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MEMORANDUM

DATE: April 17, 2024

TO: Eric Perez, City of Orange

FROM: Jason Lui; Kevin Nguyendo; LSA Associates, Inc.

SUBJECT: Noise and Vibration Impact Analysis Memorandum for the Proposed Cannon Street Widening Project in the City of Orange, County of Orange, California

INTRODUCTION

This Noise and Vibration Impact Analysis Memorandum has been prepared to evaluate the potential noise and vibration impacts associated with construction and operation of the proposed Cannon Street Widening Project (project) in the City of Orange, County of Orange, California. This memorandum is intended to satisfy the City of Orange (City) and the California Environmental Quality Act requirements for a project-specific noise and vibration impact analysis by examining the impacts of the proposed project and evaluating, if necessary, the mitigation measures to reduce potential impacts to less than significant. All references cited in this memorandum are included in Attachment A.

PROJECT LOCATION

The project is located on Cannon Street between Santiago Canyon Road and Serrano Avenue in Orange, California. The project location is shown on Figure 1 (all figures are provided in Attachment B).

PROJECT DESCRIPTION

The proposed project will widen the roadway to accommodate a third northbound lane from approximately 500 feet north of Santiago Canyon Road to Serrano Avenue where it will join the existing dedicated right-turn lane to eastbound Serrano Avenue. As such, this additional lane will function as an auxiliary lane to improve traffic operations. South of Santiago Creek, additional pavement will be constructed to the east to widen the roadway to meet minimum standard horizontal curve radii. North of Santiago Creek, the roadway will be widened to the west by approximately 6 feet. In the southbound direction, bicyclists and pedestrians will cross Santiago Creek on a new bridge just west of the existing vehicular bridge. The new bridge will clear span the creek and is expected to consist of a prefabricated steel truss, approximately 170 feet long and 12 feet wide. The new bridge will carry two-way traffic for pedestrians and southbound traffic for bicyclists. Existing pavement delineation will be reconfigured and portions of the painted median will be replaced with a raised landscaped median. A traffic signal modification is required at Taft Avenue. Figure 2 shows the proposed project improvements.

The proposed improvements are not expected to require permanent right-of-way acquisitions. Temporary construction easements will be needed from the County of Orange to construct the new pedestrian bridge. A portion of the widening will be outside of the City of Orange's jurisdiction and within the City of Villa Park. The City has been and will continue to coordinate with Villa Park regarding the project. Utilities, traffic signals, and street lighting that are in conflict with the proposed improvements will be relocated.

Construction of the new pedestrian bridge will involve excavation for and construction of concrete abutments on the top of the Santiago Creek banks. The abutments will be supported on deep foundations, either cast-in-drilled-hole piles or driven piles. Construction of the roadway widening will involve the removal of existing pavement, sidewalk, and landscaping and the placement of fill material, aggregate base, hot mix asphalt pavement, and new guard rails. Tree removal and removal of other vegetation near the new bridge abutments will be necessary for the project.

During construction, Cannon Street will remain open to traffic. Lane shifts will be used to complete the widening work. Construction is expected to have a duration of approximately 8 months.

CHARACTERISTICS OF SOUND

Noise is usually defined as unwanted sound. Noise consists of any sound that may produce physiological or psychological damage and/or interfere with communication, work, rest, recreation, and sleep. To the human ear, sound has two significant characteristics: pitch and loudness. Pitch is generally an annoyance, while loudness can affect the ability to hear. Pitch is the number of complete vibrations, or cycles per second, of a wave resulting in the tone’s range from high to low. Loudness is the strength of a sound that describes a noisy or quiet environment and is measured by the amplitude of the sound wave. Loudness is determined by the intensity of the sound waves combined with the reception characteristics of the human ear. Sound intensity refers to how hard the sound wave strikes an object, which in turn produces the sound’s effect. This characteristic of sound can be precisely measured with instruments. The analysis of a project defines the noise environment of the project area in terms of sound intensity and its effect on adjacent sensitive land uses.

Measurement of Sound

Sound intensity is measured through the A-weighted scale to correct for the relative frequency response of the human ear. That is, an A-weighted noise level deemphasizes low and very high frequencies of sound similar to the human ear’s deemphasis of these frequencies. Decibels (dB), unlike the linear scale (e.g., inches or pounds), are measured on a logarithmic scale, which is a scale based on powers of 10.

