | 14 Dec 2018 | | |
| | | ***Temperature*** | 22 | °C | ± 0.3 °C |
| ***Description*** | Larson Davis CAL200 Acoustic Calibrator | ***Humidity*** | 32 | %RH | ± 3 %RH |
| | | ***Static Pressure*** | 101.0 | kPa | ± 1 kPa |

***Evaluation Method*** The data is aquired by the insert voltage calibration method using the reference microphone's open circuit sensitivity. Data reported in dB re 20 μPa.

***Compliance Standards*** Compliant to Manufacturer Specifications per D0001.8190 and the following standards:
IEC 60942:2003 ANSI S1.40-2006

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

The quality system is registered to ISO 9001:2008.

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

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



**Standards Used**

| Description | Cal Date | Cal Due | Cal Standard |
|---|---|---|---|
| Agilent 34401A DMM | 09/06/2017 | 09/06/2018 | 001021 |
| Larson Davis Model 2900 Real Time Analyzer | 04/10/2017 | 04/10/2018 | 001051 |
| Microphone Calibration System | 08/08/2017 | 08/08/2018 | 005446 |
| 1/2" Preamplifier | 10/05/2017 | 10/05/2018 | 006506 |
| Larson Davis 1/2" Preamplifier 7-pin LEMO | 08/08/2017 | 08/08/2018 | 006507 |
| 1/2 inch Microphone - RI - 200V | 04/24/2017 | 04/24/2018 | 006510 |
| Pressure Transducer | 06/01/2017 | 06/01/2018 | 007310 |

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1681 West 820 North
Provo, UT 84601, United States
716-684-0001

ilac-MRA ACCREDITED Cert #3622.01

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## Output Level

| Nominal Level [dB] | Pressure [kPa] | Test Result [dB] | Lower limit [dB] | Upper limit [dB] | Expanded Uncertainty [dB] | Result |
|---|---|---|---|---|---|---|
| 94 | 101.0 | 94.14 | 93.80 | 94.20 | 0.14 | Pass |
| 114 | 101.4 | 114.12 | 113.80 | 114.20 | 0.13 | Pass |

-- End of measurement results--

## Frequency

| Nominal Level [dB] | Pressure [kPa] | Test Result [Hz] | Lower limit [Hz] | Upper limit [Hz] | Expanded Uncertainty [Hz] | Result |
|---|---|---|---|---|---|---|
| 94 | 101.0 | 1,000.16 | 990.00 | 1,010.00 | 0.20 | Pass |
| 114 | 101.4 | 1,000.13 | 990.00 | 1,010.00 | 0.20 | Pass |

-- End of measurement results--

## Total Harmonic Distortion + Noise (THD+N)

| Nominal Level [dB] | Pressure [kPa] | Test Result [%] | Lower limit [%] | Upper limit [%] | Expanded Uncertainty [%] | Result |
|---|---|---|---|---|---|---|
| 94 | 101.0 | 0.52 | 0.00 | 2.00 | 0.25 | Pass |
| 114 | 101.4 | 0.54 | 0.00 | 2.00 | 0.25 | Pass |

-- End of measurement results--

## Level Change Over Pressure

Tested at: 114 dB, 22 °C, 35 %RH

| Nominal Pressure [kPa] | Pressure [kPa] | Test Result [dB] | Lower limit [dB] | Upper limit [dB] | Expanded Uncertainty [dB] | Result |
|---|---|---|---|---|---|---|
| 101.3 | 101.0 | 0.00 | -0.30 | 0.30 | 0.04 ‡ | Pass |
| 108.0 | 107.6 | 0.02 | -0.30 | 0.30 | 0.04 ‡ | Pass |
| 92.0 | 92.0 | -0.03 | -0.30 | 0.30 | 0.04 ‡ | Pass |
| 83.0 | 82.9 | -0.05 | -0.30 | 0.30 | 0.04 ‡ | Pass |
| 74.0 | 74.1 | -0.05 | -0.30 | 0.30 | 0.04 ‡ | Pass |
| 65.0 | 65.0 | -0.02 | -0.30 | 0.30 | 0.04 ‡ | Pass |

-- End of measurement results--

## Frequency Change Over Pressure

Tested at: 114 dB, 22 °C, 35 %RH

| Nominal Pressure [kPa] | Pressure [kPa] | Test Result [Hz] | Lower limit [Hz] | Upper limit [Hz] | Expanded Uncertainty [Hz] | Result |
|---|---|---|---|---|---|---|
| 101.3 | 101.0 | 0.00 | -10.00 | 10.00 | 0.20 ‡ | Pass |
| 92.0 | 92.0 | 0.00 | -10.00 | 10.00 | 0.20 ‡ | Pass |
| 108.0 | 107.6 | 0.01 | -10.00 | 10.00 | 0.20 ‡ | Pass |
| 83.0 | 82.9 | 0.00 | -10.00 | 10.00 | 0.20 ‡ | Pass |
| 74.0 | 74.1 | -0.01 | -10.00 | 10.00 | 0.20 ‡ | Pass |
| 65.0 | 65.0 | -0.01 | -10.00 | 10.00 | 0.20 ‡ | Pass |

