Appendix F. Updated Memorandum: Noise Analysis of Eastbank Esplanade

UPDATED MEMORANDUM: Noise Analysis of Eastbank Esplanade

I-5 Rose Quarter Improvement Project

Original: May 31, 2019 Updated: September 16, 2020

Note: This analysis has been updated to reflect the Build alternate as shown in the Revised Environmental Assessment.

Analysis by: Daniel Burgin, ODOT Noise Program Coordinator

Reviewed by: Natalie Liljenwall, P.E., Air Quality Program Coordinator and Noise Engineer

Executive Summary

This memorandum documents a noise analysis conducted by Oregon Department of Transportation (ODOT) to analyze noise impacts at the Eastbank Esplanade in Portland, Oregon. In January 2019, a Noise Study Technical Report for the I-5 Rose Quarter Improvement Project was published as a part of the Environmental Assessment for the project. The Eastbank Esplanade was not included as a noise sensitive land use in that analysis because ODOT does not typically consider bicycle and pedestrian facilities as noise sensitive resources unless they are clearly recreational rather than for transportation use such that users spend at least an hour at one location. Since then, it has been determined that the Eastbank Esplanade is a park. As a park, the Eastbank Esplanade is classified as Noise Abatement Criteria (NAC) Category C. (Refer to Table 3.) Category C receptors are considered noise sensitive and are to be included in federally funded highway noise analysis. This noise analysis showed that the Eastbank Esplanade is noise impacted with the project (72 dBA in design year) however, no mitigation is recommended for this location because it is not cost reasonable based on usage. The difference between existing (2017) traffic noise level (71 dBA) and Build Alternative (2045) noise level (72dBA) is not perceivable by the human ear, so the noise environment will not be noticeably changed by the project.

Affected Area Description

The Eastbank Esplanade is a pedestrian and bicycle path along the east shore of the Willamette River which extends from the Hawthorne Bridge to the Steel Bridge. In addition to highway noise from nearby I-5, the Eastbank Esplanade is affected by noise from on-road vehicles and light rail on the upper deck Steel Bridge and freight and passenger rail on the lower deck of the steel bridge and on nearby rail lines.

The I-5 Rose Quarter Improvement project, as described in the project's Revised Environmental Assessment (EA) and related documentation, includes improvements on I-5 adjacent to the section of Eastbank Esplanade between the Steel Bridge and Burnside Bridge. These improvements will not widen the structure that I-5 is on where it is directly adjacent to the esplanade, but will preserve and restripe existing pavement on that structure to create a new auxiliary lane.

Methodology

The same methodology used in the EA Noise Technical Report was used to evaluate existing and future noise levels and impacts at the Eastbank Esplanade receptor in accordance with the ODOT Noise Manual and 23 CFR 772. The FHWA Traffic Noise Model 2.5 (TNM), which was used to predict sound levels at noise sensitive receptors along the project corridor, was also used to predict sound levels at the Eastbank Esplanade as part of this analysis. The specific location for measurement and modelling was selected because it is a represenative point where the shifting of the highway overhead is most pronounced and where traffic noise is the primary noise source whenever freight trains are not present. To validate the model, traffic counts from during the measurement period were converted to 1-hour traffic volumes and used as input to the model. If the difference in the model output noise level and the actual measured sound level are less than three decibels, the model is considered validated.

Noise Measurement and TNM Validation

A noise measurement was taken at the Eastbank Esplanade at the location shown in Figure 1 below on May 22, 2019 starting at 10:43 a.m. The weather during the measurement was partly sunny, with dry pavement, and calm wind conditions. The measurement was taken in the late morning to avoid peak hour traffic when congestion forces vehicles to slow down. During the measurement, videos were taken of traffic on mainline I-5 NB and SB and the I-5 SB ramp to I-84 EB so that traffic counts could be obtained.

For the first 11 minutes of the 15 minute noise reading, highway noise was the primary noise source. The A-weighted L_{eq} for this period of time was 68 dBA. For the remainder of the measurement period, a frieght train was approaching and passing which resulted in a much higher sound levels. For example, the L_{eq} for the 13^{th} minute of the measurement was 78 dBA and the L_{max} in the final minute of the measurement was 114 dBA. Consequently, the 15 min L_{eq} was 71 dBA, which was higher than the L_{eq} for the time where traffic noise was the primary traffic source.

It was determined that the appropriate time period to use for validation at this location was the 11 minutes of the measurement before the arrival of the freight train since TNM is only able to predict highway noise and not noise from other sources such as freight trains. The resulting TNM predicted sound level of 70 dBA is within 3 decibels of the measured sound level of 68 dBA, so the model is considered validated. See Table 1 for measurement and validation results. Attachment A contains supporting documentation about the noise measurements and validation.

