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45dB Project# 20067

Acoustical Noise Study:	**Architect:**	**Client, Project Owner:**
Gas/Convenience/Car Wash 17453 S. Central Ave. Carson, CA 90746	Bundy-Finkel Architects Attn: Richard Finkel, Principal rfinkel@bundyfinkel.com	Max Central Carson, Inc. Attn: Max M. Netty 1875 Central Park East #600 Los Angeles, CA 90067

Summary

45dB Acoustics, LLC (**45dB**) has conducted an acoustical analysis of the proposed automated drive-through carwash to an existing Chevron/McDonald's co-branded drive-through restaurant and fueling station in the City of Carson, CA. This analysis utilizes published traffic counts input into a noise propagation model (SoundPLAN®) along with sound levels for the various project components based upon our experience and previous measurements. The potential impact of noise from the project at the neighboring residential property lines was evaluated, as compared to the existing noise environment.

Predicted noise levels were modeled for the project area and compared to the City and County's limits on Daytime and Maximum exterior noise levels. Because the daytime exterior noise levels due to the car wash (dryers and vacuums) at some of the nearby residential homes are anticipated to exceed the 55 dBA daytime hourly limit specified by the Carson Noise Element as well as the existing ambient levels during daytime hours, additional mitigation is required.

Based on our analysis, we evaluated multiple options for mitigation and recommend implementing one of the following two mitigation options to comply with the City and County limits.

- **Option A:** Add silencers to all twelve blowers within the tunnel and add a 10-ft CMU wall next to the west side of the tunnel entrance.
- **Option B:** Reduce the number of blowers to six and add silencers to each blower.

These predictions are based upon the following assumptions:

- Car wash dryers operate continuously, 60 minutes per hour, only during daytime hours (7am-7pm).
- Absorption is added within the tunnel to reduce reverberant noise levels.

- Car wash dryer noise levels are not greater than 80dBA (for Option A, with wall in place) or 77 dBA (for Option B) when measured 10-ft from the car wash entrance, with mitigation in place. *Verification measurements to ensure this level is met are suggested.*

Assuming mitigation is effectively implemented into the project and the car wash operates with the above conditions, this project is predicted to meet the City of Carson's Noise Element and Municipal Code. However, as with anything, the design and quality of installation of car wash blowers and silencers varies. We recommend on-site sound level measurements of the operational car wash to further confirm anticipated compliance.

Vibration levels due to the car wash are anticipated to be less than the human threshold of perception and below the County's limits for ground borne vibration at the neighboring properties.

for 45dB Acoustics, LLC:

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1 Introduction

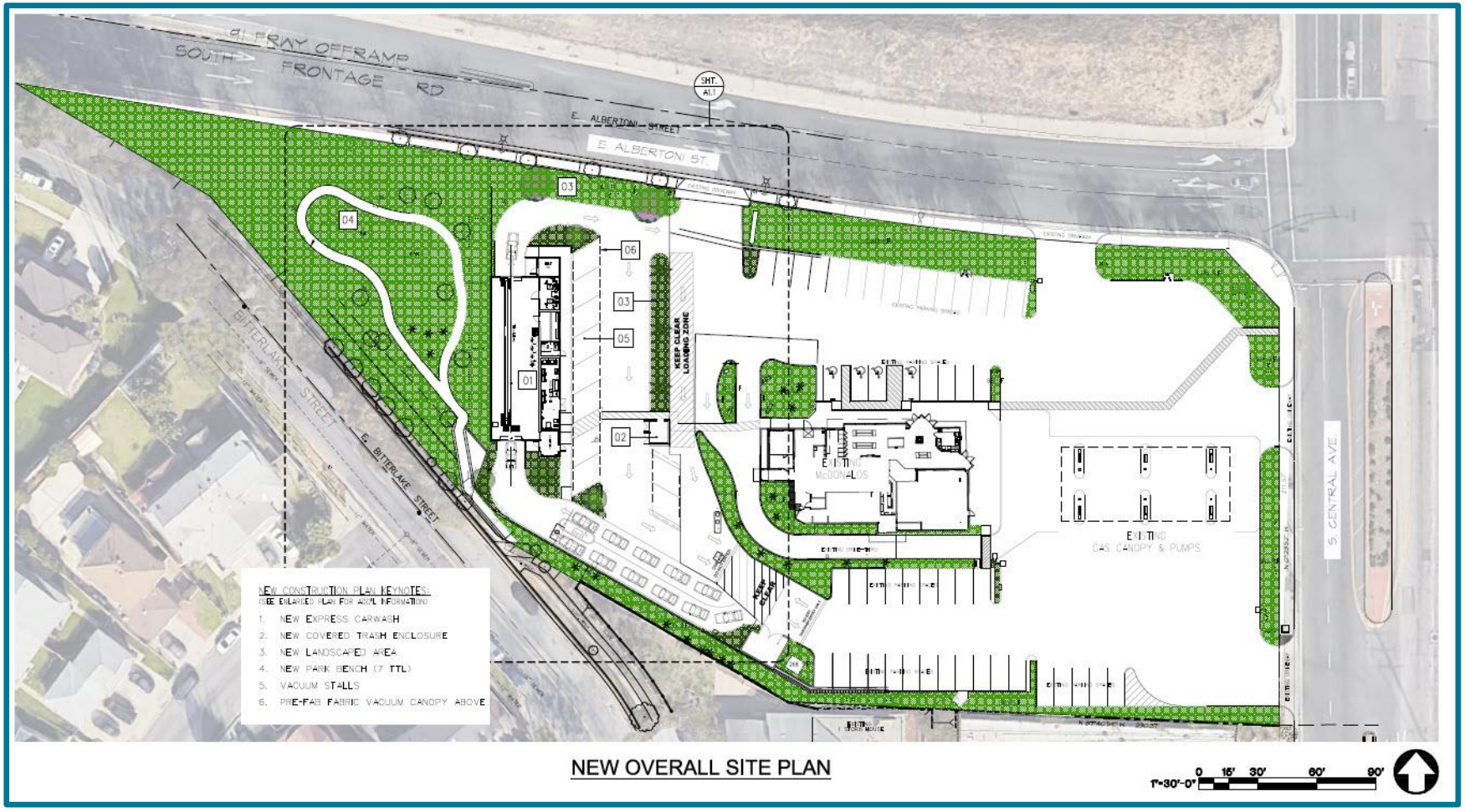
This sound level assessment is intended to determine the potential noise impacts associated with the proposed commercial project at 17453 S. Central Avenue in Carson, California. The following topics are presented in this report in response to the City of Carson requirements for stationary noise as identified by the Carson Municipal Code and Noise Element as well as the LA County Noise Control Ordinance. The following factors are considered:

- The topographical relationship of potential noise sources and the nearby potential sensitive receptors
- Identification of noise sources and their characteristics, including predicted noise spectra and sound levels at the property lines of nearby residential homes, considering present and future land usage and terrain
- Basis for the sound level prediction (i.e., acoustically modeled from published data), noise attenuation measures to be applied, and an analysis of the noise propagation considering the physical layout of built environment
- Mitigation options, to be selected from by the Client and implemented into the design
- Information on fundamentals of noise and vibration to aid in interpreting the report

The proposed project site is at the southwestern corner of S. Central Ave. and E. Albertoni Street, with Highway 91 (Garden Freeway) situated north of and below the finish grade level of the site (Figure 1). The existing site currently has a gas station and convenience store on the premises. The proposed project would add a new car wash tunnel and ten vacuum stalls located at the west side of the property, as shown in Figure 2.

Figure 1: 3D View of Site (Google Maps)

Figure 2: Project Site Plan (Reprinted From Client Drawings, dated 3/12/2024)



2 Regulatory Setting

Noise regulations are addressed by federal, state, and local government agencies, as discussed below. Local policies are generally adaptations of federal and state guidelines, adjusted to prevailing local conditions.

2.1 Federal Regulation

The adverse impact of noise was officially recognized by the federal government in the Noise Control Act of 1972, which serves three purposes:

a) Promulgating noise emission standards for interstate commerce.
b) Assisting state and local abatement efforts.
c) Promoting noise education and research.

The Department of Transportation (DOT) and California Department of Transportation (Caltrans) have assumed significant roles in roadway noise standards and regulation. The Federal Aviation Administration (FAA) regulates noise of aircraft and airports. Surface transportation system noise is regulated by the Federal Transit Administration (FTA). Freeways that are part of the interstate highway system are regulated by the Federal Highway Administration (FHWA). The Federal Railroad Administration (FRA) regulates train traffic and, subsequently, rail noise.

For this project, the nearest airport (Long Beach Airport) is approximately 6 miles to the southeast and is not a significant noise factor. Only road noise is included in the existing environment here, along with activities at the existing fueling station and drive-through fast-food restaurant.

2.2 Local Regulation

2.2.1 Noise Control Ordinance

The City of Carson Noise Control Ordinance[1], which is adopted from the Noise Control Ordinance of the County of Los Angeles[2], provides regulations and guidelines regarding non-transportation noise sources. Section 5502 (Figure 3), which is amended from the County of Los Angeles Noise Control Ordinance Section 12.08.390B (Figure 4), provides exterior (property line) noise level limits for sources operating for specified cumulative periods of time.

[1] City of Carson Municipal Code, Article V, Chapter 5, *Noise Control Ordinance*, May 2024. https://www.codepublishing.com/CA/Carson/html/Carson05/Carson050500.html#5500
[2] Los Angeles County Code, Chapter 12.08 of Title 12, August 2021. Noise Control Ordinance. https://library.municode.com/ca/los_angeles_county/codes/code_of_ordinances?nodeId=TIT12ENPR_CH12.08NOCO

Figure 3: County of Los Angeles Noise Control Ordinance, Section 12.08.390 A – Exterior noise standards

12.08.390 - Exterior noise standards—Citations for violations authorized when.