-- End of measurement results--

## Total Harmonic Distortion + Noise (THD+N) Over Pressure

Tested at: 114 dB, 22 °C, 35 %RH

| Nominal Pressure [kPa] | Pressure [kPa] | Test Result [%] | Lower limit [%] | Upper limit [%] | Expanded Uncertainty [%] | Result |
|---|---|---|---|---|---|---|
| 74.0 | 74.1 | 0.50 | 0.00 | 2.00 | 0.25 ‡ | Pass |
| 65.0 | 65.0 | 0.50 | 0.00 | 2.00 | 0.25 ‡ | Pass |
| 108.0 | 107.6 | 0.54 | 0.00 | 2.00 | 0.25 ‡ | Pass |
| 101.3 | 101.0 | 0.53 | 0.00 | 2.00 | 0.25 ‡ | Pass |
| 92.0 | 92.0 | 0.52 | 0.00 | 2.00 | 0.25 ‡ | Pass |
| 83.0 | 82.9 | 0.51 | 0.00 | 2.00 | 0.25 ‡ | Pass |

-- End of measurement results--

Signatory: *Scott Montgomery*

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# Calibration Certificate

***Certificate Number 2017013350***

***Customer:***
Widener & Associates
1902 120th Place SouthEast
Suite 202
Everett, WA 98208, United States

| | | | | | |
|---|---|---|---|---|---|
| ***Model Number*** | 2560 | ***Procedure Number*** | D0001.8387 | | |
| ***Serial Number*** | 3513 | ***Technician*** | Abraham Ortega | | |
| ***Test Results*** | **Pass** | ***Calibration Date*** | 20 Dec 2017 | | |
| ***Initial Condition*** | As Manufactured | ***Calibration Due*** | 20 Dec 2018 | | |
| | | ***Temperature*** | 23.9 | °C | ± 0.01 °C |
| ***Description*** | 1/2 inch Microphone - RI - 200V | ***Humidity*** | 34.3 | %RH | ± 0.5 %RH |
| | | ***Static Pressure*** | 101.53 | kPa | ± 0.03 kPa |

***Evaluation Method*** Tested electrically using an electrostatic actuator.

***Compliance Standards*** Compliant to Manufacturer Specifications.

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

The quality system is registered to ISO 9001:2008.

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

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

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**Standards Used**

| Description | Cal Date | Cal Due | Cal Standard |
|---|---|---|---|
| Larson Davis Model 2900 Real Time Analyzer | 07/17/2017 | 07/17/2018 | 001230 |
| Microphone Calibration System | 08/30/2017 | 08/30/2018 | 001233 |
| 1/2" Preamplifier | 12/14/2017 | 12/14/2018 | 001274 |
| Agilent 34401A DMM | 12/07/2017 | 12/07/2018 | 001329 |
| Larson Davis CAL250 Acoustic Calibrator | 01/04/2017 | 01/04/2018 | 003030 |
| 1/2" Preamplifier | 04/12/2017 | 04/12/2018 | 006506 |
| Larson Davis 1/2" Preamplifier 7-pin LEMO | 09/12/2017 | 09/12/2018 | 006507 |
| 1/2 inch Microphone - RI - 200V | 04/24/2017 | 04/24/2018 | 006510 |
| 1/2 inch Microphone - RI - 200V | 08/09/2017 | 08/09/2018 | 006519 |
| Larson Davis 1/2" Preamplifier 7-pin LEMO | 09/12/2017 | 09/12/2018 | 006530 |
| Larson Davis 1/2" Preamplifier 7-pin LEMO | 08/11/2017 | 08/11/2018 | 006531 |

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716-684-0001

ACCREDITED Cert #3622.01

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## Sensitivity

| Measurement | Test Result [mV/Pa] | Lower limit [mV/Pa] | Upper limit [mV/Pa] | Expanded Uncertainty [mV/Pa] | Result |
|---|---|---|---|---|---|
| Open Circuit Sensitivity | 47.83 | 39.81 | 51.29 | 1.00 | Pass |