Figure 1. Measurement and Modeling Location

Table 1. Measurement and Validation Results

Monitoring Site	Land Use (Activity Category)	Distance to Nearest Major Roadway (Feet) [Roadway Name]	Monitored Noise Level (dBA)	TNM Predicted Noise Level (dBA)	Difference between Monitored and TNM Predicted Noise Levels (dBA)
Eastbank Esplanade (full 15 minute duration with rail noise)	Park (C)	10 [I-5 SB]	71	N/A	N/A
Eastbank Esplanade (11 minutes while traffic noise dominates; no rail noise)	Park (C)	10 [I-5 SB]	68	70	2

Existing and Predicted Sound Levels for Worst Noise Hour

The same TNM model which was used for the Noise Study Technical Report and validated for the Eastbank Esplanade location was used to predict sound levels for the worst noise hour for existing traffic conditions, No-Build Alternative with 2045 traffic conditions, and the Build Alternative with 2045 traffic conditions. Table 2 summarizes those predicted noise levels.

Table 2. Worst Noise Hour Predicted Sound Levels for Existing and Future Conditions (L_{eq}-dBA)

Receptor	Noise Abatement Criteria	Existing (2017) Noise Level	No-Build (2045) Noise Level	Build (2045) Noise Level	Increase from Existing to Build	Increase from No-Build to Build
R101-Eastbank Esplanade	Category C (67)	71	71	72	1	1

Worst noise hour sound levels at the Eastbank Esplanade are predicted to stay the same at 71 dBA from existing year to design year for the No Build Alternate. For the Build Alternate, the sound level is predicted to increase to 72 dBA, a one decibel increase. An increase of 3 decibels is generally considered the smallest change in sound level that the average human can detect, so it is not expected that building the project would result in a noticeable difference in noise compared to existing conditions. TNM output tables can be found in attachment A. The actual TNM files will be kept on file by ODOT.

Abatement Discussion

When traffic noise impacts are identified on a federal-aid project, abatement is considered. A receptor is impacted if it increases the sound level by more than 10 dBA from existing levels in the design year for the Build alternate, or if Build alternate design year sound levels approach (within 2 dBA) or exceed the Noise Abatement Criteria (NAC). Table 3 shows the NAC set for each land use type as defined by FHWA and ODOT.

Table 3. Federal Highway Administration Noise Abatement Criteria—Oregon Department of Transportation Noise Abatement Approach Criteria Hourly A-Weighted Sound Level Decibels (dBA)

Activity Category	Activity Criteria[a] Leq (h)		Evaluation Location	Land Use Activity Description
	FHWA NAC[b]	ODOT NAAC[c]		
A	57	55	Exterior	Lands on which serenity and quiet are of extraordinary significance and serve an important public need and where preserving those qualities is essential if the area is to continue to serve its intended purpose.
B[d]	67	65	Exterior	Residential
C[d]	67	65	Exterior	Active sports areas, amphitheaters, auditoriums, campgrounds, cemeteries, day care centers, hospitals, libraries, medical facilities, parks, picnic areas, places of worship, playgrounds, public meeting rooms, public or nonprofit institutional structures, radio studios, recording studios, recreation areas, Section 4(f) sites, schools, television studios, trails, and trail crossings
D	52	50	Interior	Auditoriums, day care centers, hospitals, libraries, medical facilities, places of worship, public meeting rooms, public or nonprofit institutional structures, radio studios, recording studios, schools, and television studios
E[d]	72	70	Exterior	Hotels, motels, offices, restaurants/bars, and other developed lands, properties, or activities not included in A–D or F
F	—	—	—	Agriculture, airports, bus yards, emergency services, industrial, logging, maintenance facilities, manufacturing, mining, rail yards, retail facilities, shipyards, utilities (water resources, water treatment, electrical), and warehousing
G	—	—	—	Undeveloped lands that are not permitted

[a.] The Leq(h) Activity Criteria values are for impact determination only and are not design standards for noise abatement measures.

[b.] Federal Highway Administration noise abatement criteria

[c.] Oregon Department of Transportation noise abatement approach criteria

[d.] Includes undeveloped lands permitted for this activity category

Since the Eastbank Esplanade is a Category C receptor and its predicted sound level in the design year for the Build Alternative was 72, it exceeds the NAC and is considered an impacted receptor. For this reason, abatement was considered.

Noise abatement is recommended for inclusion in the project if and only if it is found to be both feasible and reasonable as described in sections 7.3 and 7.4 of the ODOT Noise Manual.

Considering noise abatement at the Eastbank Esplanade poses many challenges:

- Since the Eastbank Esplanade is a trail that runs parallel to the highway, a barrier along I-5 SB designed to reduce sound levels for the esplanade would have to be very long, and thus expensive.
- People using the Eastbank Esplanade are in most cases, moving along the trail and not spending time in one place.
- A barrier along I-5 SB would do nothing to reduce train noise as that noise would still pass underneath I-5.
- A barrier along I-5 SB would do nothing to reduce traffic noise from the I-5 SB to I-84 EB ramp.
- A barrier along I-5 SB would cast a shadow on the Esplanade which could be considered undesirable.

Because of the issues described, such a barrier was not modeled to see how it would perform acoustically, but a hypothetical scenario was analyzed that shows that even if a barrier as short as 10 feet tall barrier was effective, it would not be cost reasonable by usage if analyzed using the methods in Appendix F of the ODOT Noise Manual (ODOT, 2011). The analysis, which concluded that, in order for noise abatement to be considered reasonable, the number of people using the Eastbank Esplanade would have to be significantly greater than that which was observed, is included as Attachment B of this memorandum. No noise abatement is recommended for the Eastbank Esplanade.