For example, 10 dB is 10 times more intense than 0 dB, 20 dB is 100 times more intense than 0 dB, and 30 dB is 1,000 times more intense than 0 dB. Thirty decibels (30 dB) represents 1,000 times as much acoustic energy as 0 dB. The decibel scale increases as the square of the change, representing the sound pressure energy. A sound as soft as human breathing is about 10 times greater than 0 dB. The decibel system of measuring sound gives a rough connection between the physical intensity of sound and its perceived loudness to the human ear. A 10 dB increase in sound level is perceived by the human ear as only a doubling of the loudness of the sound. Ambient sounds generally range from 30 dB (very quiet) to 100 dB (very loud).

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. For a single point source, sound levels decrease approximately 6 dB for each doubling of distance from the source. This drop-off rate is appropriate for noise generated by stationary equipment. If noise is produced by a line source (e.g., highway traffic or railroad operations), the sound decreases 3 dB for each doubling of distance in a hard site environment; however, line source noise in a relatively flat environment with absorptive vegetation decreases 4.5 dB for each doubling of distance.

There are many ways to rate noise for various time periods, but an appropriate rating of ambient noise affecting humans also accounts for the annoying effects of sound. The equivalent continuous sound level (L_{eq}) is the total sound energy of time-varying noise over a sample period. However, the predominant rating scales for human communities in the State of California are the L_{eq} and Community Noise Equivalent Level (CNEL) or the day-night average noise level (L_{dn}) based on A-weighted decibels (dBA). CNEL is the time-varying noise over a 24-hour period, with a 5 dBA weighting factor applied to the hourly L_{eq} for noises occurring from 7:00 p.m. to 10:00 p.m. (defined as relaxation hours), and a 10 dBA weighting factor applied to noises occurring from 10:00 p.m. to 7:00 a.m. (defined as sleeping hours). L_{dn} is similar to the CNEL scale but without the adjustment for events occurring during the evening hours. CNEL and L_{dn} are within 1 dBA of each other and are normally interchangeable. The City of Orange uses the CNEL noise scale for long-term noise impact assessment.

Other noise rating scales of importance when assessing the annoyance factor include the maximum noise level (L_{max}), which is the highest exponential time-averaged sound level that occurs during a stated time period. The noise environments discussed in this analysis for short-term noise impacts are specified in terms of maximum levels denoted by L_{max}, which reflects peak operating conditions and addresses the annoying aspects of intermittent noise. L_{max} is often used together with another noise scale, or noise standards in terms of percentile noise levels, in noise ordinances for enforcement purposes. For example, the L_{10} noise level represents the noise level exceeded 10 percent of the time during a stated period. The L_{50} noise level represents the median noise level. Half the time the noise level exceeds this level, and half the time it is less than this level. The L_{90} noise level represents the noise level exceeded 90 percent of the time and is considered the background noise level during a monitoring period. For a relatively constant noise source, the L_{eq} and L_{50} are approximately the same.

Noise impacts can be described in three categories. The first category includes audible impacts that refer to increases in noise levels noticeable to humans. Audible increases in noise levels generally refer to a change of 3 dB or greater because this level has been found to be barely perceptible in exterior environments. The second category, potentially audible, refers to a change in the noise level between 1 dB and 3 dB. This range of noise levels has been found to be noticeable only in laboratory environments. The last category includes changes in noise levels of less than 1 dB, which are inaudible to the human ear. Only audible changes in existing ambient or background noise levels are considered potentially significant.

Physiological Effects of Noise

Physical damage to human hearing begins at prolonged exposure to noise levels higher than 85 dBA. Exposure to high noise levels affects the entire system, with prolonged noise exposure in excess of 75 dBA increasing body tensions, thereby affecting blood pressure and functions of the heart and the nervous system. In comparison, extended periods of noise exposure above 90 dBA would result in permanent cell damage. When the noise level reaches 120 dBA, a tickling sensation occurs in the human ear, even with short-term exposure. This level of noise is called the threshold of feeling. As the sound reaches 140 dBA, the tickling sensation is replaced by the feeling of pain in the ear (the threshold of pain). A sound level of 160–165 dBA will result in dizziness or loss of equilibrium. The ambient or background noise problem is widespread and generally more concentrated in urban areas than in outlying, less developed areas. Table A lists definitions of acoustical terms, and Table B shows common sound levels and their sources.

FUNDAMENTALS OF VIBRATION

Vibration refers to ground-borne noise and perceptible motion. Ground-borne vibration is almost exclusively a concern inside buildings and is rarely perceived as a problem outdoors, where the motion may be discernible, but without the effects associated with the shaking of a building there is less adverse reaction. Vibration energy propagates from a source through intervening soil and rock layers to the foundations of nearby buildings. The vibration then propagates from the foundation throughout the remainder of the structure. Building vibration may be perceived by occupants as the motion of building surfaces, the rattling of items sitting on shelves or hanging on walls, or a low-frequency rumbling noise. The rumbling noise is caused by the vibration of walls, floors, and ceilings that radiate sound waves.