A. Unless otherwise herein provided, the following exterior noise levels shall apply to all receptor properties within a designated noise zone:

EXPAND

Noise Zone	Designated Noise Zone Land Use (Receptor property)	Time Interval	Exterior Noise Level (dB)
I	Noise-sensitive area	Anytime	45
II	Residential properties	10:00 pm to 7:00 am (nighttime)	45
		7:00 am to 10:00 pm (daytime)	50
III	Commercial properties	10:00 pm to 7:00 am (nighttime)	55
		7:00 am to 10:00 pm (daytime)	60
IV	Industrial properties	Anytime	70

Figure 4: City of Carson Noise Control Ordinance, Amendment to LA County 12.08.390, subsection B

5502 Amendments to Noise Control Ordinance.

Notwithstanding the provisions of CMC 5500, the Noise Control Ordinance is hereby amended as follows:

(a) By amending Section 12.08.180 to read:

12.08.180. "Health officer" means the Director of Public Safety of the City of Carson and shall be deemed to include the Director of the Department Health Services of the County of Los Angeles, or his duly authorized representatives, while performing public health services, including noise level measurements, under contract with the City.

(b) By amending subsection B of Section 12.08.390 to read:

12.08.390B. Unless otherwise herein provided, no person shall operate or cause to be operated, any source of sound at any location within the unincorporated county, or allow the creation of any noise on property owned, leased, occupied or otherwise controlled by such person which causes the noise level, when measured on any other property either incorporated or unincorporated, to exceed any of the following exterior noise standards:

Standard No. 1 shall be the exterior noise level which may not be exceeded for a cumulative period of more than 15 minutes in any 30 minute period. Standard No. 1 shall be the applicable noise level from subsection A of this Section; or, if the ambient L_{50} exceeds the foregoing level, then the ambient L_{50} becomes the exterior noise level for Standard No. 1.

Standard No. 2 shall be the exterior noise level which may not be exceeded for a cumulative period of more than 7.5 minutes in any 30 minute period. Standard No. 2 shall be the applicable noise level from subsection A of this Section plus 5dB; or, if the ambient L_{25} exceeds the foregoing level, then the ambient L_{25} becomes the exterior noise level for Standard No. 2.

Standard No. 3 shall be the exterior noise level which may not be exceeded for a cumulative period of more than 2.5 minutes in any 30 minute period. Standard No. 3 shall be the applicable noise level from subsection A of this Section plus 20dB; or, if the ambient $L_{8.3}$ exceeds the foregoing level, then the ambient $L_{8.3}$ becomes the exterior noise level for Standard No. 3.

Standard No. 4 shall be the exterior noise level which may not be exceeded for a cumulative period of more than 30 seconds in any 30 minute period. Standard No. 4 shall be the applicable noise level from subsection A of this Section plus 15dB; or, if the ambient $L_{1.7}$ exceeds the foregoing level, then the ambient $L_{1.7}$ becomes the exterior noise level for Standard No. 4.

Standard No. 5 shall be the exterior noise level which may not be exceeded for any period of time. Standard No. 5 shall be the applicable noise level from subsection A of this Section plus 20dB; or, if the ambient L_0 exceeds the foregoing level then the ambient L_0 becomes the exterior noise level for Standard No. 5.

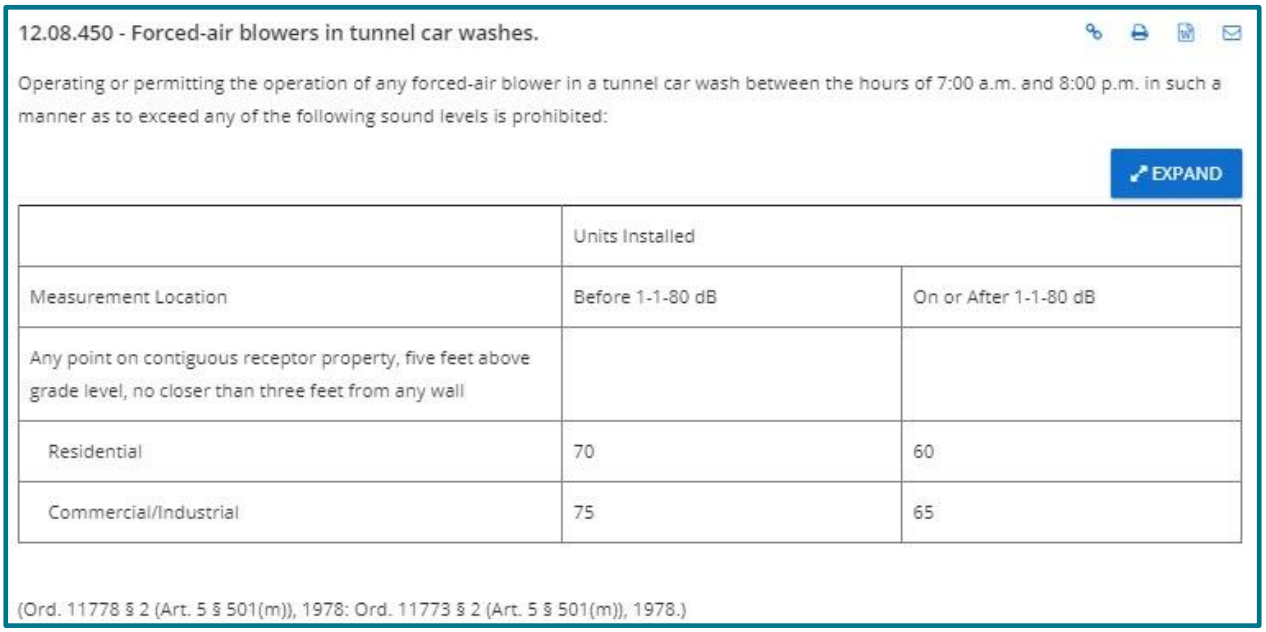
For levels such as those emitted from a car wash dryer, which would operate up to 60 minutes per hour, Standard No. 1 would apply and states that the exterior noise level ("LAeq") at Residential properties may not exceed 50dBA daytime and 45dBA nighttime. For locations where the ambient noise level exceeds the published limits, the allowable levels are adjusted to "equal" the ambient level.

Technically, this could be interpreted to mean that, if absolutely no increase in noise level were permitted, there could never be any additional noise sources or projects in the City. This is because, adding a noise source of even 10dB or 20 dB below the ambient level will add some small fraction of a decibel to the existing ambient; decibels add together logarithmically (See 8.1 for some background on sound). However, it is generally accepted that an increase of less than 2 or 3 dB is considered less-than-significant, on either an hourly or daily equivalent level basis, due to the inability of the human ear to discern a change this small. (See Section 8.1 for a guide

on perception of decibel changes.) In this report, we regard an increase of no more than 2 dB as being less-than-significant, and a reasonable criterion for compliance with the Code.

Additionally, the County of Los Angeles Noise Control Ordinance, Section 12.08.450 (reprinted in Figure 5), limits noise levels from forced-air blowers in tunnel car washes and only permits their operation between 7:00am and 8:00pm.

Figure 5: County of Los Angeles Noise Control Ordinance, Section 12.08.450 – Forced-air blowers in tunnel car washes



12.08.450 - Forced-air blowers in tunnel car washes.

Operating or permitting the operation of any forced-air blower in a tunnel car wash between the hours of 7:00 a.m. and 8:00 p.m. in such a manner as to exceed any of the following sound levels is prohibited:

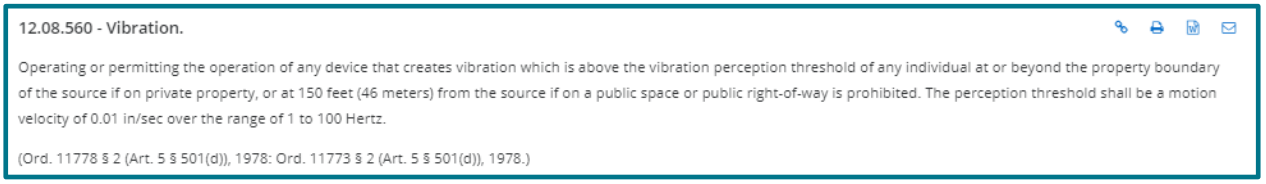
EXPAND

	Units Installed	
Measurement Location	Before 1-1-80 dB	On or After 1-1-80 dB
Any point on contiguous receptor property, five feet above grade level, no closer than three feet from any wall		
Residential	70	60
Commercial/Industrial	75	65

(Ord. 11778 § 2 (Art. 5 § 501(m)), 1978: Ord. 11773 § 2 (Art. 5 § 501(m)), 1978.)

The County of Los Angeles Noise Control Ordinance, Section 12.08.560 (reprinted in Figure 6), prohibits perceptible ground borne vibration levels at private properties to levels below 0.01 in/sec.

Figure 6: County of Los Angeles Noise Control Ordinance, Section 12.08.560 – Vibration



12.08.560 - Vibration.

Operating or permitting the operation of any device that creates vibration which is above the vibration perception threshold of any individual at or beyond the property boundary of the source if on private property, or at 150 feet (46 meters) from the source if on a public space or public right-of-way is prohibited. The perception threshold shall be a motion velocity of 0.01 in/sec over the range of 1 to 100 Hertz.

(Ord. 11778 § 2 (Art. 5 § 501(d)), 1978: Ord. 11773 § 2 (Art. 5 § 501(d)), 1978.)

2.2.2 Noise Element

The Noise Element of the General Plan for the City of Carson provides standards for non-transportation noise sources that include limits for daytime hourly noise levels (L_{eq}) at the property line. As shown below in Figure 7, the levels may not exceed 55 dBA during daytime hours (7am – 10pm). These limits are for the noise source itself, without any ambient or transportation noise.

The Noise Element also states (our highlighting in yellow in Figure 7) that if there are any discrepancies between the Noise Ordinance and the General Plan (Noise Element), the General Plan prevails.

Figure 7: City of Carson Noise Element, Noise Standards for Non-Transportation Sources

TABLE 9-3: NOISE GENERATION PERFORMANCE STANDARDS FOR NON-TRANSPORTATION SOURCES

Noise Level Descriptor	*Daytime (7 a.m.-10 p.m.)*	*Nighttime (10 p.m. to 7 a.m.)*
Hourly L_{eq}, dB	55	45
Maximum Level, dB	75	65

1. Each of the noise levels specified above shall be lowered by 5 dB for simple tone noises, noises consisting primarily of speech or music, or for recurring impulsive noises.

Table 9-3 provides standards for noise generation from non-transportation noise sources such as industrial facilities, automotive servicing, or equipment yards. These standards apply to the noise sources themselves, as measured at the edge of the property line; noise caused by motor vehicles traveling to and from the site is exempt from this standard.