Conclusion

The Eastbank Esplanade is a popular bicycle and pedestrian facility despite currently high noise levels. Increases in highway noise at the esplanade due to the project are not predicted to exceed one decibel. This difference is smaller than the average human ear can detect, so there will be no appreciable change in the noise environment for users of the esplanade. While absolute noise levels do exceed the Noise Abatement Criteria, noise abatement in the form of barriers is found to not be cost effective and therefore not reasonable. Noise abatement at this location is not recommended.

References

Federal Highway Administration and Oregon Department of Transportation. 2019. I-5 Rose Quarter Improvement Project Environmental Assessment. February 15, 2019.

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

Oregon Department of Transportation. 2019. I-5 Rose Quarter Improvement Project Noise Study Technical Report. January 8, 2019.

Attachment A.

Documentation of Noise Measurements, Validation and Modelling of Existing and Predicted Sound Levels

Note: A TNM 2.5 map view of the receiver location and output tables are included in this attachment. The electronic TNM 2.5 files will be maintained on file with ODOT.

Table A.1. Traffic Counts for Validation

I-5 SB	**Count During 11 minute measurement for validation**	**Equivalent 1-hour traffic**
Automobiles	336	1833
Medium Trucks	17	93
Heavy Trucks	46	251
Busses	0	0
Motorcycles	3	16
I-5 NB	**Count During 11 minute measurement for validation**	**Equivalent 1-hour traffic**
Automobiles	335	1827
Medium Trucks	23	125
Heavy Trucks	33	180
Busses	0	0
Motorcycles	0	0
I-5 SB ramp to I-84 EB	**Count During 11 minute measurement for validation**	**Equivalent 1-hour traffic**
Automobiles	191	1042
Medium Trucks	11	60
Heavy Trucks	16	87
Busses	0	0
Motorcycles	0	0

Note: All speeds were 50 mph.

Figure A.1. Photo of Sound Level Meter at measurement site facing east. I -5 is visible in the upper foreground. Union Pacific Railroad and the ramp from I-84 to I-5 NB are visible in the background.