Typical sources of ground-borne vibration are construction activities (e.g., blasting, pile driving, and operating heavy-duty earthmoving equipment), steel-wheeled trains, and occasional traffic on rough roads. When roadways are smooth, vibration from traffic, even heavy trucks, is rarely perceptible (FTA 2018). It is assumed for most projects that the roadway surface will be smooth enough that ground-borne vibration from street traffic will not exceed the impact criteria.

Ground-borne vibration has the potential to disturb people and damage buildings. Although it is very rare for train-induced ground-borne vibration to cause even cosmetic building damage, it is not uncommon for construction processes (e.g., blasting and pile driving) to cause vibration of sufficient amplitudes to damage nearby buildings (FTA 2018). Ground-borne vibration is usually measured in terms of vibration velocity, either the root-mean-square (RMS) velocity or peak particle velocity (PPV).

Table A: Definitions of Acoustical Terms

Term	Definitions
Decibel, dB	A unit of measurement that denotes the ratio between two quantities that are proportional to power; the number of decibels is 10 times the logarithm (to the base 10) of this ratio.
Frequency, Hz	Of a function periodic in time, the number of times that the quantity repeats itself in 1 second (i.e., number of cycles per second).
A-Weighted Sound Level, dBA	The sound level obtained by use of A-weighting. The A-weighting filter deemphasizes the very low- and very high-frequency components of the sound in a manner similar to the frequency response of the human ear and correlates well with subjective reactions to noise. (All sound levels in this report are A-weighted, unless reported otherwise.)
L_{01}, L_{10}, L_{50}, L_{90}	The fast A-weighted noise levels that are equaled or exceeded by a fluctuating sound level 1%, 10%, 50%, and 90% of a stated time period.
Equivalent Continuous Noise Level, L_{eq}	The level of a steady sound that, in a stated time period and at a stated location, has the same A-weighted sound energy as the time-varying sound.
Community Noise Equivalent Level, CNEL	The 24-hour A-weighted average sound level from midnight to midnight, obtained after the addition of 5 dBA to sound levels occurring in the evening from 7:00 PM to 10:00 PM and after the addition of 10 dBA to sound levels occurring in the night between 10:00 PM and 7:00 AM.
Day/Night Noise Level, L_{dn}	The 24-hour A-weighted average sound level from midnight to midnight, obtained after the addition of 10 dBA to sound levels occurring in the night between 10:00 PM and 7:00 AM.
L_{max}, L_{min}	The maximum and minimum A-weighted sound levels measured on a sound level meter, during a designated time interval, using fast time averaging.
Ambient Noise Level	The all-encompassing noise associated with a given environment at a specified time; usually a composite of sound from many sources at many directions, near and far; no particular sound is dominant.
Intrusive	The noise that intrudes over and above the existing ambient noise at a given location. The relative intrusiveness of a sound depends upon its amplitude, duration, frequency, and time of occurrence and tonal or informational content, as well as the prevailing ambient noise level.

Source: *Handbook of Acoustical Measurements and Noise Control* (Harris 1991).

Table B: Common Sound Levels and Their Noise Sources

Noise Source	A-Weighted Sound Level in Decibels	Noise Environments	Subjective Evaluations
Near Jet Engine	140	Deafening	128 times as loud
Civil Defense Siren	130	Threshold of Pain	64 times as loud
Hard Rock Band	120	Threshold of Feeling	32 times as loud
Accelerating Motorcycle at a Few Feet Away	110	Very Loud	16 times as loud
Pile Driver; Noisy Urban Street/Heavy City Traffic	100	Very Loud	8 times as loud
Ambulance Siren; Food Blender	95	Very Loud	—
Garbage Disposal	90	Very Loud	4 times as loud
Freight Cars; Living Room Music	85	Loud	—
Pneumatic Drill; Vacuum Cleaner	80	Loud	2 times as loud
Busy Restaurant	75	Moderately Loud	—
Near Freeway Auto Traffic	70	Moderately Loud	—
Average Office	60	Quiet	One-half as loud
Suburban Street	55	Quiet	—
Light Traffic; Soft Radio Music in Apartment	50	Quiet	One-quarter as loud
Large Transformer	45	Quiet	—
Average Residence without Stereo Playing	40	Faint	One-eighth as loud
Soft Whisper	30	Faint	—
Rustling Leaves	20	Very Faint	—
Human Breathing	10	Very Faint	Threshold of Hearing
—	0	Very Faint	—

Source: Compiled by LSA (2015).