-- End of measurement results--

## Capacitance

| Measurement | Test Result [pF] | |
|---|---|---|
| Capacitance | 21.00 | ‡ |

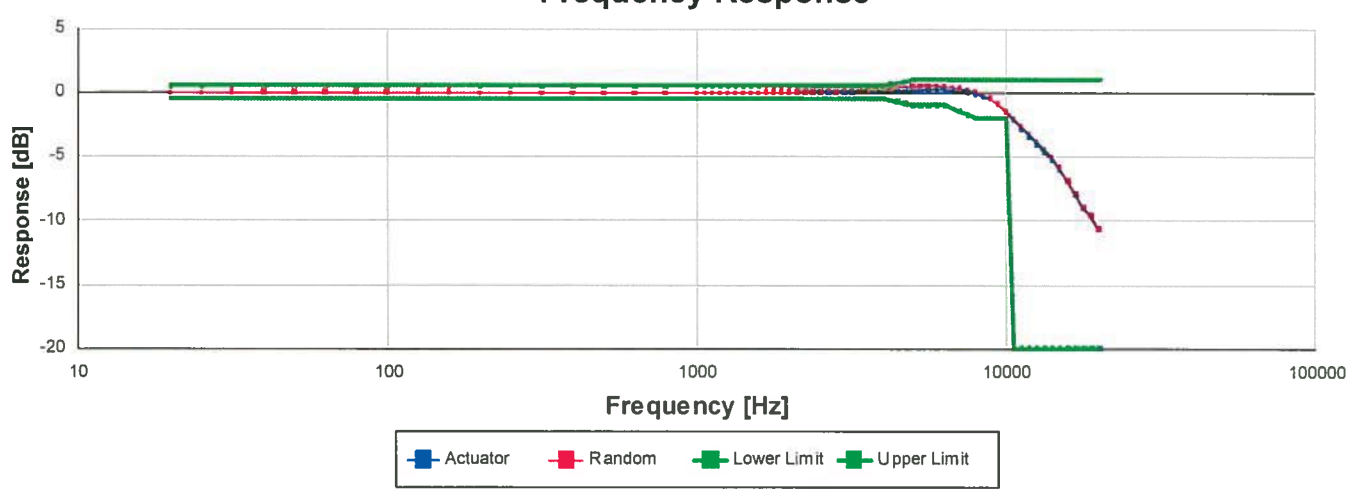
-- End of measurement results--

## Lower Limiting Frequency

| Measurement | Test Result [Hz] | Lower limit [Hz] | Upper limit [Hz] | Result |
|---|---|---|---|---|
| -3 dB Frequency | 1.21 | 1.00 | 2.00 | Pass ‡ |

-- End of measurement results--

## Frequency Response




Data is normalized for 0 dB @ 251.19 Hz.

| Frequency [Hz] | Actuator [dB] | Random [dB] | Lower limit [dB] | Upper limit [dB] | Result |
|---|---|---|---|---|---|
| 19.95 | -0.03 | -0.03 | -0.50 | 0.50 | Pass ‡ |
| 25.12 | 0.00 | 0.00 | -0.50 | 0.50 | Pass ‡ |
| 31.62 | 0.01 | 0.01 | -0.50 | 0.50 | Pass ‡ |
| 39.81 | 0.02 | 0.02 | -0.50 | 0.50 | Pass ‡ |
| 50.12 | 0.02 | 0.02 | -0.50 | 0.50 | Pass ‡ |
| 63.10 | 0.02 | 0.02 | -0.50 | 0.50 | Pass ‡ |
| 79.43 | 0.02 | 0.02 | -0.50 | 0.50 | Pass ‡ |
| 100.00 | 0.01 | 0.01 | -0.50 | 0.50 | Pass ‡ |
| 125.89 | 0.01 | 0.01 | -0.50 | 0.50 | Pass ‡ |
| 158.49 | 0.01 | 0.01 | -0.50 | 0.50 | Pass ‡ |
| 199.53 | 0.00 | 0.00 | -0.50 | 0.50 | Pass ‡ |