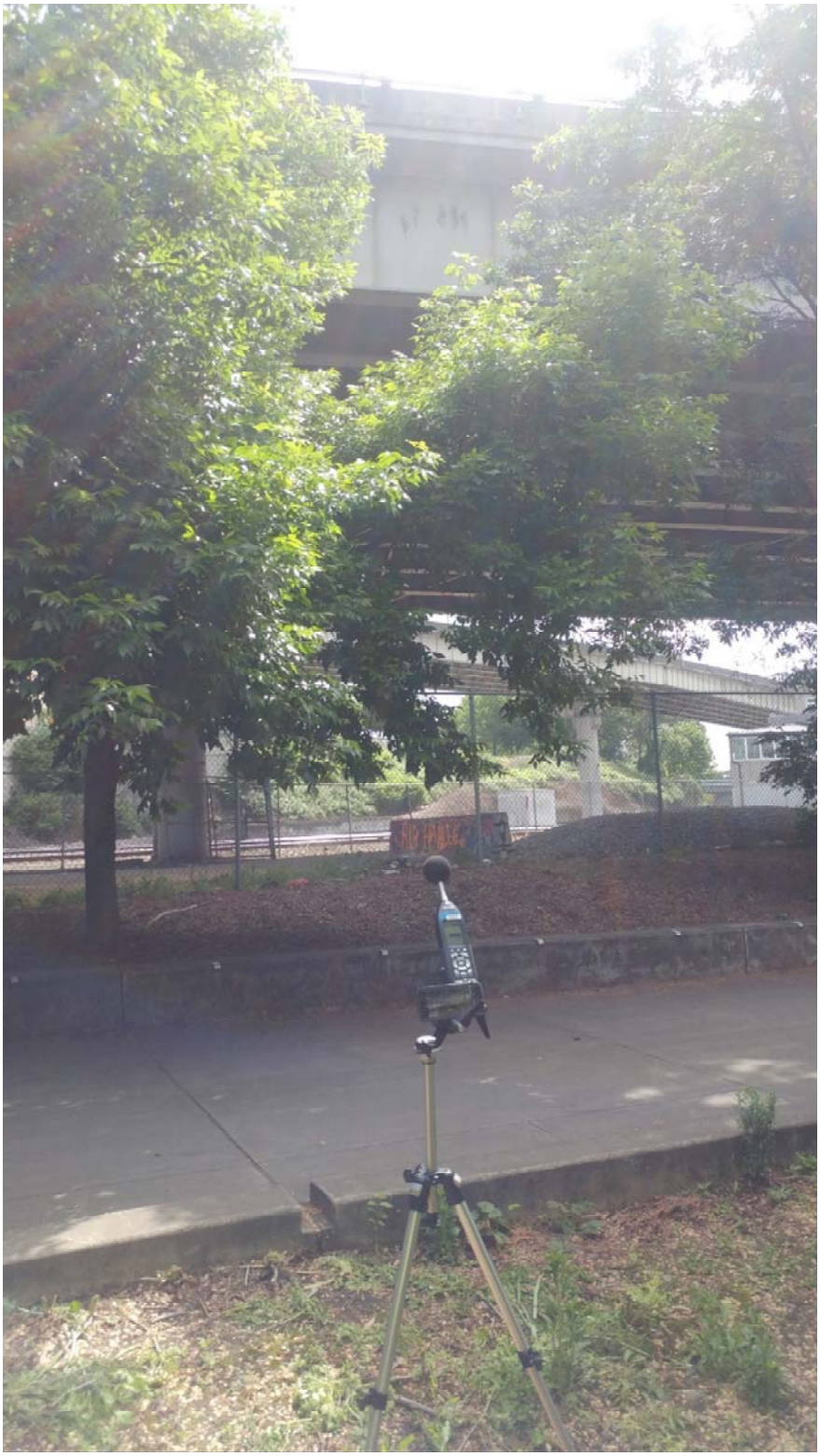


Figure A.2 Photo of Sound Level meter at measurement site facing northeast. I-5 and Union Pacific Railroad are visible.

Figure A.3. Photo of Sound Level Meter at measurement site facing south. I-5 is on the left and the ramp from I-5 SB to I-84 EB is on the right.

Oregon Department of Transportation

Geo-Environmental Section

Noise Measurement Data Sheet

Project Name: Rose Quarter	Key Number:
Measurement Site: East bank Esplanade	Address:
Date: 10-22-18	Location:
Analyst: DB w/ MY and SE	Noise Meter: LXT
Start Time: 10:43:57 AM	Duration: 15 min

Weather: Mostly Sunny

Temperature: 60°F

Wind: Calm

Calibration Pre-check: 113.90

Calibration Post-check: 113.93

Concurrent Traffic Count

Roadway Name: _____

Autos: _____

Medium Trucks: _____

Heavy Trucks: _____

Buses: _____

Motorcycles: _____

Speed: _____

video recorded by SE & MY

Results

Leq	71.0

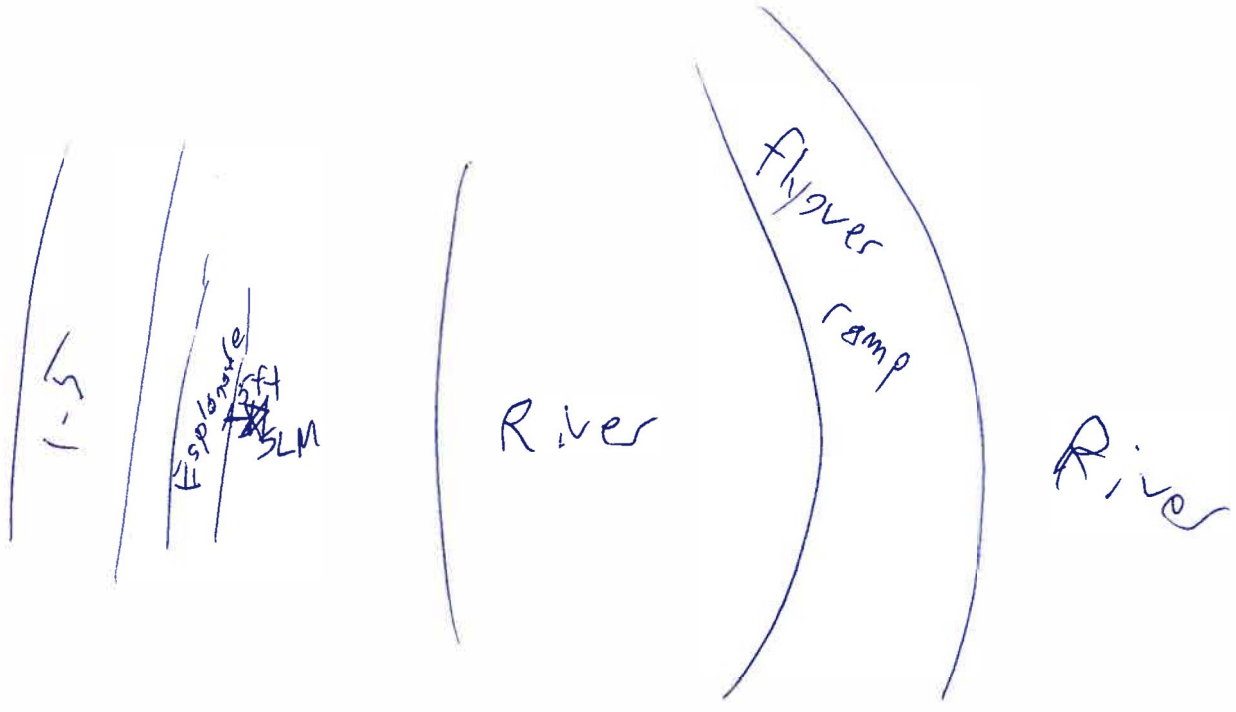
data file # 8

Notes/Other Noises/Excluded minutes:

Min 11-12

Freight train

Sketch of meter location:
(include distances to important features and roadway details)



Measurement Report

Report Summary

Meter's File Name	LxT_Data.008	Computer's File Name	SLM_0003340_LxT_Data_008.00.ldbin
Meter	LxT SE 0003340		
Firmware	2.302		
User	Daniel Burgin	Location	
Description	I-5 Rose Quarter		
Note			
Start Time	2019-05-22 10:43:57	Duration	0:15:00.0
End Time	2019-05-22 10:58:57	Run Time	0:15:00.0
Pause Time	0:00:00.0		