REGULATORY SETTING

State Guidelines

California Department of Transportation (Caltrans)

Vibration standards included in the Caltrans *Transportation and Construction Vibration Guidance Manual* (2020) were used to evaluate vibration impacts because the City of Orange does not have vibration standards. Table C provides the criteria for assessing the annoyance potential, while Table D provides the criteria for assessing damage potential associated with construction activities.

Table C: Vibration Annoyance Potential Criteria

Human Response	Maximum PPV (in/sec)	
	Transient Sources	Continuous/Frequent Intermittent Sources
Barely perceptible	0.04	0.01
Distinctly perceptible	0.25	0.04
Strongly perceptible	0.9	0.10
Severe	2.0	0.4

Source: *Transportation and Construction Vibration Guidance Manual* (Caltrans 2020).
Note: Transient sources create a single isolated vibration event, such as blasting or drop balls. Continuous/frequent intermittent sources include impact pile drivers, pogo-stick compactors, crack-and-seat equipment, vibratory pile drivers, and vibratory compaction equipment.
Caltrans = California Department of Transportation
in/sec = inches per second
PPV = peak particle velocity

Table D: Vibration Damage Potential Threshold Criteria

Structure and Condition	Maximum PPV (in/sec)	
	Transient Sources	Continuous/Frequent Intermittent Sources
Extremely fragile historic buildings, ruins, ancient monuments	0.12	0.08
Fragile buildings	0.2	0.1
Historic and some old buildings	0.5	0.25
Older residential structures	0.5	0.3
New residential structures	1.0	0.5
Modern industrial/commercial buildings	2.0	0.5

Source: *Transportation and Construction Vibration Guidance Manual* (Caltrans 2020).
Note: Transient sources create a single isolated vibration event, such as blasting or drop balls. Continuous/frequent intermittent sources include impact pile drivers, pogo-stick compactors, crack-and-seat equipment, vibratory pile drivers, and vibratory compaction equipment.
Caltrans = California Department of Transportation
in/sec = inches per second
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Local Regulations

City of Orange

General Plan Noise Element. The City of Orange General Plan Noise Element (City of Orange 2010) has established noise standards for various land uses and has goals and policies to meet the City's noise-related goals. The City's exterior noise standard for residential uses is 65 dBA CNEL. Applicable goals and policies for the project are listed below:

- **Goal 7.0:** Minimize construction, maintenance vehicle, and nuisance noise in residential areas and near noise-sensitive land uses.
  - **Policy 7.1**: Schedule City maintenance and construction projects so that they generate noise during less sensitive hours.
  - **Policy 7.2**: Require developers and contractors to employ noise minimizing techniques during construction and maintenance operations.
  - **Policy 7.3**: Limit the hours of construction and maintenance operations located adjacent to noise-sensitive land uses.
  - **Policy 7.4**: Encourage limitations on the hours of operations and deliveries for commercial, mixed-use, and industrial uses abutting residential zones.

Municipal Code. Section 8.24.050(E) of the City of Orange Municipal Code exempts construction, repair, remodeling, or grading of any real property between the hours of 7:00 a.m. to 8:00 p.m., Monday through Saturday, or between the hours of 9:00 a.m. to 8:00 p.m. on Sundays and federal holidays.

In addition, Section 8.24.050(K) of the Municipal Code exempts any maintenance or construction activity undertaken by a public agency or utility within street right-of-way.

City of Villa Park

General Plan Noise Element. The City of Villa Park General Plan Noise Element (City of Villa Park 2010) has established the acceptable noise levels for noise-sensitive land uses and has goals and policies to meet the City's noise-related goals. Noise-sensitive land uses include residences, rest homes, hospitals, places of worship, and schools. The City's acceptable noise levels for noise-sensitive land uses is 60 dBA CNEL. Applicable goals and policies for the project are listed below:

- **Noise Goal #1:** Continue to provide acceptable noise environments for residential land use.
  - **Policy N #1:** Continue to apply noise considerations into the community planning process to prevent noise/land use conflicts.
  - **Policy N #2:** Minimize through traffic in residential areas by promoting peripheral routing.
  - **Policy N #3:** Promote, where appropriate, sound attenuation measures. These may include the use of berms and wall barriers, the placement of buildings away from the noise source, or a combination of sound attenuation measures.

Municipal Code. Section 6-6.7(e) of the City of Villa Park Municipal Code exempts construction, repair, remodeling, or grading of any real property between the hours of 7:00 a.m. to 8:00 p.m., Monday through Friday or between the hours of 8:00 a.m. to 8:00 p.m. on Saturday. Construction is prohibited on Sunday or on a federal holiday.