| Frequency [Hz] | Actuator [dB] | Random [dB] | Lower limit [dB] | Upper limit [dB] | Result |
|---|---|---|---|---|---|
| 251.19 | 0.00 | 0.00 | -0.50 | 0.50 | Pass ‡ |
| 316.23 | 0.00 | 0.00 | -0.50 | 0.50 | Pass ‡ |
| 398.11 | -0.01 | -0.01 | -0.50 | 0.50 | Pass ‡ |
| 501.19 | -0.01 | -0.01 | -0.50 | 0.50 | Pass ‡ |
| 630.96 | -0.01 | -0.01 | -0.50 | 0.50 | Pass ‡ |
| 794.33 | -0.02 | -0.02 | -0.50 | 0.50 | Pass ‡ |
| 1,000.00 | -0.01 | -0.01 | -0.50 | 0.50 | Pass ‡ |
| 1,059.25 | -0.01 | -0.01 | -0.50 | 0.50 | Pass ‡ |
| 1,122.02 | -0.01 | -0.01 | -0.50 | 0.50 | Pass ‡ |
| 1,188.50 | -0.01 | -0.01 | -0.50 | 0.50 | Pass ‡ |
| 1,258.93 | -0.01 | 0.00 | -0.50 | 0.50 | Pass ‡ |
| 1,333.52 | -0.01 | 0.00 | -0.50 | 0.50 | Pass ‡ |
| 1,412.54 | -0.01 | 0.00 | -0.50 | 0.50 | Pass ‡ |
| 1,496.24 | -0.01 | 0.00 | -0.50 | 0.50 | Pass ‡ |
| 1,584.89 | -0.01 | 0.00 | -0.50 | 0.50 | Pass ‡ |
| 1,678.80 | 0.00 | 0.01 | -0.50 | 0.50 | Pass ‡ |
| 1,778.28 | 0.01 | 0.02 | -0.50 | 0.50 | Pass ‡ |
| 1,883.65 | 0.01 | 0.02 | -0.50 | 0.50 | Pass ‡ |
| 1,995.26 | 0.01 | 0.02 | -0.50 | 0.50 | Pass ‡ |
| 2,113.49 | 0.02 | 0.04 | -0.50 | 0.50 | Pass ‡ |
| 2,238.72 | 0.03 | 0.05 | -0.50 | 0.50 | Pass ‡ |
| 2,371.37 | 0.04 | 0.06 | -0.50 | 0.50 | Pass ‡ |
| 2,511.89 | 0.05 | 0.08 | -0.50 | 0.50 | Pass ‡ |
| 2,660.73 | 0.07 | 0.11 | -0.50 | 0.50 | Pass ‡ |
| 2,818.38 | 0.03 | 0.08 | -0.50 | 0.50 | Pass ‡ |
| 2,985.38 | 0.05 | 0.12 | -0.50 | 0.50 | Pass ‡ |
| 3,162.28 | 0.07 | 0.15 | -0.50 | 0.50 | Pass ‡ |
| 3,349.65 | 0.09 | 0.19 | -0.50 | 0.50 | Pass ‡ |
| 3,548.13 | 0.10 | 0.22 | -0.50 | 0.50 | Pass ‡ |
| 3,758.37 | 0.11 | 0.25 | -0.50 | 0.50 | Pass ‡ |
| 3,981.07 | 0.13 | 0.29 | -0.50 | 0.50 | Pass ‡ |
| 4,216.97 | 0.15 | 0.34 | -0.63 | 0.63 | Pass ‡ |
| 4,466.84 | 0.16 | 0.39 | -0.75 | 0.75 | Pass ‡ |
| 4,731.51 | 0.18 | 0.45 | -0.88 | 0.88 | Pass ‡ |
| 5,011.87 | 0.19 | 0.49 | -1.00 | 1.00 | Pass ‡ |
| 5,308.84 | 0.21 | 0.52 | -1.00 | 1.00 | Pass ‡ |
| 5,623.41 | 0.22 | 0.53 | -1.00 | 1.00 | Pass ‡ |
| 5,956.62 | 0.22 | 0.51 | -1.00 | 1.00 | Pass ‡ |
| 6,309.57 | 0.21 | 0.46 | -1.00 | 1.00 | Pass ‡ |
| 6,683.44 | 0.19 | 0.40 | -1.25 | 1.00 | Pass ‡ |
| 7,079.46 | 0.13 | 0.31 | -1.50 | 1.00 | Pass ‡ |
| 7,498.94 | 0.06 | 0.20 | -1.75 | 1.00 | Pass ‡ |
| 7,943.28 | -0.07 | 0.03 | -2.00 | 1.00 | Pass ‡ |
| 8,413.95 | -0.26 | -0.17 | -2.00 | 1.00 | Pass ‡ |
| 8,912.51 | -0.51 | -0.44 | -2.00 | 1.00 | Pass ‡ |
| 9,440.61 | -0.95 | -0.89 | -2.00 | 1.00 | Pass ‡ |
| 10,000.00 | -1.51 | -1.43 | -2.00 | 1.00 | Pass ‡ |
| 10,592.54 | -2.07 | -1.98 | | 1.00 | Pass ‡ |
| 11,220.19 | -2.79 | -2.66 | | 1.00 | Pass ‡ |
| 11,885.02 | -3.39 | -3.22 | | 1.00 | Pass ‡ |
| 12,589.25 | -3.99 | -3.77 | | 1.00 | Pass ‡ |
| 13,335.21 | -4.63 | -4.37 | | 1.00 | Pass ‡ |
| 14,125.38 | -5.22 | -4.97 | | 1.00 | Pass ‡ |

| Frequency [Hz] | Actuator [dB] | Random [dB] | Lower limit [dB] | Upper limit [dB] | Result |
|---|---|---|---|---|---|
| 14,962.36 | -6.05 | -5.84 | | 1.00 | Pass ‡ |
| 15,848.93 | -6.97 | -6.81 | | 1.00 | Pass ‡ |
| 16,788.04 | -8.00 | -7.88 | | 1.00 | Pass ‡ |
| 17,782.80 | -9.03 | -8.92 | | 1.00 | Pass ‡ |
| 18,836.49 | -9.68 | -9.57 | | 1.00 | Pass ‡ |
| 19,952.62 | -10.70 | -10.62 | | 1.00 | Pass ‡ |