CITY OF CARSON NOISE ORDINANCE

In 1995, Carson adopted the Noise Control Ordinance of the County of Los Angeles, as amended, as the City's Noise Control Ordinance. The adopted Noise Ordinance sets standards for noise levels citywide and provides the means to enforce the reduction of obnoxious or offensive noise. The noise sources enumerated in the Noise Ordinance include radios, phonographs, loudspeakers and amplifiers, electric motors or engines, animals, motor vehicles and construction equipment. The Noise Ordinance sets interior and exterior noise levels for all properties within designated noise zones, unless exempted. Enforcing the Noise Ordinance includes requiring proposed development projects to show compliance with the ordinance and requiring construction activity (including operation of construction vehicles and other equipment) to comply with established scheduling limits. Environmental impacts of construction noise are assessed in the General Plan EIR, and future projects may also be subject to project-level analysis. In case of any discrepancies between the General Plan and the Noise Ordinance standards, standards in the General Plan prevail.

NOISE SENSITIVE RECEPTORS

The City has identified residences, public and private school/preschool classrooms, churches, hospitals and elderly care facilities as noise sensitive receptors. The maximum interior exposure for these land uses, consistent with State standards, is 45 dBA CNEL (maximum exterior exposure is 65 dBA CNEL).

The potential exists for noise sensitive receptors located adjacent to roadways to experience excessive noise levels. Depending on the setback location of these adjacent noise sensitive receptors and nature of existing noise attenuation features (if any), the 65 CNEL contour may fall within the outdoor living areas of these land uses (i.e., playground or backyard). Noise sensitive land uses are generally distributed throughout the city and directly abut noise generating uses in some areas. Please see the Land Use and Revitalization Element for more about existing land use patterns and General Plan land use designations.

3 Modeled Outdoor Noise Levels

SoundPLAN® is a state-of-the-art sound propagation modeling software package that calculates sound levels, taking into account air and ground attenuation factors, terrain variation and the built environment, road pavement types, and other relevant factors.

3.1 Existing Noise Environment

3.1.1 Traffic Noise

Traffic counts in annual average daily traffic (AADT) are input directly into SoundPLAN®, which predicts exterior (outdoor) noise levels due to those noise sources. Traffic counts are input into SoundPLAN® which, by default, apportions the count into vehicle types including automobiles and medium trucks using the implemented Federal Highway Administration's Traffic Noise Model 3.0 (TNM). SoundPLAN apportions counts into daytime, evening, and nighttime hours, and appropriate vehicle speeds, pavement type, ground attenuation factor, etc. are chosen in order to predict outdoor noise levels. As shown in Table 1, traffic counts have been provided for Highway 91 from CalTrans, and for Artesia Blvd. and Central Ave. by the City of Carson. Traffic counts for the applicable roads and interstate highway were increased by 1% per year to 2024 for present-day noise contours.

Table 1: Traffic Count Data and 2024 Projections

Road	AADT	Year	Years to Project	2021 AADT Projection with 1% Annual Growth
Hwy 91 - east of Central Ave	202,000	2022	2	206,060
Hwy 91 - west of Central Ave	197,000	2022	2	200,960
S. Central Ave	16,821	2018	6	17,856
E. Bitterlake St. / Amantha Ave.	4,000	2020	4	4,162
Artesia Blvd.	20,000	2020	4	20,812

Sources: https://dot.ca.gov/programs/traffic-operations/census, https://ci.carson.ca.us/content/files/pdfs/BusinessDev/demographics/Traffic_Count_Map.pdf

3.1.2 Existing Drive-Through Restaurant

Levels due to the existing drive-through restaurant include the following:

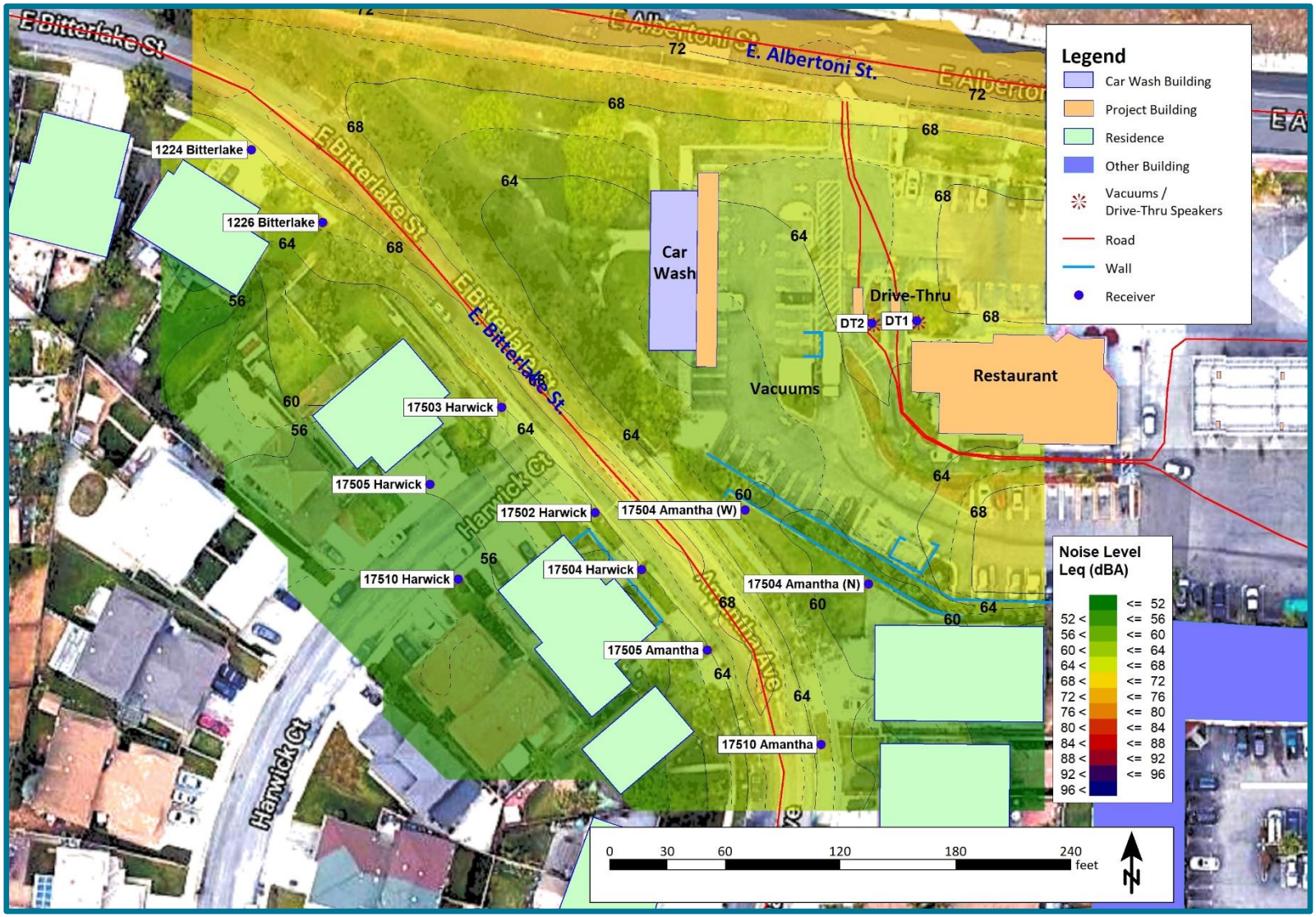
- **Cars** associated with the drive-through restaurant, which not only generally emit low sound levels but for the customer ordering at the speaker box also block some noise from the west (i.e., proposed car wash).

- **Drive-through speaker** incorporating an AVC (Adjustable Volume Control) loudspeaker, which adjusts volume according to the ambient levels and does not allow the levels to exceed 15 dB above the background noise. Documentation on this system is also included at the end of this report.
- **Idling delivery trucks for the restaurant and fueling station**, which we would estimate at 1-2 trucks per day on average, idling for approximately 30 minutes as a worst-case estimation. Because truck deliveries are not a regular occurrence throughout the day here, and because delivery trucks should in practice turn off their engines when making deliveries, noise from trucks was not included in our noise model, and are not expected to significantly contribute or increase the hourly sound levels due to the car wash project, over the dryers and vacuums which are the dominant/principle noise source for the project.

3.1.3 Modeled Existing Noise Levels

Figure 8 shows the daytime hourly "Ld" noise contours from traffic throughout the area along with the traffic and speakers for the existing drive-through restaurant. The FHWA's Traffic Noise Model utilizes an average hourly traffic count (AADT) that is the same for all daytime hours—on any given day or hour, traffic counts may vary from this annualized average. 45dB Acoustics LLC finds this annualized average, based upon historical traffic but adjusted to the present year, to be the most accurate method of establishing existing ambient sound levels for planning purposes *for areas where traffic noise dominates*, rather than a single day field measurement at one single point. This serves as the ambient background noise environment to which the additional sound sources from the project are added. In general, the daytime ambient sound levels for the existing situation are anticipated to be 55-68 dBA at the nearest residential locations to the south and southwest of the project site.