EXISTING SETTING

The primary existing noise sources in the project area are transportation facilities. Traffic on Cannon Street, Serrano Avenue, Taft Avenue, and Santiago Canyon Road are a steady source of ambient noise in the project vicinity. Uses located adjacent to the project include residential uses, a parking lot for the Santiago Creek Trail and Bike Path, a pump station site, and a former landfill (vacant land).

Ambient Noise Measurements

Two long-term (24-hour) noise level measurements were conducted within the limits of the project using Larson Davis Spark 706RC dosimeters to document the existing noise environment. The long-term noise level measurements at LT-1 were conducted from Thursday, February 22, to Friday, February 23, 2024, and LT-2 were conducted from Tuesday, March 19, to Wednesday, March 20, 2024. Table E summarizes the results of the long-term noise level measurements along with a description of the measurement locations and noise sources that occurred during the measurements. As shown in Table E, the calculated CNEL levels at LT-1 and LT-2 were 59.2 dBA and 58.8 dBA, respectively. In addition, the daytime noise levels ranged from 55.3 to 60.1 dBA L_{eq}, evening noise levels ranged from 52.5 to 55.7 dBA L_{eq}, and nighttime average noise levels ranged from 42.3 to 57.6 L_{eq}. Also, the daytime maximum instantaneous noise levels ranged from 67.3 to 80.5 dBA, evening maximum instantaneous noise levels ranged from 68.4 to 76.0 dBA, and the nighttime maximum instantaneous noise levels ranged from 57.8 to 77.5 dBA. The long-term noise level measurement survey sheets along with the hourly L_{eq}, L_{max}, and L_{min} results are provided in Attachment C. Figure 3 shows the long-term monitoring locations.

Table E: Long-Term Ambient Noise Level Measurements

Monitoring No.	Location Description	Noise Levels (dBA)							Noise Sources
		Daytime[1]		Evening[2]		Nighttime[3]		CNEL	
		L_{eq}	L_{max}	L_{eq}	L_{max}	L_{eq}	L_{max}		
LT-1	1854 N Carlsbad Street, Orange, CA. Near the center of a backyard on a tree.	55.6-60.1	69.2-80.5	54.7-55.7	68.4-70.5	43.5-55.4	59.5-69.0	59.2	Traffic on Cannon Street.
LT-2	1732 N Williamsburg Street, Orange, CA. In the backyard.	55.3-58.1	67.3-79.6	52.5-55.6	69.5-76.0	42.3-57.6	57.8-77.5	58.8	Traffic on Cannon Street.

Source: Compiled by LSA (2024).
1 Daytime = Hours between 7:00 a.m. and 7:00 p.m.
2 Evening = Hours between 7:00 p.m. and 10:00 p.m.
3 Nighttime = Hours between 10:00 p.m. and 7:00 a.m.
CNEL = Community Noise Equivalent Level
dBA = A-weighted decibel(s)
L_{eq} = equivalent continuous sound level
L_{max} = maximum instantaneous noise level

Existing Aircraft Noise

Airport-related noise levels are primarily associated with aircraft engine noise made while aircraft are taking off, landing, or running their engines while still on the ground. The closest airports to the project area are the John Wayne Airport and the Fullerton Municipal Airport, which are located approximately 9.6 miles southwest and 10.8 miles northwest of the project limits. The project limits are outside the 60 dBA CNEL noise contour of John Wayne Airport and Fullerton Municipal Airport based on the Airport Environs Land Use Plan for John Wayne Airport (OCALUC 2008) and Fullerton

Municipal Airport (OCALUC 2019), respectively. In addition, the project limits are not located in the vicinity of a private airstrip. The proposed project is a transportation project and would not involve the introduction of residential or employment uses in the project area. Therefore, the project would not expose people residing or working in the project vicinity to aviation-related excessive noise levels, and this topic is not further discussed.

Existing Traffic Noise

The Federal Highway Administration (FHWA) *Highway Traffic Noise Prediction Model* (FHWA RD-77-108) was used to evaluate existing traffic-related noise conditions in the vicinity of the project limits. This model requires various parameters (including traffic volumes, vehicle mix, vehicle speed, and roadway geometry) to compute typical equivalent noise levels during daytime, evening, and nighttime hours. The resultant noise levels are weighted and summed over 24-hour periods to determine the CNEL values. The existing average daily traffic (ADT) volumes were obtained from the *Proposed Improvements to Cannon Street Traffic Memorandum* (LSA 2024b). The standard vehicle mix for Southern California roadways was used for traffic on these roadway segments. Table F provides the existing traffic noise levels adjacent to roadway segments in the project vicinity. These noise levels represent worst-case scenarios, which assume that no shielding is provided between the traffic and the location where the noise contours are drawn. The specific assumptions used in developing these noise levels and the model printouts are provided in Attachment D.