**-- End of measurement results--**

Signatory: *Abraham Ortega*

# Appendix B: Data Used in Model

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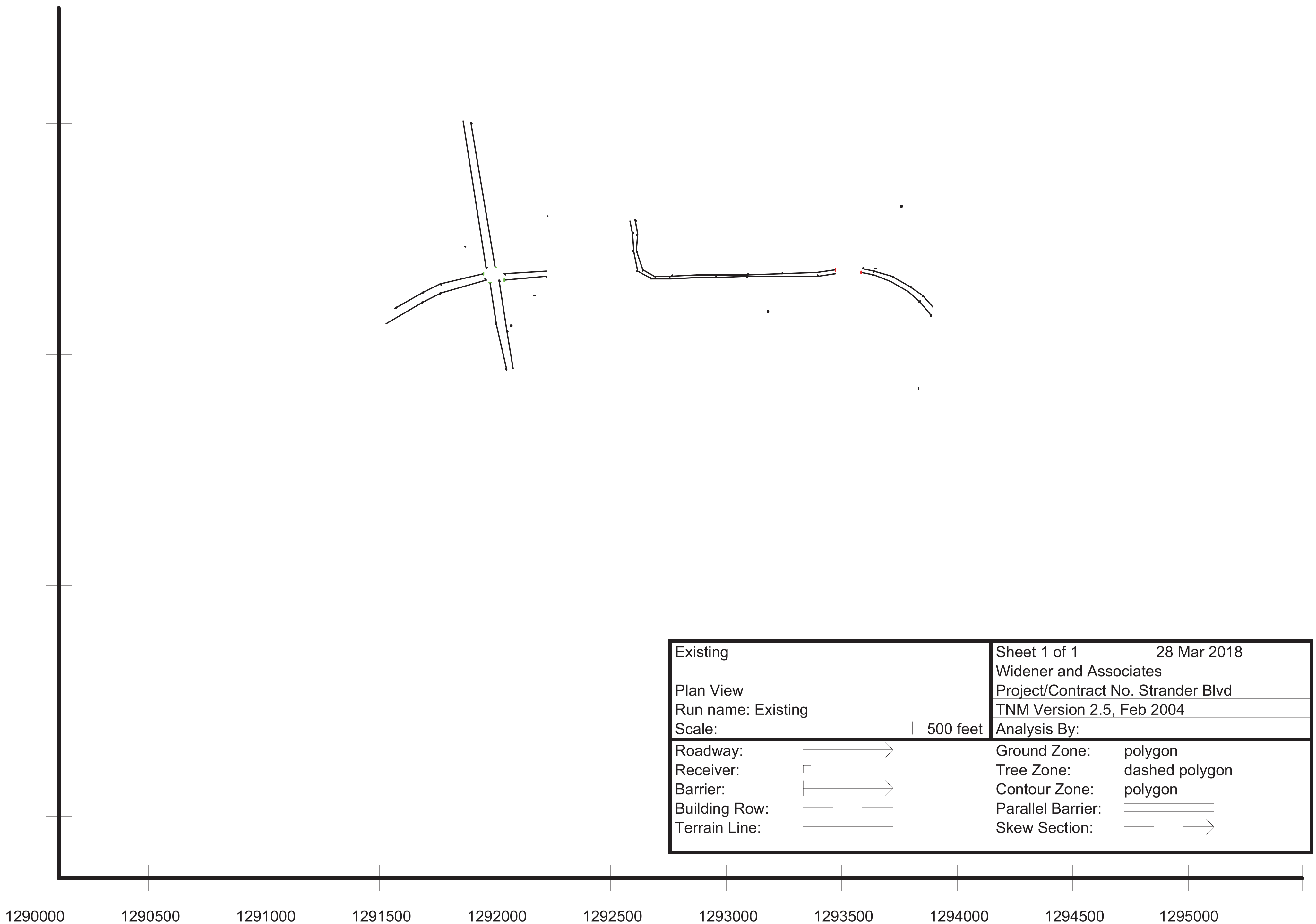
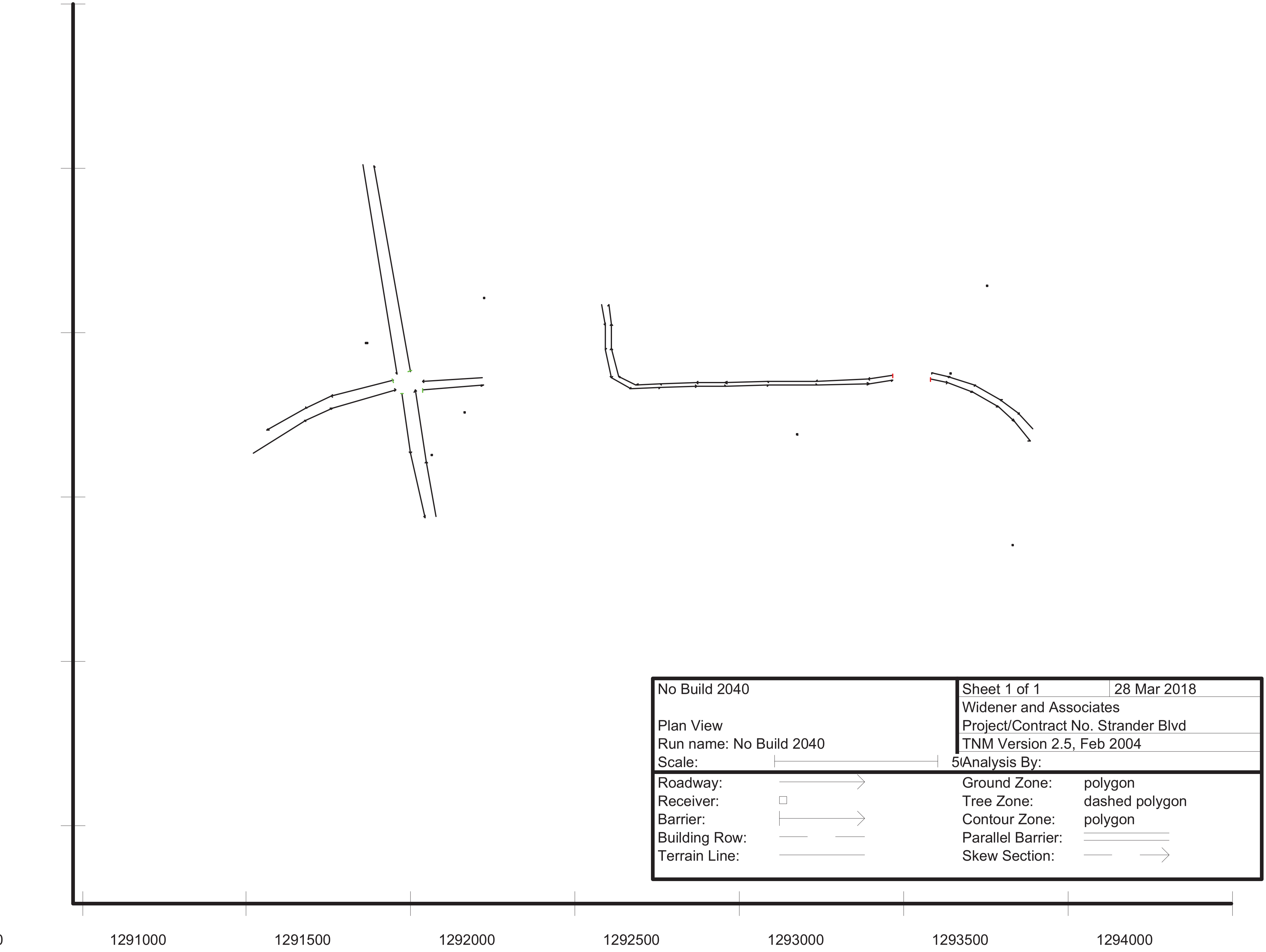