Results

Overall Metrics

LA_{eq}	71.0 dB		
LAE	100.5 dB	SEA	--- dB
EA	1.3 mPa²h		
LAS_{peak}	113.8 dB	2019-05-22 10:58:29	
LAS_{max}	83.5 dB	2019-05-22 10:58:29	
LAS_{min}	64.2 dB	2019-05-22 10:50:11	
LA_{eq}	71.0 dB		
LC_{eq}	86.9 dB	LC_{eq} - LA_{eq}	15.9 dB
LAI_{eq}	73.5 dB	LAI_{eq} - LA_{eq}	2.5 dB

Exceedances

	Count	Duration
LAS > 85.0 dB	0	0:00:00.0
LAS > 115.0 dB	0	0:00:00.0
LASpeak > 135.0 dB	0	0:00:00.0
LASpeak > 137.0 dB	0	0:00:00.0
LASpeak > 140.0 dB	0	0:00:00.0

Community Noise

LDN	LDay	LNight
71.0 dB	71.0 dB	0.0 dB

LDEN	LDay	LEve	LNight
71.0 dB	71.0 dB	--- dB	--- dB

Any Data

	A		C		Z	
	Level	Time Stamp	Level	Time Stamp	Level	Time Stamp
L_{eq}	71.0 dB		--- dB		--- dB	
$LS_{(max)}$	83.5 dB	2019-05-22 10:58:29	--- dB		--- dB	
$LS_{(min)}$	64.2 dB	2019-05-22 10:50:11	--- dB		--- dB	
$L_{Peak(max)}$	113.8 dB	2019-05-22 10:58:29	--- dB		--- dB	

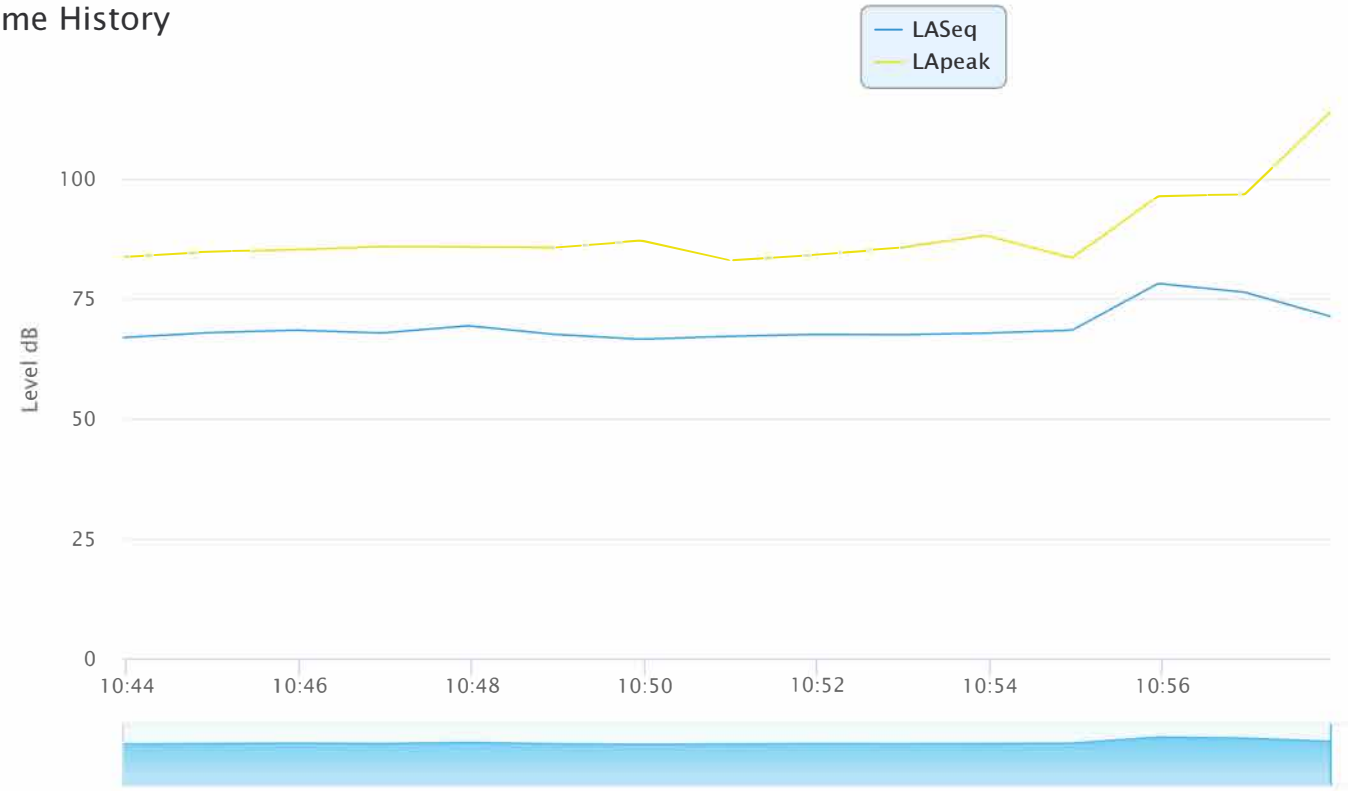
Overloads

Count	Duration	OBA Count	OBA Duration
0	0:00:00.0	1	0:14:59.9

Statistics

LAS 5.0	76.5 dB
LAS 10.0	73.6 dB
LAS 33.3	68.7 dB
LAS 50.0	67.7 dB
LAS 66.6	67.0 dB
LAS 90.0	65.7 dB