Table F: Existing Traffic Noise Levels

Roadway Segment	ADT	Centerline to 70 CNEL (ft)	Centerline to 65 CNEL (ft)	Centerline to 60 CNEL (ft)	CNEL (dBA) 50 ft from Roadway Centerline
Cannon Street Between Serrano Avenue and Taft Avenue	33,096	81	167	356	72.8
Cannon Street Between Taft Avenue and Santiago Canyon Road	30,297	76	157	335	72.5

Source: Compiled by LSA (2024).
Note: Traffic noise within 50 ft of the roadway centerline should be evaluated with site-specific information.
ADT = average daily traffic
CNEL = Community Noise Equivalent Level
dBA = A-weighted decibels
ft = foot/feet

IMPACT ANALYSIS

Short-Term Construction Noise Impacts

Two types of short-term noise impacts would occur during project construction. The first type would be from construction crew commutes and the transport of construction equipment and materials to the project limits and would incrementally raise noise levels on roadways leading to the site. The pieces of construction equipment for construction activities would move on site, would remain for the duration of each construction phase, and would not add to the daily traffic volume in the project vicinity. Although there would be a relatively high single-event noise exposure potential causing intermittent noise nuisance (passing trucks at 50 ft would generate up to a maximum of 84 dBA), the effect on longer-term ambient noise levels would be small because the daily construction-related vehicle trips are small when compared to the existing daily traffic volume on Cannon Street. The grading and excavation phase would generate the most trips out of all of the construction phases, at 212 trips per day based on the California Emissions Estimator Model (CalEEMod, Version 2022.1) output detailed in Attachment B of the *Air Quality Technical Memorandum for the Cannon Street Widening Project* (LSA 2024a). Based on the *Proposed Improvements to Cannon Street Traffic Memorandum* (LSA 2024b), Cannon Street has an existing ADT volume of 30,297 within the project limits. Based on the information above, construction-related traffic would increase noise by up to 0.03 dBA. A noise level increase of less than 3 dBA would not be perceptible to the human ear in an outdoor environment. Therefore, no short-term construction-related impacts associated with worker commutes and transport of construction equipment and material to the project limits would occur, and no noise reduction measures would be required.

The second type of short-term noise impact is related to noise generated from construction activities. Construction is performed in discrete steps, each of which has its own mix of equipment and, consequently, its own noise characteristics. The proposed project anticipates site preparation, grading, building construction, paving, and architectural coating phases of construction. These various sequential phases change the character of the noise generated on a project site. Therefore, the noise levels vary as construction progresses. Despite the variety in the type and size of construction equipment, similarities in the dominant noise sources and patterns of operation allow construction-related noise ranges to be categorized by work phase. Table G lists the L_{max} recommended for noise impact assessments for typical construction equipment included in the FHWA *Highway Construction Noise Handbook* (2006), based on a distance of 50 ft between the equipment and a noise receptor.

The site preparation phase, which includes excavation and grading of the site, tends to generate the highest noise levels because the noisiest construction equipment is earthmoving equipment. Earthmoving equipment includes excavating machinery, such as backfillers, bulldozers, draglines, and front loaders. Earthmoving and compacting equipment includes compactors, scrapers, and graders. Typical operating cycles for these types of construction equipment may involve 1 or 2 minutes of full-power operation, followed by 3 or 4 minutes at lower power settings.

Construction of the proposed project is expected to require on-site use of bulldozers, front-end loaders, and water/pickup trucks. Noise associated with the use of construction equipment is estimated to be between 55 and 85 dBA L_{max} at a distance of 50 ft from the active construction area during grading/excavation. As shown in Table G, the maximum noise level generated by each bulldozer is assumed to be approximately 85 dBA L_{max} at 50 ft from the bulldozer. Each front-end loader would generate approximately 80 dBA L_{max} at 50 ft. The maximum noise level generated by water trucks/pickup trucks is approximately 55 dBA L_{max} at 50 ft from these vehicles. Each doubling of the sound source with equal strength increases the noise level by 3 dBA. Assuming that each piece of construction equipment operates at some distance from the other equipment, the worst-case combined noise level during this phase of construction would be 86 dBA L_{max} at a distance of 50 ft from the active construction area. Based on a usage factor of 40 percent, the worst-case combined noise level during this phase of construction would be 82 dBA L_{eq} at a distance of 50 ft from the active construction area.