| | | | |
|---|---|---|---|
| Existing | | Sheet 1 of 1 | 28 Mar 2018 |
| | | Widener and Associates | |
| Plan View | | Project/Contract No. Strander Blvd | |
| Run name: Existing | | TNM Version 2.5, Feb 2004 | |
| Scale: | 500 feet | Analysis By: | |
| Roadway: | | Ground Zone: | polygon |
| Receiver: | | Tree Zone: | dashed polygon |
| Barrier: | | Contour Zone: | polygon |
| Building Row: | | Parallel Barrier: | |
| Terrain Line: | | Skew Section: | |

Existing Conditions

| | Total | Heavy Trucks | Med Trucks | Cars |
|---|---|---|---|---|
| 27th ST WB | 180 | 9 | 16 | 155 |
| 27th ST EB | 455 | 18 | 41 | 396 |
| | | 0 | 0 | 0 |
| Strander WB 3 | 315 | 16 | 28 | 271 |
| Strander EB 3 | 361 | 14 | 32 | 314 |
| | | | | |
| Strander WB 2 | 51 | 3 | 5 | 44 |
| Strander EB 2 | 61 | 2 | 5 | 53 |
| Strander WB 1 | 712 | 7 | 43 | 662 |
| Strander EB 1 | 697 | 77 | 42 | 579 |
| W Valley Hwy NB 1 | 1413 | 57 | 99 | 1258 |
| W Valley Hwy SB 1 | 1424 | 57 | 71 | 1296 |
| W Valley Hwy NB 2 | 1273 | 64 | 102 | 1108 |
| W Valley Hwy SB 2 | 1018 | 41 | 92 | 886 |