Figure 8: Daytime Ambient Noise Contours (7am – 7pm) From Traffic and Restaurant



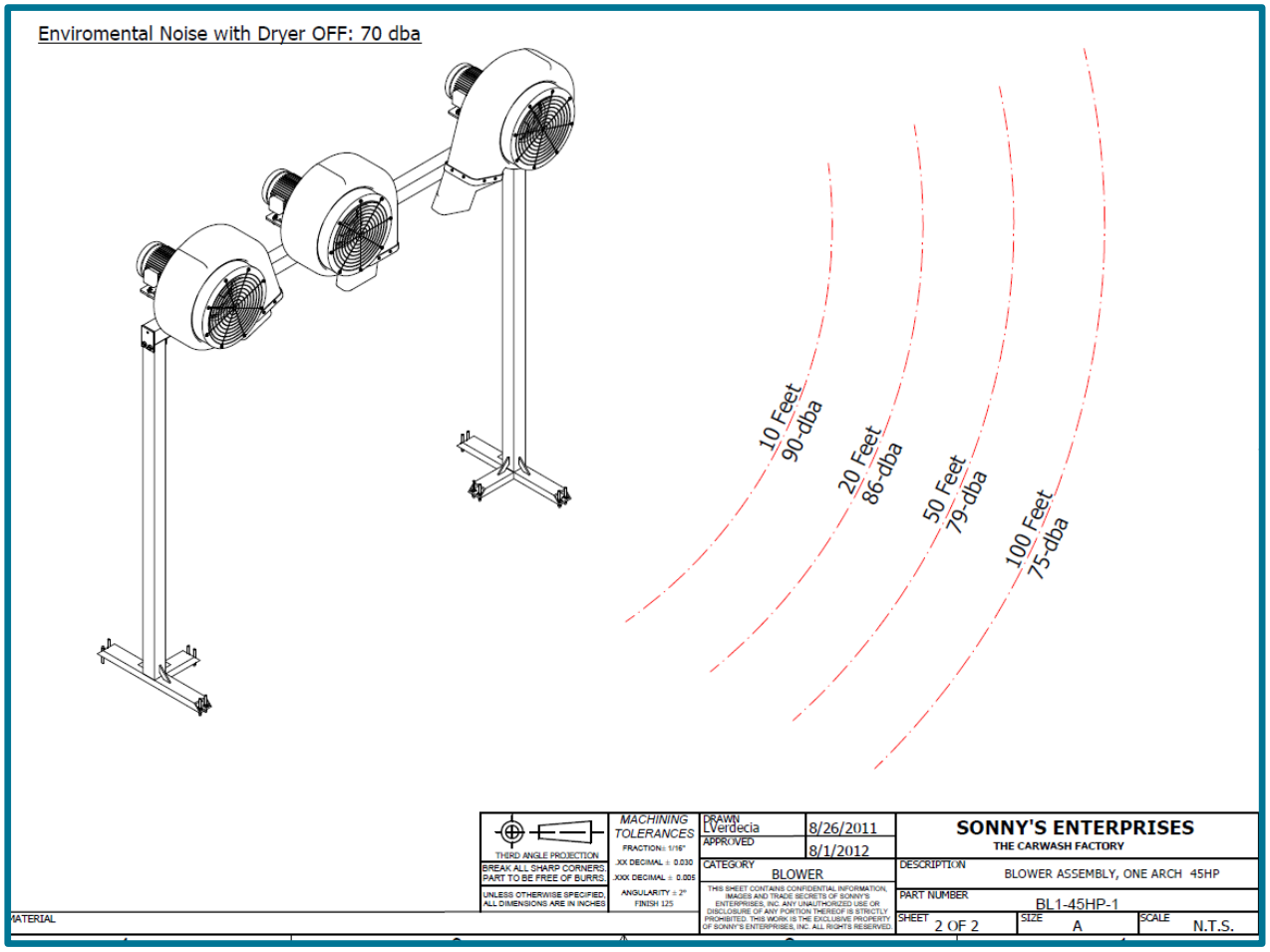
3.2 Expected Noise Levels with Project

3.2.1 Project Noise Sources

All sources that would potentially add a significant increase to the resulting noise levels for the area are included in the next several sound level contour figures in this subsection. Those are, namely:

- **Car wash blower dryers**, located overhead, approximately 10-feet from the end of the exit tunnel. Manufacturer levels for this system are shown in Figure 9. Sound levels were provided by the Client from Sonny's Enterprises. Car wash dryers are conservatively assumed to operate continuously (60 minutes per hour) at maximum capacity and were initially modeled with 12 blowers.

Figure 9: Car Wash Tunnel Blowers/Dryers Definition



Sound levels in the model and the sound attenuation within the tunnel were checked against levels measured at a similar car wash in Lauderhill, Florida with dryers from the

same manufacturer (per consultant's report[5] provided by Client). We assume the Lauderhill car wash also included 12 dryers. Based on these measured levels, we also determined there was approximately 1.5 dB of attenuation for every 10 ft of the tunnel length, which can be attributed to sound absorption within the tunnel as well as objects (vehicles, car wash equipment) blocking sound transmission from the blowers to the entrance of the tunnel. See Table 2, below, for comparison of the measured levels for the Lauderhill car wash with modeled levels for the proposed Carson car wash, with and without silencers on the blowers. Differences in sound levels can be attributed to the variation in tunnel sizes and placement of the blowers.

Table 2: Details and Comparison of Measured and Modeled Noise Levels for the Lauderhill and Proposed Carson Car Washes

	Lauderhill, FL		Carson, CA (proposed)	
Number of Blowers	12	12	12	12
Tunnel Length (ft)	90	90	83	83
Distance from Exit to Blowers (ft)	22	22	10	10
Silencers	No	Yes	No	Yes
Location	**Measured L_{eq} (dBA)**		**Modeled L_{eq} (dBA)**	
At 31 ft before entrance	77.7	76.5	71.6	70.4
At car wash entrance	88.3	87.1	87.9	86.7
At car wash exit	96.3	92.8	101.5	97.0
At 29 ft past exit	84.8	80.3	85.0	80.5

It is also important to note that the sound level from the dryers far exceeds the sound levels produced during the wash cycle and they are the principal sound source for the tunnel. The car wash cycles were modeled for the daytime hours of 7am – 7pm only, as permitted by the Noise Control Ordinance. *If a different / louder dryer system is selected, the car wash may not comply.*

- **Twelve (12) Vacutech vacuum cleaner nozzles** associated with the new car wash, which are modeled as point sources each with a sound power level "L_{WA}" of 72.7 dBA. (See the Appendix for definitions of sound pressure and sound power levels.) The vacuum turbine motors will be enclosed within the vacuum equipment room in the car wash building, which will be constructed with concrete block, and are not expected to be a significant source for this Project. Levels associated with the nozzles were modeled per

[5] WSP, "Sonny's Car Wash Blower and Silencer Noise Measurement Tests 10/3/18, Prestige Car Wash – 4921 N. University Drive, Lauderhill FL 33351"

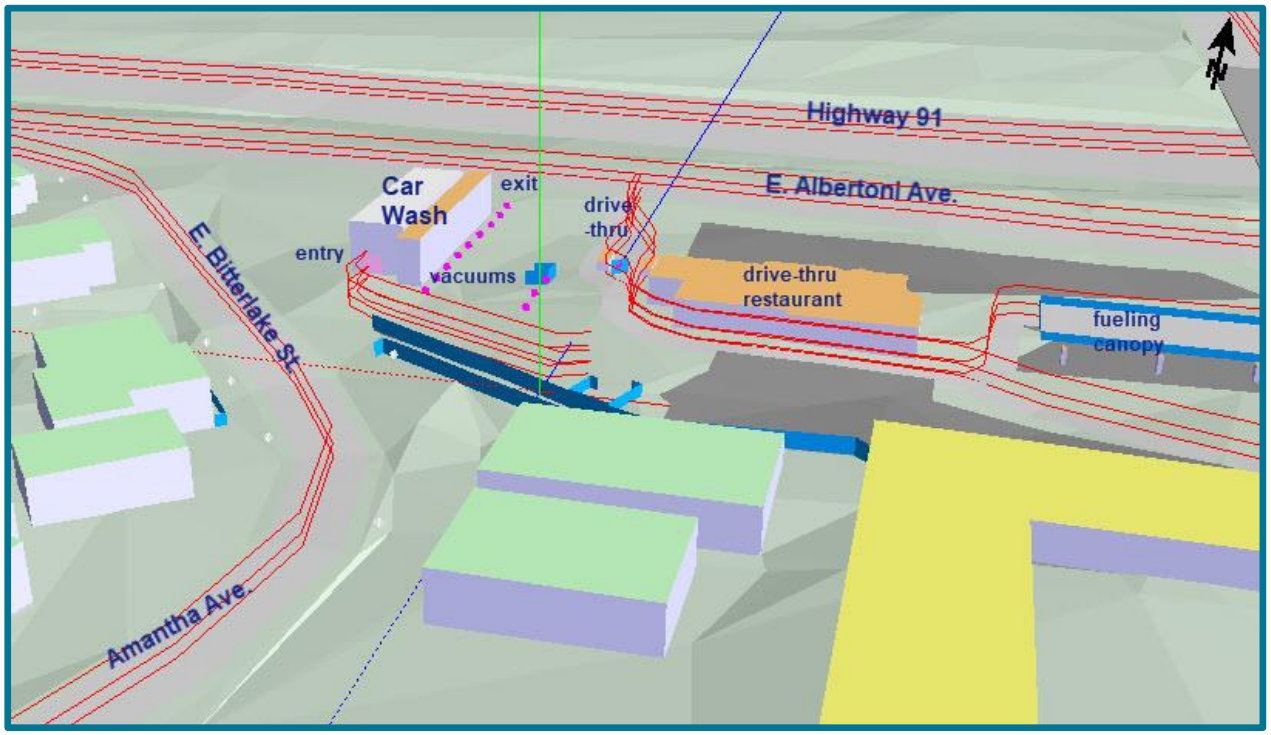
levels measured by MD Acoustics for a similar project using Vacutech equipment.[6] Equipment was assumed to operate at 50% duty, or no more than 30 minutes per hour.

- **Cars** associated with the car wash, conservatively modeled as a full queue of cars with a maximum capacity of 125 vehicles per hour.

3.2.2 Project Site

A 3D visualization of the project site model is shown below in Figure 10, based on the site plan from Figure 2. The mitigation previously recommended has been re-evaluated based upon this revised site plan.