The closest residence is located within 50 ft of the project construction area. Therefore, these receptor locations may be subject to short-term noise reaching 86 dBA L_{max} (82 dBA L_{eq}) or higher generated by construction activities in the project area. Although the noise generated by project construction activities would be higher than the ambient noise levels and would result in a temporary increase in the ambient noise levels, construction noise would stop once project construction is completed. Construction activities shall be limited to between the hours of 7:00 a.m.

Table G: Typical Construction Equipment Noise Levels

Equipment Description	Acoustical Usage Factor[1] (%)	Maximum Noise Level (L_{max}) at 50 ft[2]
Backhoe	40	80
Compactor (ground)	20	80
Compressor	40	80
Crane	16	85
Dozer	40	85
Dump Truck	40	84
Excavator	40	85
Flatbed Truck	40	84
Man Lift (Forklift)	20	85
Front-End Loader	40	80
Generator	50	82
Generator (<25KVA, VMS signs)	50	70
Grader	40	85
Jackhammer	20	85
Pavement Scarifier	20	85
Paver	50	85
Pickup Truck	40	55
Pneumatic Tools	50	85
Pump	50	77
Rock Drill	20	85
Roller	20	85
Scraper	40	85
Tractor	40	84
Welder/Torch	40	73

Source: *FHWA Highway Construction Noise Handbook,* Table 9.1 (FHWA 2006).
Note: The noise levels reported in this table are rounded to the nearest whole number.
1 Usage factor is the percentage of time during a construction noise operation that a piece of construction equipment is operating at full power.
2 Maximum noise levels were developed based on Specification 721.560 from the CA/T program to be consistent with the City of Boston, Massachusetts, Noise Code for the "Big Dig" project.
CA/T = Central Artery/Tunnel
FHWA = Federal Highway Administration
ft = foot/feet
L_{max} = maximum instantaneous noise level

and 8:00 p.m., Monday through Friday, and between the hours of 8:00 a.m. and 8:00 p.m. on Saturday pursuant to Section 6-6.7(e) of the City of Villa Park Municipal Code because construction activities during these hours are exempt by the City of Villa Park, and the City of Orange exempts construction activities undertaken by a public agency within street right-of-way pursuant to Section 8.24.050(K) of the City of Orange Municipal Code. The implementation of construction hour limits would minimize construction noise. Therefore, noise generated from project construction activities would be less than significant. No mitigation measures are required.

Short-Term Construction Vibration Impacts

Vibration generated by construction equipment can result in varying degrees of ground vibration, depending on the equipment. The operation of construction equipment causes ground vibrations that spread through the ground and diminish in strength with distance. Buildings on soil near an active construction area respond to these vibrations, which range from imperceptible to low rumbling sounds with perceptible vibrations and slight damage at the highest vibration levels. Typically, construction-related vibration does not reach vibration levels that would result in damage to nearby structures.

The Caltrans *Transportation and Construction Vibration Guidance Manual* (Caltrans 2020) shows that the vibration damage threshold for continuous/frequent intermittent sources is 0.25 PPV (in/sec) for historic and old buildings. The manual shows the vibration annoyance potential criteria to be barely perceptible at 0.01 PPV (in/sec), distinctly perceptible at 0.04 PPV (in/sec), and strongly perceptible at 0.10 PPV (in/sec) for continuous/frequent intermittent sources. These thresholds were used to evaluate the potential for short-term construction-related ground-borne vibration during construction of the proposed project.

Table H shows the reference vibration levels at a distance of 25 ft for each type of standard construction equipment from the *Transportation and Construction Vibration Guidance Manual* (Caltrans 2020). Project construction is expected to require the use of large bulldozers and loaded trucks, which would generate ground-borne vibration levels of up to 0.089 PPV (in/sec) and 0.076 PPV (in/sec), respectively, when measured at 25 ft.

The formula for vibration transmission is provided below:

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

Table H: Vibration Source Amplitudes for Construction Equipment

Equipment	Reference PPV (in/sec) at 25 ft
Vibratory roller	0.210
Large bulldozer[1]	**0.089**
Caisson drilling	0.089
Loaded trucks[1]	**0.076**
Jackhammer	0.035
Small bulldozer	0.003

Source: Transportation and Construction Vibration Guidance Manual (Caltrans 2020).
[1] The equipment shown in **bold** is expected to be used on site.
ft = foot/feet PPV = peak particle velocity
in/sec = inches per second

Bulldozers and trucks used for construction of the proposed project would generate the highest ground-borne vibration levels. Based on the *Caltrans Transportation and Construction Vibration Guidance Manual*, a large bulldozer and loaded trucks would generate vibration levels of 0.089 PPV (in/sec) and 0.076 PPV (in/sec), respectively, when measured at 25 ft. The closest building structure is a residential building (19231 Parker Circle, Villa Park, California), approximately 20 ft from the project construction boundary, and this structure would experience vibration levels of up to 0.124 PPV (in/sec). Although this vibration level would be strongly perceptible, vibration levels would not exceed the damage threshold of 0.3 PPV (in/sec) because the condition of the residential building would be equivalent to or better than older residential structures. Other building structures adjacent to the project would experience lower vibration levels because they are farther away and would be constructed equivalent to or better than older residential structures. Therefore, short-term construction impacts related to ground-borne vibration or ground-borne noise would be less than significant. No mitigation measures are required.