Time History



Record #	Record Type	Date	Time	LASeq	LApeak	OVLD	Marker
1	alibration Chang	2019-05-22	10:40:12				
2	Run	2019-05-22	10:43:57				
3		2019-05-22	10:43:57	66.8	83.5	No	
4		2019-05-22	10:44:57	67.8	84.6	No	
5		2019-05-22	10:45:57	68.3	85.0	No	
6		2019-05-22	10:46:57	67.7	85.7	No	
7		2019-05-22	10:47:57	69.2	85.6	No	
8		2019-05-22	10:48:57	67.4	85.5	No	
9		2019-05-22	10:49:57	66.4	86.9	No	
10		2019-05-22	10:50:57	67.0	82.8	No	
11		2019-05-22	10:51:57	67.4	84.0	No	
12		2019-05-22	10:52:57	67.3	85.4	No	
13		2019-05-22	10:53:57	67.7	88.0	No	
14		2019-05-22	10:54:57	68.3	83.3	No	
15		2019-05-22	10:55:57	78.0	96.2	No	
16		2019-05-22	10:56:57	76.2	96.5	No	
17		2019-05-22	10:57:57	71.1	113.8	No	
18	Stop	2019-05-22	10:58:57				
19	alibration Chang	2019-05-22	11:00:37				

Calculation of Leq for these 11

63295027.2	5754093.385	67.6

66.8	6.7	4734302.458
67.8	6.8	5969500.597
68.3	6.8	6734122.309
67.7	6.8	5875596.994
69.2	6.9	8326068.891
67.4	6.7	5505946.663
66.4	6.6	4372441.423
67.0	6.7	5004468.961
67.4	6.7	5515158.524
67.3	6.7	5412413.891
67.7	6.8	5845006.521

Calculation of Leq for these 11

=SUM(C6:C16)	=B2/11	=10*LOG(C2)

66.75256	=A6/10	=10^B6
67.75938	=A7/10	=10^B7
68.28281	=A8/10	=10^B8
67.69052	=A9/10	=10^B9
69.2044	=A10/10	=10^B10
67.40832	=A11/10	=10^B11
66.40724	=A12/10	=10^B12
66.99358	=A13/10	=10^B13
67.41558	=A14/10	=10^B14
67.33391	=A15/10	=10^B15
67.66785	=A16/10	=10^B16

Calibration Certificate

Certificate Number 2019004926

Customer:
Oregon Department of Transportation
4040 Fairview Drive SE
Salem,OR 97302,United States

Model Number	CAL200	***Procedure Number***	D0001.8386
Serial Number	16740	***Technician***	Scott Montgomery
Test Results	**Pass**	***Calibration Date***	24 Apr 2019
Initial Condition	As Manufactured	***Calibration Due***	
		Temperature	23 °C ± 0.3 °C
Description	Larson Davis CAL200 Acoustic Calibrator	***Humidity***	32 %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 60942:2017 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 9001:2015.

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	09/06/2018	09/06/2019	001021
Larson Davis Model 2900 Real Time Analyzer	04/02/2019	04/02/2020	001051
Microphone Calibration System	03/04/2019	03/04/2020	005446
1/2" Preamplifier	09/20/2018	09/20/2019	006506
Larson Davis 1/2" Preamplifier 7-pin LEMO	08/07/2018	08/07/2019	006507
1/2 inch Microphone - RI - 200V	05/10/2018	05/10/2019	006510
Pressure Transducer	07/18/2018	07/18/2019	007368

Calibration Certificate

Certificate Number 2019001226

Customer:

Oregon Department of Transportation
4040 Fairview Drive SE
Salem, OR 97302, United States

Model Number	LxT SE	***Procedure Number***	D0001.8378		
Serial Number	0003340	***Technician***	Ron Harris		
Test Results	**Pass**	***Calibration Date***	30 Jan 2019		
Initial Condition	AS RECEIVED same as shipped	***Calibration Due***	30 Jan 2020		
		Temperature	22.7	°C	± 0.25 °C
Description	Sound Expert LxT Class 1 Sound Level Meter Firmware Revision: 2.302	***Humidity***	50.4	%RH	± 2.0 %RH
		Static Pressure	86.42	kPa	± 0.13 kPa

Evaluation Method Tested electrically using Larson Davis PRMLxT1L S/N 027659 and a 12.0 pF capacitor to simulate microphone capacitance. Data reported in dB re 20 µPa assuming a microphone sensitivity of 23.6 mV/Pa.

Compliance Standards Compliant to Manufacturer Specifications and the following standards when combined with Calibration Certificate from procedure D0001.8384:

IEC 60651:2001 Type 1	ANSI S1.4-2014 Class 1
IEC 60804:2000 Type 1	ANSI S1.4 (R2006) Type 1
IEC 61252:2002	ANSI S1.11 (R2009) Class 1
IEC 61260:2001 Class 1	ANSI S1.25 (R2007)
IEC 61672:2013 Class 1	ANSI S1.43 (R2007) Type 1

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 International System of Units (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 9001:2015.