Figure 10: 3D View of Model Geometry

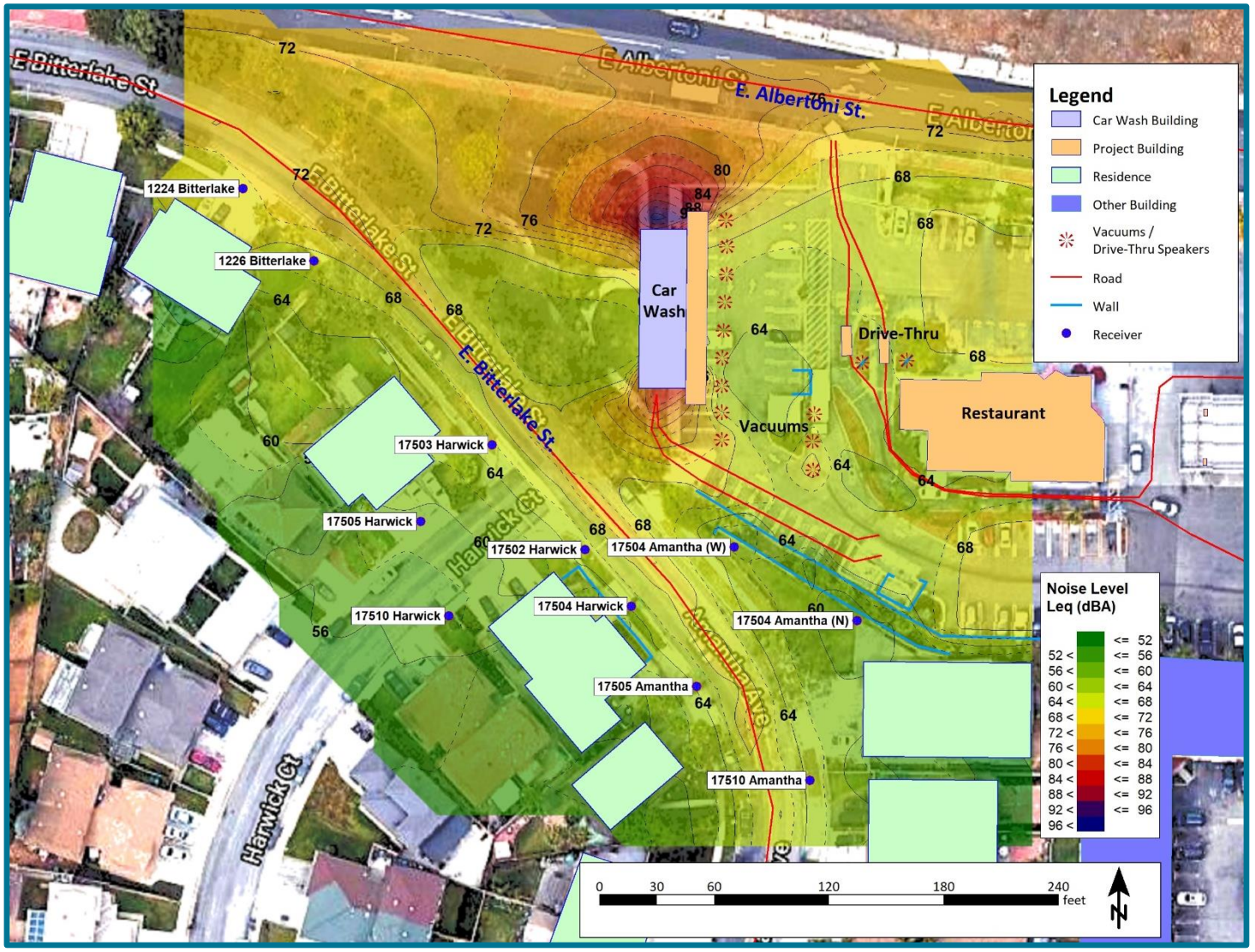


3.2.3 Modeled Expected Noise Levels

The resulting maximum expected noise contours are shown below in Figure 11. These represent the expected sound levels with the car wash dryers operating continuously and twelve vacuums running 30 minutes per hour.

[6] MD Acoustics, LLC, "Quick Quack Car Wash Laurel Plaza (Store #8-034) Noise Impact Study", 2021. https://www.ci.oakley.ca.us/wp-content/uploads/2022/02/Quick-Quack-Updated-Noise-Impact-Study_2021-12-08.pdf

Figure 11: Daytime Noise Contours (7am – 7pm) With Project



4 Project Compliance Evaluation

Receiver locations at the residential locations to the south and southwest of the project site were identified and evaluated for potential impact, as identified above by their residential addresses in Figure 11. As previously discussed in Section 2.2.2, per the Carson Noise Element, hourly levels due to car wash noise may not exceed 55 dBA during the daytime hours. Where ambient levels are greater than 55 dBA, an increase of 3 dB or more over the ambient noise level is considered a significant increase (as discussed with the LA County Noise Control Ordinance in Section 2.2.1).

The daytime hourly levels during operating hours ("$L_{eq,7am-7pm}$") and maximum ("L_{max}") levels at each of the residential receiver locations are shown below in Table 3 along with the source contribution of the car wash dryers and vacuums only, without traffic. With the project in place, daytime levels at residential locations are expected to increase by up to 3.2 dB over the daytime ambient levels. Levels due only to the car wash (dryers and vacuums) are also expected to exceed the 55 dBA limit at several locations. Due to this exceedance, and because an increase of 2 dB or more over the ambient noise level is considered to be a significant increase, mitigation is required.

Table 3: Hourly and Maximum Sound Levels at Selected Residential Locations With Proposed Car Wash During Operating Hours (7am – 7pm)

Receiver Location	*Ambient* $L_{eq,\ 7am-7pm}$ dB(A)	*(Car Wash Dryers + Vacuums Only)* $L_{eq,\ 7am-7pm}$ dB(A)	*Total (Dryers + Vacs + Traffic)* $L_{eq,\ 7am-7pm}$ dB(A)	*Maximum* L_{max}* dB(A)	*Increase over Ambient (Total – Ambient)* $L_{eq,\ 7am-7pm}$ dB(A)
1224 Bitterlake	68	65	70	**65**	1.9
1226 Bitterlake	67	59	68	**59**	0.8
17502 Harwick	64	60	65	**59**	1.5
17503 Harwick	64	61	66	**61**	2.0
17504 Amantha (N)	59	51	60	51	0.7
17504 Amantha (W)	61	55	62	55	1.1
17504 Harwick	64	59	65	**58**	1.2
17505 Amantha	64	55	64	54	0.6
17505 Harwick	**56**	56	59	**56**	**3.2**
17510 Amantha	63	51	63	51	0.3
17510 Harwick	55	55	58	54	**3.0**

* L_{max} levels are due solely to the car wash dryers and vacuums and do not include local traffic

5 Mitigation

5.1 Methods for Mitigation

Based on our analysis, we found that the car wash dryers are significantly louder than noise from the vacuums at the nearby residential property lines. In order to comply with the City and County noise limits, noise levels from the most significant source of noise at the project, the car wash dryers, must be reduced.

We have evaluated combinations of the following methods for mitigating the noise from the car wash blowers to the nearby residential properties, including reducing the number of blowers, adding silencers, and a wall near the entrance to the car wash tunnel. From this analysis, we found two options that would provide appropriate mitigation for the proposed car wash with the dryers operating continuously.

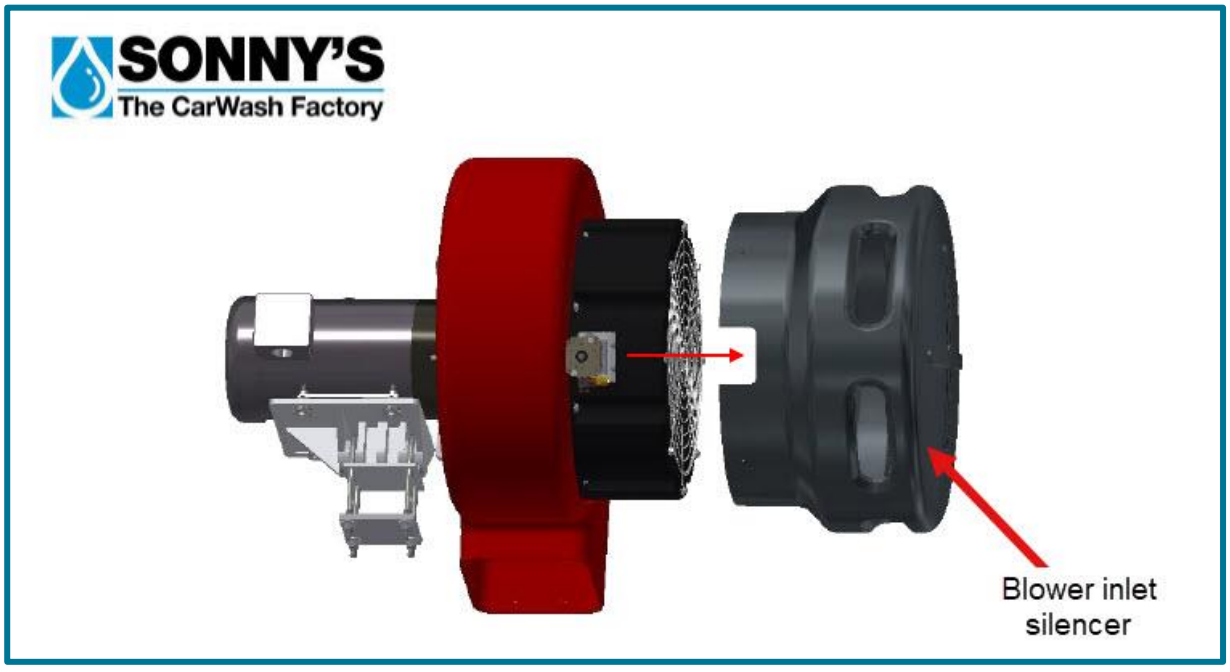
5.1.1 Reduced Number of Blowers

The array of dryers within the tunnel can be reduced from 12 blowers to 6 or 8 blowers.

5.1.2 Silencers on Car Wash Blowers

To reduce noise levels, Sonny's offers **Car wash blower silencers** (shown below in Figure 12) installed on each blower inlet. The Lauderhill car wash noise report (referenced above in Section 3.2.1) provides sound levels at a similar car wash tunnel, which we utilized to adjust our car wash to match those levels in and near the tunnel exit and entrance. Levels at the car wash exit were reduced by 4.5 dB and levels at the entrance were reduced by 1.2 dB with the silencers added; these reductions were incorporated into our mitigated noise model.