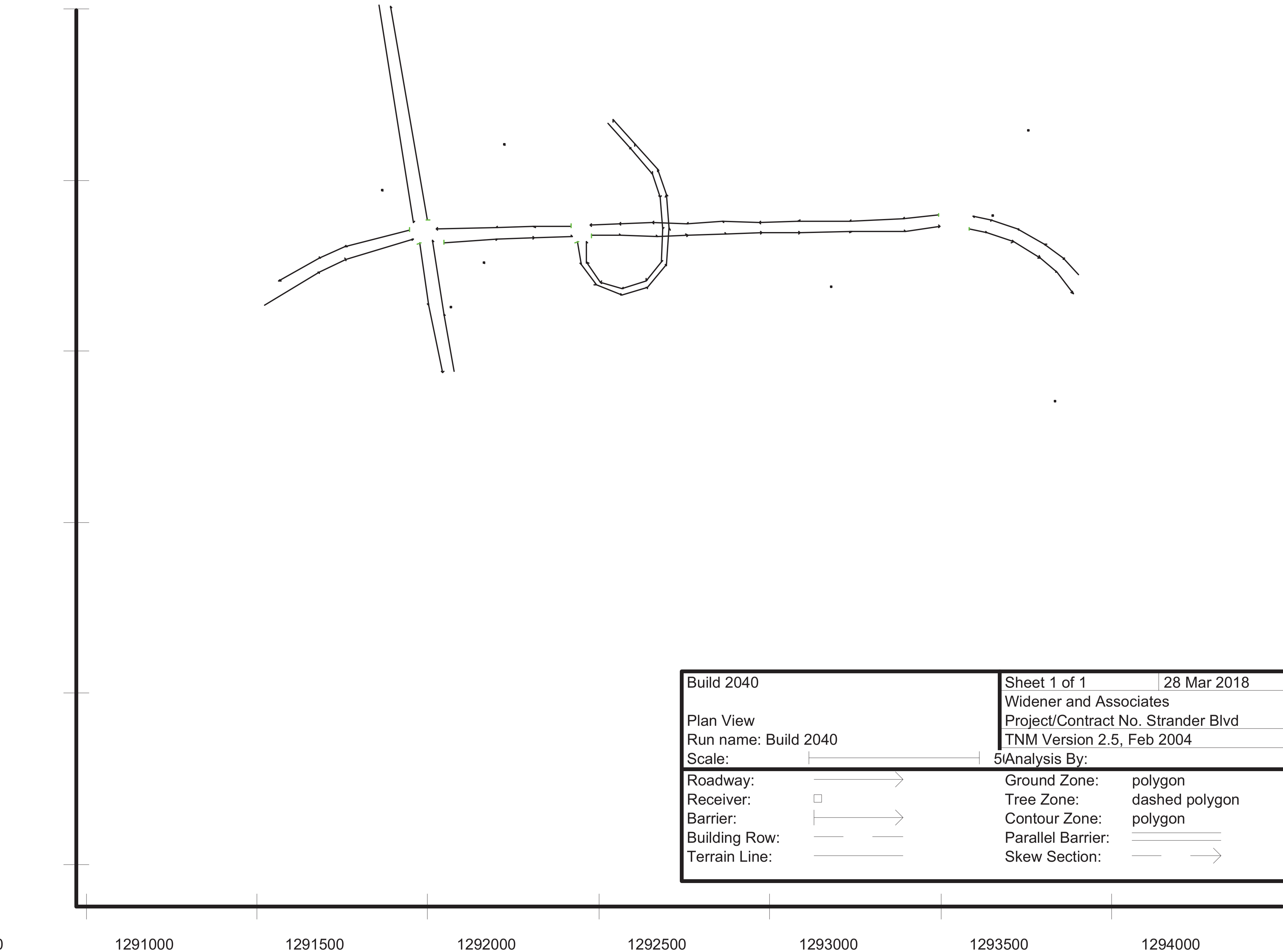



| | | |
|---|---|---|
| No Build 2040 | Sheet 1 of 1 | 28 Mar 2018 |
| | Widener and Associates | |
| Plan View | Project/Contract No. Strander Blvd | |
| Run name: No Build 2040 | TNM Version 2.5, Feb 2004 | |
| Scale: 5( | Analysis By: | |

| | |
|---|---|
| Roadway: | Ground Zone: polygon |
| Receiver: | Tree Zone: dashed polygon |
| Barrier: | Contour Zone: polygon |
| Building Row: | Parallel Barrier: |
| Terrain Line: | Skew Section: |

No Build 2040

| | Total | Heavy Trucks | Med Trucks | Cars |
|---|---|---|---|---|
| 27th ST WB | 240 | 12 | 22 | 206 |
| 27th ST EB | 630 | 25 | 57 | 548 |
| | | 0 | 0 | 0 |
| Strander WB 3 | 410 | 21 | 37 | 353 |
| Strander EB 3 | 395 | 16 | 36 | 344 |
| | | | | |
| Strander WB 2 | 80 | 4 | 7 | 69 |
| Strander EB 2 | 90 | 4 | 8 | 78 |
| Strander WB 1 | 950 | 10 | 57 | 884 |
| Strander EB 1 | 1030 | 113 | 62 | 855 |
| W Valley Hwy NB 1 | 1820 | 73 | 127 | 1620 |
| W Valley Hwy SB 1 | 1700 | 68 | 85 | 1547 |
| W Valley Hwy NB 2 | 1710 | 86 | 137 | 1488 |
| W Valley Hwy SB 2 | 1660 | 66 | 149 | 1444 |




| | | | |
|---|---|---|---|
| Build 2040 | | Sheet 1 of 1 | 28 Mar 2018 |
| | | Widener and Associates | |
| Plan View | | Project/Contract No. Strander Blvd | |
| Run name: Build 2040 | | TNM Version 2.5, Feb 2004 | |
| Scale: | 5( | Analysis By: | |
| Roadway: | | Ground Zone: | polygon |
| Receiver: | | Tree Zone: | dashed polygon |
| Barrier: | | Contour Zone: | polygon |
| Building Row: | | Parallel Barrier: | |
| Terrain Line: | | Skew Section: | |

Build 2040

| | Total | Heavy Trucks | Med Trucks | Cars |
|---|---|---|---|---|
| 27th ST WB | 760 | 38 | 68 | 654 |
| 27th ST EB | 1230 | 49 | 111 | 1070 |
| | | 0 | 0 | 0 |
| Strander WB 3 | 1080 | 54 | 97 | 929 |
| Strander EB 3 | 1120 | 45 | 101 | 974 |
| Tukwila Access NB | 40 | 2 | 4 | 35 |
| Tukwila Access SB | 370 | 15 | 33 | 322 |
| | | | | |
| Strander WB 2 | 1230 | 62 | 111 | 1058 |
| Strander EB 2 | 930 | 37 | 84 | 809 |
| Strander WB 1 | 1390 | 14 | 83 | 1293 |
| Strander EB 1 | 1290 | 142 | 77 | 1071 |
| W Valley Hwy NB 1 | 2160 | 86 | 151 | 1922 |
| W Valley Hwy SB 1 | 1830 | 73 | 92 | 1665 |
| W Valley Hwy NB 2 | 1670 | 84 | 134 | 1453 |
| W Valley Hwy SB 2 | 1540 | 62 | 139 | 1340 |