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.

Correction data from Larson Davis LxT Manual for SoundTrack LxT & SoundExpert Lxt, I770.01 Rev J Supporting Firmware Version 2.301, 2015-04-30

Calibration Check Frequency: 1000 Hz; Reference Sound Pressure Level: 114 dB re 20 µPa

LARSON DAVIS - A PCB PIEZOTRONICS DIV.
1681 West 820 North
Provo, UT 84601, United States
716-684-0001

ilac-MRA ACCREDITED Cert. #3622.01

LARSON DAVIS
A PCB PIEZOTRONICS DIV.

Calibration Certificate

Certificate Number 2019001235
Customer:
Oregon Department of Transportation
4040 Fairview Drive SE
Salem, OR 97302, United States

Model Number	PRMLxT1L	***Procedure Number***	D0001.8383		
Serial Number	027659	***Technician***	Ron Harris		
Test Results	**Pass**	***Calibration Date***	30 Jan 2019		
Initial Condition	AS RECEIVED same as shipped	***Calibration Due***	30 Jan 2020		
		Temperature	23.2	°C	± 0.01 °C
Description	Larson Davis 1/2" Preamplifier for LxT Class 1 -1 dB	***Humidity***	50.9	%RH	± 0.5 %RH
		Static Pressure	86.41	kPa	± 0.03 kPa

Evaluation Method Tested electrically using a 12.0 pF capacitor to simulate microphone capacitance. Data reported in dB re 20 µPa assuming a microphone sensitivity of 50.0 mV/Pa.

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 ‡ in the uncertainties column do not fall within this laboratory's scope of accreditation.

The quality system is registered to ISO 9001:2015.

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
Larson Davis Model 2900 Real Time Analyzer	03/07/2018	03/07/2019	003003
Hart Scientific 2626-H Temperature Probe	02/02/2018	02/02/2019	006767
Agilent 34401A DMM	06/29/2018	06/29/2019	007165
SRS DS360 Ultra Low Distortion Generator	10/04/2018	10/04/2019	007167

Calibration Certificate

Certificate Number 2019001236

Customer:

Oregon Department of Transportation
4040 Fairview Drive SE
Salem, OR 97302, United States

Model Number	LxT SE	***Procedure Number***	D0001.8384		
Serial Number	0003340	***Technician***	Ron Harris		
Test Results	**Pass**	***Calibration Date***	30 Jan 2019		
Initial Condition	AS RECEIVED same as shipped	***Calibration Due***	30 Jan 2020		
Description	Sound Expert LxT Class 1 Sound Level Meter Firmware Revision: 2.302	***Temperature***	22.79	°C	± 0.25 °C
		Humidity	50.9	%RH	± 2.0 %RH
		Static Pressure	86.4	kPa	± 0.13 kPa

Evaluation Method ***Tested with:*** ***Data reported in dB re 20 µPa.***

Larson Davis PRMLxT1L. S/N 027659
PCB 377B02. S/N LW136694
Larson Davis CAL200. S/N 9079
Larson Davis CAL291. S/N 0108

Compliance Standards Compliant to Manufacturer Specifications and the following standards when combined with Calibration Certificate from procedure D0001.8378:

IEC 60651:2001 Type 1	ANSI S1.4-2014 Class 1
IEC 60804:2000 Type 1	ANSI S1.4 (R2006) Type 1
IEC 61252:2002	ANSI S1.11 (R2009) Class 1
IEC 61260:2001 Class 1	ANSI S1.25 (R2007)
IEC 61672:2013 Class 1	ANSI S1.43 (R2007) Type 1

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 International System of Units (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 9001:2015.

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.

Correction data from Larson Davis LxT Manual for SoundTrack LxT & SoundExpert Lxt, I770.01 Rev J Supporting Firmware Version 2.301, 2015-04-30

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Attachment B.

Documentation that a barrier along I-5 at Eastbank Esplanade would not be cost effective.

The purpose of this hypothetical barrier analysis is to show that even if a barrier was acoustically feasible to benefit the Eastbank Esplanade, it would not be found to be reasonable in the cost effectiveness calculation. This calculation follows the methods in Appendix F of the ODOT Noise Manual.

A number of assumptions were made. These are generous assumptions to show that it would be very difficult if not impossible to justify a barrier. For example, 10 feet is used as barrier height, when a taller barrier may be required to achieve the appropriate noise reduction, and the rate of bike/ped travel is assumed to be 3mph while the actual average speed would certainly be something greater.

- Assume a barrier 600 foot long and 10 feet tall along I-5, adjacent to Eastbank Esplanade as shown in Figure 2.
- The average amount of time a person spends per visit must be estimated
    - During the 15 minute field measurement the following bicycle and pedestrian pass-bys were observed:
        - 10 bicycling
        - 9 running or jogging
        - 4 walking
    - On another occasion, lunchtime on Friday May 24, 2019, the following were observed over 20 minutes:
        - 26 bicycling
        - 16 running or jogging
        - 11 walking
    - Despite this, for the sake of counting the most time, for this hypothetical, visitors will be assumed to walk at a moderate pace of 3 mph
    - It takes 136 seconds to walk 600 feet at 3mph so this will be the assumed time spent by each visitor in the area protected by the noise wall.