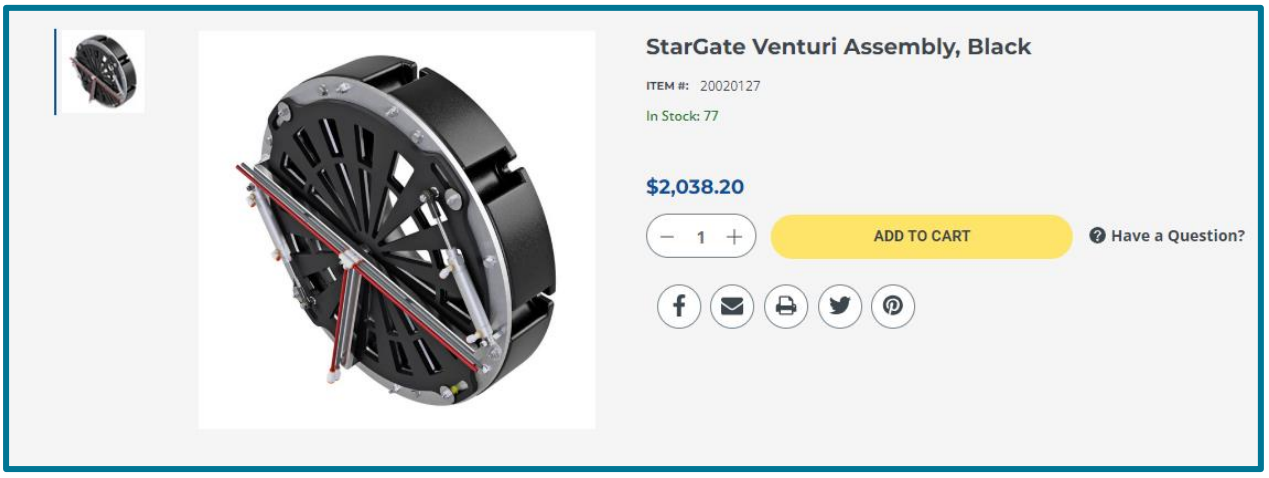
Figure 12: Car Wash Blower with Silencer



5.1.3 Stargate Venturi

The **Stargate Venturi** assembly, shown below in Figure 13, can be added to each blower by shutting off air flow through the device in order to lower noise levels between vehicle dry cycle. A noise level reduction was not provided; therefore, this option was not evaluated.

Figure 13: StarGate System



5.1.4 Noise Barrier Walls

Solid CMU walls near the entrance and/or exit can be constructed to reduce noise levels radiated from the car wash tunnel ends to the nearby residential properties.

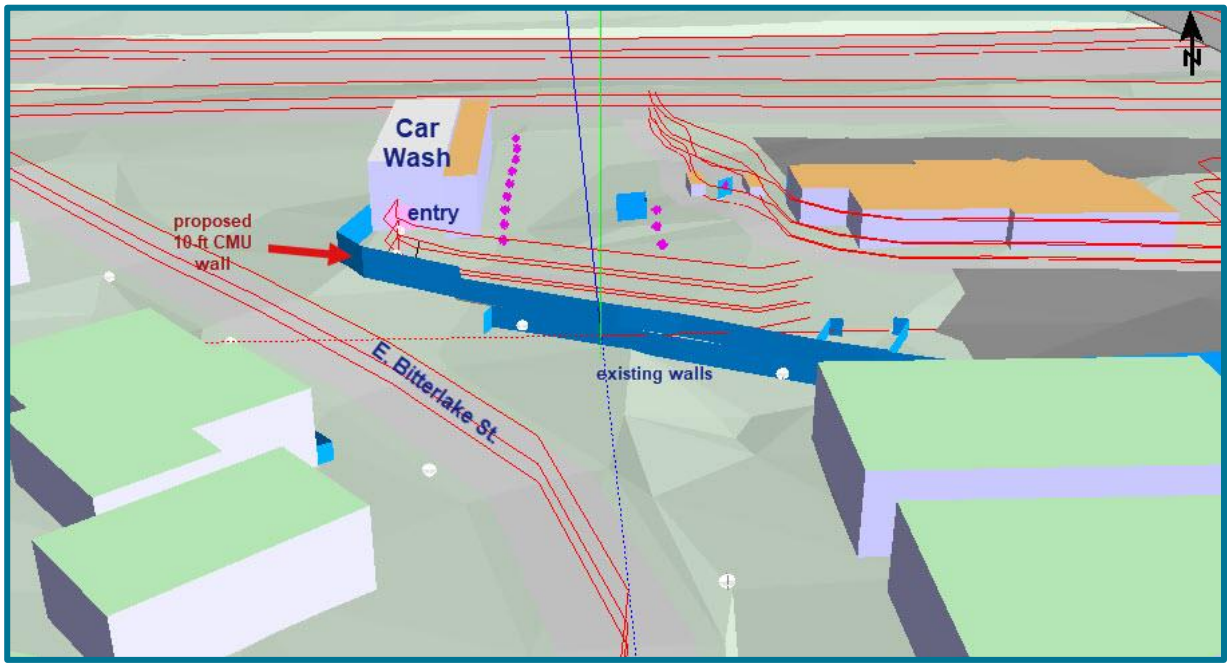
5.1.5 Sound Absorptive Materials

Sound absorptive materials can be added within the tunnel to reduce reverberant noise levels produced by the car wash dryers. As modeled initially in Section 3.2.3, we assume that the proposed tunnel will have interior absorptive materials similar to the car wash discussed in the Lauderhill car wash report (Section 3.2.1).

5.2 Mitigation Option A

Option A, which includes silencers on all twelve blowers in combination with a 10-ft CMU wall next to the car wash tunnel entrance (along the west side of the entrance driveway, as pictured in Figure 14 below), provides a high level of mitigation and meets the Noise Element at all but one residential receiver location. The resulting levels are shown below in Table 4. As highlighted in bold, red text, the mitigated hourly sound level at 1224 Bitterlake Rd, due to the car wash only, would be 61 dBA, however the total noise level would only exceed the ambient sound level by less than 1 dB, which is less than significant. A wall at the west side of the car wash exit *may* sufficiently reduce the levels at 1224 Bitterlake to meet the Noise Element. Levels at all other residential locations will not exceed the Noise Element limit of 55 dBA for non-transportation noise. Additionally, the maximum (L_{max}) levels do not exceed the existing ambient levels or the Noise Element limit of 75 dBA.

Figure 14: 3D View of Model Geometry with 10-ft CMU Wall at Entry (Mitigation Option A)



5.3 Mitigation Option B

Option B, which may be more cost-effective than option A, includes a reduction in the number of blowers to 6, with silencers, and would also provide a high level of mitigation to meet the Noise Element at all but two residential receiver locations. The resulting levels are shown below in Table 4. As with Option A, the overall hourly noise level at these locations only exceeds the ambient sound level by less than 1 dB. Levels at all other residential locations will not exceed the Noise Element hourly daytime limit of 55 dBA for non-transportation noise and the maximum (L_{max}) levels do not exceed the existing ambient levels or the Noise Element's maximum limit of 75 dBA.

Table 4: Comparison of Mitigated Receiver Levels at Residential Locations During Operating Hours (7am – 7pm)

Receiver Location	*AMBIENT*	*PROPOSED PROJECT: 12 blowers, no mitigation*				*MITIGATION OPTION A: 12 blowers + silencers + 10-ft wall at entrance*				*MITIGATION OPTION B: 6 blowers + silencers*			
	L_{eq},7a-7p dB(A)	L_{eq},7a-7p dB(A)	L_{max} * dB(A)	L_{eq},7a-7p Carwash only dB(A)	Increase over Ambient L_{eq}	L_{eq},7a-7p dB(A)	L_{max} * dB(A)	L_{eq},7a-7p Carwash only dB(A)	Increase over Ambient L_{eq}	L_{eq},7a-7p dB(A)	L_{max} * dB(A)	L_{eq},7a-7p Carwash only dB(A)	Increase over Ambient L_{eq}
1224 Bitterlake	**68**	70	65	**65**	1.9	69	61	**61**	0.7	68	58	**58**	0.4
1226 Bitterlake	**67**	68	59	**59**	0.8	67	55	55	0.3	67	52	52	0.2
17502 Harwick	**64**	65	59	**60**	1.5	64	49	50	0.2	64	55	55	0.6
17503 Harwick	**64**	66	61	**61**	2.0	64	52	53	0.5	65	57	**57**	0.9
17504 Amantha (N)	**59**	60	51	51	0.7	59	48	49	0.3	59	46	47	0.2
17504 Amantha (W)	**61**	62	55	**55**	1.1	62	52	53	0.6	62	51	51	0.5
17504 Harwick	**64**	65	58	**59**	1.2	64	50	51	0.2	64	54	54	0.5
17505 Amantha	**64**	64	54	55	0.6	64	48	48	0.2	64	50	50	0.2
17505 Harwick	**56**	59	56	**56**	3.2	57	47	49	0.7	57	51	52	1.4
17510 Amantha	**63**	63	51	51	0.3	63	49	49	0.2	63	47	47	0.1
17510 Harwick	**55**	58	54	55	3.0	56	46	47	0.6	56	50	50	1.3

* L_{max} levels are due solely to the car wash dryers and vacuums and do not include local traffic

5.4 Source Contribution Levels

The resulting sound level at any location is the summation of the road noise and project noise levels, and our software modeling includes the contribution of three reflections of each frequency band—an aspect of propagation often overlooked by more simplistic forms of acoustical analysis where 3D modeling software is not utilized. The source contributions of the road noise and project noise (with the most significant sources for each indicated in parentheses) are detailed below for the "1224 Bitterlake" receiver in Table 5.

Table 5: Source Contribution Levels at Receiver "1224 Bitterlake"

	Ambient	Proposed		Mitigated - Option A	
Noise Source	$L_{eq,7am-7pm}$ dB(A)	$L_{eq,7am-7pm}$ dB(A)	L_{max} dB(A)	$L_{eq,7am-7pm}$ dB(A)	L_{max} dB(A)
Road Noise (Hwy 91), Drive-Thru Speakers, and Site Traffic	68	68	--	68	--
Project Noise (Car Wash Dryers + Vacuums)	--	65	65	61	61
Total Noise Level	**68**	**70**	**65**	**69**	**61**

While the Noise Element states that daytime hourly levels due to the project may not exceed 55 dBA at the residential locations, where the existing ambient level is much greater, the total cumulative noise levels at some residential locations is minimally impacted. For example, when adding two sound levels of equal sound level, the total becomes 3 dB greater.

At some locations, the noise level from the proposed project sources (car wash dryers and vacuums) alone will not exceed the existing ambient level due to road noise—noise levels due to the car wash alone are at or below the existing levels due primarily to road traffic, as well as the existing drive-through restaurant and fuel station.

Even if the car wash sound levels were 10 dB lower than the existing ambient, the total noise level would increase by 0.4 dB—it is impossible to add any sound source, however small, to an existing environment without causing some increase to the ambient, however small and imperceptible it may be. We therefore interpret the Code to mean that sound levels due to the project alone must be at or below the existing ambient, which will maintain the increase in total/cumulative sound levels with the project to no greater than a 3 dB increase, which is generally not a significant or perceptible change in level for the average human ear.