# Appendix C: Sound Level Data Sheets

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## Sound Level Data Collection Sheet

| | |
|---|---|
| DATE/TIME: 12-30-17 \| 2:43pm | LOCATION: East of Tracks by Kaiser |
| PROJECT NO.: | PERSONNEL: Jordan Widener |
| SITE: | WIND SPEED: Ave 6 \| High 11 WIND. DIR: North East |
| REL. HUMIDITY: 41 | TEMP: Dry Bulb 49 Wet Bulb 49 |

| | |
|---|---|
| EQUIPMENT MODEL: | SERIAL NO.: |
| CALIBRATION:<br><br>Initial__________ Final__________ | PROBLEMS: |
| DESCRIPTOR: | INTEGRATION RATE: |
| WEIGHTING: | SAMPLE RATE: |

SITE DESCRIPTION / DRAWING:

See Photos

| | |
|---|---|
| SOUND LEVEL 1: LEQ 61.8 | SOUND LEVEL 2: |

NOTES:

@ 6:42 min helicopter flew over

@ 5:03 min Plane flew over

@ 13:02 min – Plane flew over

@ 9:46 to 12:10 – Frieght Train

**Traffic Counts**

Site Number: Timing Number: 15min

Temp: 49° Relative Humidity: 41

Wind Speed: Ave 6 High 11 Wind Direction: NE

Direction of Traffic: East LEQ 61.8

Distance for Timed Cars (15 - 30ft)

| Heavy Trucks | Medium Trucks | Cars | Bus | Bikes | Timed Cars |
|---|---|---|---|---|---|
| | | 𝍸 | I | | |

Direction of Traffic: West

Distance for Timed Cars (5 - 15ft)

| Heavy Trucks | Medium Trucks | Cars | Bus | Bikes | Timed Cars |
|---|---|---|---|---|---|
| | | II | I | | |

Facing South

Facing West

## Sound Level Data Collection Sheet

| | |
|---|---|
| DATE/TIME: 12-30-17 / 1:45pm | LOCATION: South of Jack in the Box |
| PROJECT NO.: | PERSONNEL: Jordan Widener |
| SITE: Strander Ave | WIND SPEED: 0    WIND. DIR: N/A |
| REL. HUMIDITY: 41 | TEMP: Dry Bulb 49    Wet Bulb 49 |

| | |
|---|---|
| EQUIPMENT MODEL: | SERIAL NO.: |
| CALIBRATION: Initial________ Final________ | PROBLEMS: |
| DESCRIPTOR: | INTEGRATION RATE: |
| WEIGHTING: | SAMPLE RATE: |

SITE DESCRIPTION / DRAWING:

See Photos

| | |
|---|---|
| SOUND LEVEL 1: LEQ 71.4 | SOUND LEVEL 2: |

NOTES: Helicopter flew over @ 12:05 min

LEQ 71.4

## Traffic Counts

Car Total = 283

Site Number:  Timing Number: 8 12

Temp: 48°
Wind Speed: 0

Relative Humidity: 41
Wind Direction: N/A
Distance for Timed Cars: far (15 to 30ft)

Direction of Traffic: South

| Heavy Trucks | Medium Trucks | Cars | Bus | Bikes | Timed Cars |
|---|---|---|---|---|---|
| 1 | 1 1 | | | | |

Direction of Traffic: North

Distance for Timed Cars: close (5 to 15ft)

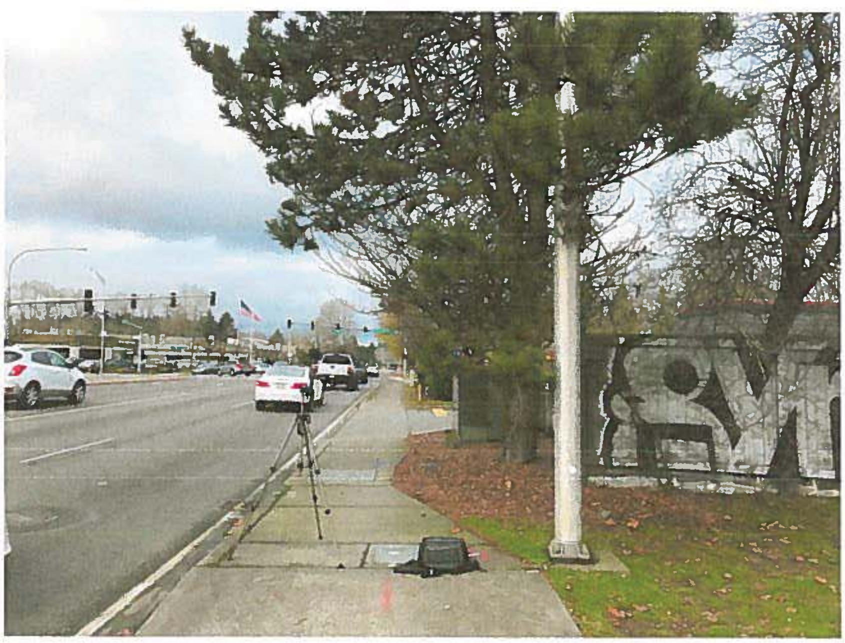
| Heavy Trucks | Medium Trucks | Cars | Bus | Bikes | Timed Cars |
|---|---|---|---|---|---|
| 1 | 1 | 6 | | | |

6 7 5 7 7

CARS Total = 180

Facing West

Facing South



Facing North