Figure B.1. Hypothetical 600 foot barrier along I-5 SB

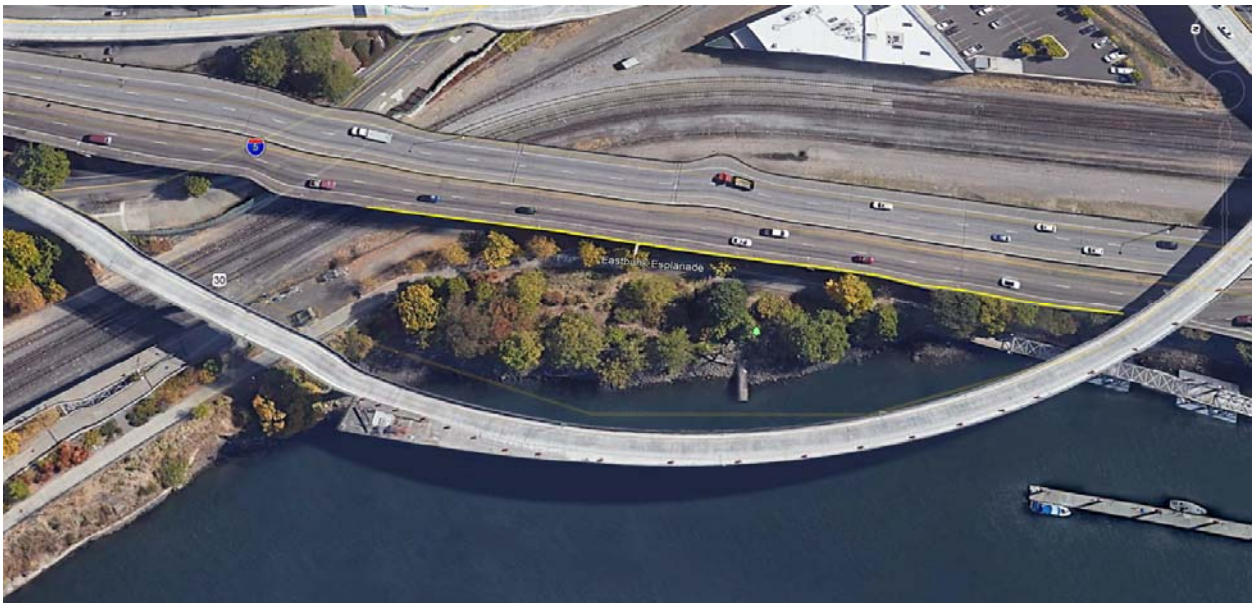

Table B.1. Cost effectiveness calculation for Hypothetical 600 foot barrier along I-5 SB

Line number	Criteria	Input	Comments
1	Enter length of proposed barrier	600 ft	Assumption described above
2	Enter height of proposed barrier	10 ft	Assumption described above
3	Multiple line 1 by line 2	6000 ft^2	Calculation
4	Enter the average amount of time that a person stays at the site per visit	136 sec= 0.0378 hr	Assumption described above and converted to hours
5	Enter the average number of people that use this site per day that will receive at least 5 dBA benefit from abatement at the site	Number of daily visitors =x	Choosing to represent this as variable x.
6	Multiply item 4 by item 5	$0.0378x$ person-hrs	Calculation
7	Divide item 3 by item 6	$\frac{158{,}730}{x}\ \frac{ft^2}{person\text{ - }hr}$	Calculation
8	Multiply $25,000 by item 7	$\frac{\$3{,}968{,}253{,}968}{x}\ \frac{ft^2}{person\ hour}$	Calculation
9	Does item 8 exceed the "abatement cost factor" of: English units = $518,758/person-hr/$ft^2$?	No, if $x > 7650$ Yes, if $x \leq 7650$ Because: $\frac{\$518{,}758 ft^2}{person\ hour} = \frac{\$3{,}968{,}253{,}968 ft^2}{x * person\ hour}$ Results in: $x = 7650$	The result varies depending on the value of x. Setting Line 8 equal to the "abatement cost factor" in the line 9 description and solving for x allows for determining a threshold number of daily visitors that must be present for the criteria to be met.
10	If item 9 is no, abatement meets reasonable criteria		
11	If item 9 is yes, abatement does not meet reasonable criteria		

As table B.1. demonstrates, using the assumptions set forth for this hypothetical situation, noise abatement would only be reasonable if there were greater than 7650 average daily users on this section of the Eastbank Esplanade. For reference, if the number of users who were observed on the day of the measurement over 15 minutes is multiplied by 4 (15 min to 1 hour) and 24 (hours to day) to obtain a daily average, it would be 2208 people. Similar extrapolation of the Friday lunchtime count leads to

3816 people. This does not take into account the fact that most users are travelling through the area faster than a moderate walking pace and that traffic varies by hour especially overnight.

Since the average daily number of users of this portion of the Eastbank Esplanade is certainly less than 7650, this shows that even in an ideal scenario, noise abatement would not be found reasonable at this location.