Conversely, if there is concern about time periods where the ambient noise levels are significantly quieter than predicted, i.e., traffic is reduced significantly, the car wash noise in Table 5 would still be significantly lower than the ambient levels. For example, if the traffic is reduced by 50%, the ambient levels would be reduced by approximately 3 dB to 65 dBA and the total hourly noise level, with traffic plus the car wash dryers and vacuums, would be 66 dBA and still only a 1 dB increase over the ambient.

Under controlled conditions in an acoustics laboratory, the trained, healthy human ear is able to discern changes in sound levels of 1 dB when exposed to steady, single-frequency signals in the mid-frequency range. Outside such controlled conditions, the *trained* ear can detect changes of 2 dBA in normal environmental noise. It is widely accepted that the average healthy ear, however, can barely perceive noise level changes of 3 dB. A change of 5 dB is readily perceptible, and a change of 10 dB is perceived as twice, or half, as loud. (See Appendix, Section 8.1.)

Since an increase of 3 dB is barely perceptible by the average person's ear, the daytime and nighttime levels with the proposed project (with either mitigation option) would comply with the City and County limits. Additionally, the proposed car wash levels with both mitigation options are equal to or less than the existing noise levels due to road traffic and existing drive-through restaurant and fuel station.

6 Construction Noise and Vibration

6.1 Short Term Construction Noise and Vibration

Construction noise is regulated by the County of Los Angeles Noise Control Ordinance, Section 12.08.440, excerpted below in Figure 15. Construction noise is only permitted from 7am to 7pm daily, except for Sundays and legal holidays, and must not exceed the levels at residential property lines as specified below for mobile and station equipment.

Figure 15: County of Los Angeles Noise Control Ordinance, Section 12.08.440 – Construction noise

12.08.440 - Construction noise.

A. Operating or causing the operation of any tools or equipment used in construction, drilling, repair, alteration or demolition work between weekday hours of 7:00 p.m. and 7:00 a.m., or at any time on Sundays or holidays, such that the sound therefrom creates a noise disturbance across a residential or commercial real-property line, except for emergency work of public service utilities or by variance issued by the health officer is prohibited.

B. Noise Restrictions at Affected Structures. The contractor shall conduct construction activities in such a manner that the maximum noise levels at the affected buildings will not exceed those listed in the following schedule:

1. At Residential Structures.

a. Mobile Equipment. Maximum noise levels for nonscheduled, intermittent, short-term operation (less than 10 days) of mobile equipment:

EXPAND

	Single-family Residential	Multi-family Residential	Semiresidential/ Commercial
Daily, except Sundays and legal holidays, 7:00 a.m. to 8:00 p.m.	75dBA	80dBA	85dBA
Daily, 8:00 p.m. to 7:00 a.m. and all day Sunday and legal holidays	60dBA	64dBA	70dBA

b. Stationary Equipment. Maximum noise level for repetitively scheduled and relatively long-term operation (periods of 10 days or more) of stationary equipment:

EXPAND

	Single-family Residential	Multi-family Residential	Semiresidential/ Commercial
Daily, except Sundays and legal holidays, 7:00 a.m. to 8:00 p.m.	60dBA	65dBA	70dBA
Daily, 8:00 p.m. to 7:00 a.m. and all day Sunday and legal holidays	50dBA	55dBA	60dBA

2. At Business Structures.

a. Mobile equipment. Maximum noise levels for nonscheduled, intermittent, short-term operation of mobile equipment:

Daily, including Sunday and legal holidays, all hours: maximum of 85dBA.

C. All mobile or stationary internal-combustion-engine powered equipment or machinery shall be equipped with suitable exhaust and air-intake silencers in proper working order.

D. In case of a conflict between this chapter and any other ordinance regulating construction activities, provisions of any specific ordinance regulating construction activities shall control.

(Ord. 11778 § 2 (Art. 5 § 501(c)), 1978: Ord. 11778 § 2 (Art. 5 § 501(c)), 1978.)

Construction of the project would generate noise that may temporarily increase noise levels at nearby residential receivers. Noise impacts resulting from construction depend on the noise generated by various pieces of construction equipment operating on site, the timing and duration of noise generating activities, and the distance between construction noise sources and sensitive receptors.

Short-term construction activities for a project of this scope can generate moderate noise levels, especially during the construction of project infrastructure when limited heavy equipment is used. Noise impacts resulting from construction depend on the noise generated by various pieces of construction equipment, the timing and duration of noise generating activities, and the distance between construction noise sources and noise sensitive receptors. Specific sound levels from construction equipment are shown in Table 6. Since the nearest homes are approximately 100 feet away from the nearest project buildings, noise levels are expected to be in the 69-83 dBA range at those receptors for the type of equipment expected here (see Table 6).

Table 6: Typical Construction Equipment Noise Levels (dBA)

Equipment Onsite	Typical Noise Level 50ft from Source	Typical Noise Level 400ft from Source	Typical Noise Level 800ft from Source	Typical Noise Level 1,000ft from Source	Typical Noise Level 1,600ft from Source
Air Compressor	78	60	54	52	**48**
Backhoe	78	60	54	52	**48**
Bobcat Tractor	78	60	54	52	**48**
Concrete Mixer	79	61	55	53	**49**
Bulldozer	82	64	58	56	**52**
Jack Hammer	89	71	65	63	**59**
Pavement Roller	80	62	56	54	**50**
Street Sweeper	82	64	58	56	**52**
Man Lift	75	57	51	49	**45**
Dump Truck	76	58	52	50	**46**

Notes:

1) **The distances shown in this table represent minimum distances at which sources can be located from construction activity before a potentially significant impact would occur.**
2) **Noise levels based on actual maximum measured noise levels at 50 feet (Lmax).**
3) **Noise levels assume a noise attenuation rate of 6 dBA per doubling of distance.**

Source: FHWA Roadway Construction Noise Model (2006) Users Guide Table 1.

The project developer/applicant is expected to adhere to the City's requirements for construction activities with respect to hours of operation, muffling of internal combustion engines, and other factors which affect construction noise generation and its effects on noise sensitive land uses. Therefore, the following controls should be adhered to during Project construction:

- Limit noise-generating construction operations to between the least noise-sensitive periods of the daytime hours Monday through Saturday; no construction operations on Sundays or holidays.
- Ensure that construction equipment is properly maintained and equip all internal combustion engine-driven equipment with intake and exhaust mufflers that are in good condition and appropriate for the equipment.
- Locate stationary noise generating equipment (e.g., compressors) and equipment staging areas as far as possible from adjacent residential receivers.

With the implementation of these controls, and the limited duration of the noise-generating construction period, the substantial temporary increase in ambient noise levels associated with construction activities would be less-than-significant.

6.2 Vibration

The potential for vibration near a highway is defined and described in the Federal Transit Administration (FTA) *Transit Noise and Vibration Impact Assessment Manual*[7]. The approximate human threshold of perception to vibration is 70 VdB (Vibration Velocity Level, dB). Buses, trucks and heavy street traffic at 50 feet distance from the highway is equal to 70 VdB or less. Vibration levels along transportation corridors are proportional to the speed and weight of the vehicles as well as the condition of the roadway and vehicle engines and tires. Typically, the setback to the 70 VdB contour along roadways is 100 feet or less from the centerline.

As discussed previously in Section 2.2, the County of Los Angeles Noise Control Ordinance, Section 12.08.560 (Figure 6), prohibits perceptible ground borne vibration levels at private properties to levels below 0.01 in/sec. According to the FTA *Transit Noise and Vibration Assessment Manual*, a loaded truck would have a vibration level of 0.076 in/sec when measured at 25 feet. At 100 feet, this would be approximately 0.0095 in/sec and below the County's limits for ground borne vibration.

Residential locations near the current project are located 75 feet or more from the project. Vibration levels due to the car wash are anticipated to be less than the human threshold of perception and below the County's limits for ground borne vibration at neighboring properties.

[7] Federal Transit Administration, prepared by John A. Volpe National Transportation Systems Center. Transit Noise and Vibration Impact Assessment Manual. Sept 2018. https://www.transit.dot.gov/sites/fta.dot.gov/files/docs/research-innovation/118131/transit-noise-and-vibration-impact-assessment-manual-fta-report-no-0123_0.pdf

7 Conclusions and Recommendations

Predicted noise levels were modeled for the project area and compared to the City and County's limits on Daytime and Maximum exterior noise levels. Because the daytime exterior noise levels due to the car wash (dryers and vacuums) at some of the nearby residential homes are anticipated to exceed the 55 dBA daytime hourly limit specified by the Carson Noise Element as well as the existing ambient levels during daytime hours, additional mitigation is required.

Based on our analysis, we evaluated multiple options for mitigation and recommend implementing one of the following two mitigation options to comply with the City and County limits.

- **Option A:** Add silencers to all twelve blowers within the tunnel and add a 10-ft CMU wall next to the west side of the tunnel entrance.
- **Option B:** Reduce the number of blowers to six and add silencers to each blower.

These predictions are based upon the following assumptions:

- Car wash dryers operate continuously, 60 minutes per hour, only during daytime hours (7am-7pm).
- Absorption is added within the tunnel to reduce reverberant noise levels.
- Car wash dryer noise levels are not greater than 80dBA (for Option A) or 77 dBA (for Option B) when measured 10-ft from the car wash entrance, with mitigation in place. *We recommend verification measurements to ensure this level is met.*

Assuming mitigation is effectively implemented into the project and the car wash operates with the above conditions, this project is predicted to meet the City of Carson's Noise Element and Municipal Code. However, as with anything, the design and quality of installation of car wash blowers and silencers varies. We recommend on-site sound level measurements of the operational car wash to further confirm anticipated compliance.

Residential locations near the current project are located 75 feet or more from the project. Vibration levels due to the car wash are anticipated to be less than the human threshold of perception and below the County's limits for ground borne vibration at neighboring properties.

The conclusions and recommendations of this acoustical analysis are based upon the information known to 45dB Acoustics, LLC ("**45dB**") at the time the analysis was prepared concerning the proposed site plans, traffic volumes, proposed mechanical and car wash equipment, hours of operation, and reference noise level data. Any significant changes to these factors will require a reevaluation of the findings of this report. Additionally, any significant future changes in equipment, noise regulations or other factors beyond **45dB**'s control may result in long-term noise results different from those described by this analysis.

8 Appendix

8.1 Characteristics of Sound

When an object vibrates, it radiates part of its energy as acoustical pressure in the form of a sound wave. Sound can be described in terms of amplitude (loudness), frequency (pitch), or duration (time). The human hearing system is not equally sensitive to sound at all frequencies. Therefore, to approximate this human, frequency-dependent response, the A-weighted filter system is used to adjust measured sound levels. The normal range of human hearing extends from approximately 0 to 140 dBA. Unlike linear units such as inches or pounds, decibels are measured on a logarithmic scale, representing points on a sharply rising curve. Because of the physical characteristics of noise transmission and of noise perception, the relative loudness of sound does not closely match the actual amounts of sound energy. Table 7 below presents the subjective effect of changes in sound pressure levels[8].

Table 7: Sound Level Change and Relative Loudness/Acoustic Energy Loss

Change in Level	Relative Loudness Perception
0 dB	Reference 0%
+/- 3 dB	Just Perceptible Change 50%
+/- 5 dB	Readily Perceptible Change 67%
+/-10 dB	Half as Loud 90%
-20 dB	1/4 as Loud 99%
-30 dB	1/8 as Loud 99.9%

Sound levels are generated from a source and their decibel level decreases as the distance from that source increases. Sound dissipates exponentially with distance from the noise source. This phenomenon is known as spreading loss. Generally, sound levels from a point source will decrease by 6 dBA for each doubling of distance. Sound levels for a highway line source vary differently with distance because sound pressure waves propagate along the line and overlap at the point of measurement. A closely spaced, continuous line of vehicles along a roadway becomes a line source and produces a 3 dBA decrease in sound level for each doubling of distance. However, experimental evidence has shown that where sound from a highway propagates close to “soft” ground (e.g., plowed farmland, grass, crops, etc.), a more suitable drop-off rate to use is not 3.0 dBA but rather 4.5 dBA per distance doubling (FHWA 2010).

When sound is measured for distinct time intervals, the statistical distribution of the overall sound level during that period can be obtained. The L_{eq} is the most common parameter associated

[8] Highway Traffic Noise Analysis and Abatement Policy and Guidance, U.S. Department of Transportation, Federal Highway Administration, Office of Environment and Planning, Noise and Air Quality Branch, June 1995.

with such measurements. The L_{eq} metric is a single-number noise descriptor that represents the average sound level over a given period of time. For example, the L50 noise level is the level that is exceeded 50 percent of the time. This level is also the level that is exceeded 30 minutes in an hour. Similarly, the L02, L08 and L25 values are the noise levels that are exceeded 2, 8, and 25 percent of the time or 1, 5, and 15 minutes per hour. Other values typically noted during a noise survey are the L_{min} and L_{max}. These values represent the minimum and maximum root-mean-square noise levels obtained over the measurement period.

Because community receptors are more sensitive to unwanted noise intrusion during the evening and at night, State law requires that, for planning purposes, an artificial dB increment be added to quiet-time noise levels in a 24-hour noise descriptor called the CNEL or L_{dn}. This increment is incorporated in the calculation of CNEL or L_{dn}, described earlier.

8.2 Terminology/Glossary

A-Weighted Sound Level (dBA)
The sound pressure level in decibels as measured on a sound level meter using the internationally standardized A-weighting filter or as computed from sound spectral data to which A-weighting adjustments have been made. A-weighting de-emphasizes the low and very high frequency components of the sound in a manner similar to the response of the average human ear. A-weighted sound levels correlate well with subjective reactions of people to noise and are universally used for community noise evaluations.

Air-borne Sound
Sound that travels through the air, differentiated from structure-borne sound.

Ambient Sound Level
The prevailing general sound level existing at a location or in a space, which usually consists of a composite of sounds from many sources near and far. The ambient level is typically defined by the L_{eq} level.

Background Sound Level
The underlying, ever-present lower-level noise that remains in the absence of intrusive or intermittent sounds. Distant sources, such as Traffic, typically make up the background. The background level is generally defined by the L90 percentile noise level.

Community Noise Equivalent Level (CNEL)
The L_{eq} of the A-weighted noise level over a 24-hour period with a 5-dB penalty applied to noise levels between 7 p.m. and 10 p.m. and a 10-dB penalty applied to noise levels between 10 p.m. and 7 a.m. CNEL is similar to L_{dn}.

Day-Night Sound Level (L_{dn} or DNL)
The L_{eq} of the A-weighted noise level over a 24-hour period with a 10-dB penalty applied to noise levels between 10 p.m. and 7 a.m. L_{dn} is similar to CNEL.

Decibel (dB)
The decibel is a measure on a logarithmic scale of the magnitude of a particular quantity (such as sound pressure, sound power, sound intensity) with respect to a reference quantity.

DBA or dB(A)
A-weighted sound level. The ear does not respond equally to all frequencies, and is less sensitive at low and high frequencies than it is at medium or speech range frequencies. Thus, to obtain a single number representing the sound level of a noise containing a wide range of frequencies in a manner representative of the ear's response, it is necessary to reduce the effects of the low and high frequencies with respect to the medium frequencies. The resultant sound level is said to be A-weighted, and the units are dBA. The A-weighted sound level is also called the noise level.

Energy Equivalent Level (L_{eq})
Because sound levels can vary markedly in intensity over a short period of time, some method for describing either the average character of the sound or the statistical behavior of the variations must be utilized. Most commonly, one describes ambient sounds in terms of an average level that has the same acoustical energy as the summation of all the time-varying events. This energy-equivalent sound/noise descriptor is called L_{eq} . In this report, an hourly period is used.

Field Sound Transmission Class (FSTC)
A single number rating similar to STC, except that the transmission loss values used to derive the FSTC are measured in the field. All sound transmitted from the source room to the receiving room is assumed to be through the separating wall or floor-ceiling assembly.

Noise Reduction (NR)
Noise reduction is the difference between outdoor sound level and indoor sound level. It is not identical to Sound Transmission Class.

Outdoor-Indoor Transmission Class (OITC)
A single number classification, specified by the American Society for Testing and Materials (ASTM E 1332 issued 1994), that establishes the A-weighted sound level reduction provided by building facade components (walls, doors, windows, and combinations thereof), based upon a reference sound spectrum that is an average of typical air, road, and rail transportation sources. The OITC is the preferred rating when exterior façade components are exposed to a noise environment dominated by transportation sources. Once built, as much as a 5-point reduction in Apparent Outside-Inside Transmission Class (OITC) from the original, as-designed OITC may be expected.

Percentile Sound Level, Ln
The noise level exceeded during *n* percent of the measurement period, where *n* is a number between 0 and 100 (e.g., L10 or L90)

Sound Transmission Class (STC)
STC is a single number rating, specified by the American Society for Testing and Materials, which can be used to measure the sound insulation properties for comparing the sound transmission capability, in decibels, of interior building partitions for noise sources such as speech, radio, and television. It is used extensively for rating sound insulation characteristics of building materials and products.

Structure-Borne Sound
Sound propagating through building structure. Rapidly fluctuating elastic waves in gypsum board, joists, studs, etc.

Sound Exposure Level (SEL)
SEL is the sound exposure level, defined as a single number rating indicating the total energy of a discrete noise-generating event (e.g., an aircraft flyover) compressed into a 1-second time duration. This level is handy as a consistent rating method that may be combined with other SEL and L_{eq} readings to provide a complete noise scenario for measurements and predictions. However, care must be taken in the use of these values since they may be misleading because their numeric value is higher than any sound level which existed during the measurement period.

Subjective Loudness Level
In addition to precision measurement of sound level changes, there is a subjective characteristic which describes how most people respond to sound:

- A change in sound level of 3 dBA is *barely perceptible* by most listeners.
- A change in level of 6 dBA is *clearly perceptible*.
- A change of 10 dBA is perceived by most people as being *twice* (or *half*) as loud.

8.3 SoundPLAN® Acoustics Software

SoundPLAN®, the software used for this acoustic analysis, is an acoustic ray-tracing program dedicated to the prediction of noise in the environment. Noise emitted by various sources propagates and disperses over a given terrain in accordance with the laws of physics. The software calculates sound attenuation of environmental noise, even over complex terrain, uneven ground conditions, and with complex obstacles. Up to three reflections for each noise source are taken into account to closely and accurately predict real-world acoustics. Worldwide, governments and engineering associations have created algorithms to calculate acoustical phenomena to standardize the assessment of physical scenarios. Accuracy has been validated in published studies to be + / - 2.7 dBA with an 85% confidence level, for a wide variety of large-scale models and situations.

8.4 ISO 9613-2

For industrial and other noise sources besides road traffic, SoundPLAN calculates the sound field in accordance with ISO 9613-2 “Acoustics - Attenuation of sound during propagation outdoors, Part 2: General Method of Calculation.” The standard states that “this part of ISO 9613 specifies an engineering method for calculating the attenuation of sound during propagation outdoors, in order to predict the levels of environmental noise at a distance from a variety of sources. The method predicts the equivalent continuous A-weighted sound pressure level under meteorological conditions favorable to propagation from sources of known sound emissions. These conditions are for downwind propagation under a well-developed moderate ground-based temperature inversion, such as commonly occurs at night.” Uncertainty of calculations with this method are +/-1 dB for sources less than 10m in height and within 1000m of the receiver.

8.5 Traffic Noise Model (TNM)

The Federal Highway Administration Traffic Noise Model (TNM), implemented into the SoundPLAN® software, was used for the road traffic sound level modeling in this study. TNM contains the following components:

1. Modeling of five standard vehicle types, including automobiles, medium trucks, heavy trucks, buses, and motorcycles, as well as user-defined vehicles.
2. Modeling both constant- and interrupted-flow traffic using a field-measured data base.
3. Modeling effects of different pavement types, as well as the effects of graded roadways.
4. Sound level computations based on a one-third octave-band data base and algorithms.
5. Graphically-interactive noise barrier design and optimization.
6. Attenuation over/through rows of buildings and dense vegetation.
7. Multiple diffraction analysis.
8. Parallel barrier analysis.
9. Contour analysis, including sound level contours, barrier insertion loss contours, and sound-level difference contours.

These components are supported by a scientifically founded and experimentally calibrated acoustic computation methodology, as well as a flexible database, made up of over 6000 individual pass-by events measured at forty sites across the country.