Long-Term Traffic Noise Impacts

The FHWA Highway Traffic Noise Prediction Model (FHWA-RD-77 108) (FHWA 1977) was used to evaluate traffic-related noise conditions along the roadway segments of Cannon Street. This model requires various parameters, including traffic volumes, vehicle mix, vehicle speed, and roadway geometry to compute typical equivalent noise levels during daytime, evening, and nighttime hours. The resultant noise levels are weighted and summed over 24-hour periods to determine the CNEL values. The existing ADT volumes were obtained from the *Proposed Improvements to Cannon Street Traffic Memorandum* (LSA 2024b). The standard vehicle mix for Southern California roadways was used for traffic on these roadway segments. Table I provides the traffic noise levels for the existing (2023) with and without project scenario. These noise levels represent worst-case scenarios, which assume that no shielding is provided between the traffic and the location where the noise contours are drawn. The specific assumptions used in developing these noise levels and the model printouts are provided in Attachment D.

As shown in Table I, project-related traffic noise would increase by up to 0.1 dBA. Noise level increases below 3 dBA would not be perceptible to the human ear in an outdoor environment. Therefore, no traffic noise impacts from project-related traffic on off-site sensitive receptors would occur. No mitigation measures are required.

Long-Term Vibration Impacts

Roads with smooth surfaces are not typically major sources of ground-borne noise or vibration. Ground-borne vibration is mostly associated with passenger vehicles and trucks traveling on roads with poor conditions, such as potholes, bumps, expansion joints, or other discontinuities in the road surface. Passenger vehicles and trucks would cause effects such as rattling of windows, and the sources are almost always airborne noise. The proposed project would include new asphalt pavement with proper maintenance. As a result, there would be no potholes, bumps, or other discontinuities in the road surface that would generate ground-borne vibration or noise impacts from vehicular traffic traveling on Cannon Street within the project limits. Therefore, ground-borne vibration and noise impacts generated by vehicles traveling on Cannon Street within the project limits would be less than significant. No mitigation measures are required.

REGULATORY COMPLIANCE MEASURES

The following measure would ensure than construction noise be only generated during allowable times:

- The construction contractor shall limit construction activities to between the hours of 7:00 a.m. to 8:00 p.m. Monday through Friday and between the hours of 8:00 a.m. and 8:00 p.m. on Saturday. Construction is prohibited outside these hours and on Sundays and federal holidays.

Attachments: A: References
B: Figures
C: Noise Survey Sheets
D: FHWA Traffic Noise Model Printouts

Table I: Existing (2023) Traffic Noise Levels Without and With Project

Roadway Segment	Without Project Traffic Conditions					With Project Traffic Conditions					
	ADT	Centerline to 70 dBA CNEL (ft)	Centerline to 65 dBA CNEL (ft)	Centerline to 60 dBA CNEL (ft)	CNEL (dBA) 50 ft from Roadway Centerline	ADT	Centerline to 70 dBA CNEL (ft)	Centerline to 65 dBA CNEL (ft)	Centerline to 60 dBA CNEL (ft)	CNEL (dBA) 50 ft from Roadway Centerline	Increase from Baseline Conditions
Cannon Street Between Serrano Avenue and Taft Avenue	33,096	81	167	356	72.8	33,096	82	167	356	72.9	0.1
Cannon Street Between Taft Avenue and Santiago Canyon Road	30,297	76	157	335	72.5	30,297	78	158	336	72.5	0.0

Source: Compiled by LSA (2024)

Note: Traffic noise within 50 ft of the roadway centerline should be evaluated with site-specific information.

ADT = average daily traffic

CNEL = Community Noise Equivalent Level

dBA = A-weighted decibels

ft = foot/feet

ATTACHMENT A

REFERENCES

California Department of Transportation (Caltrans). 2020. Transportation and Construction Vibration Guidance Manual. April. Website: https://dot.ca.gov/-/media/dot-media/programs/environmental-analysis/documents/env/tcvgm-apr2020-a11y.pdf (accessed April 2024).

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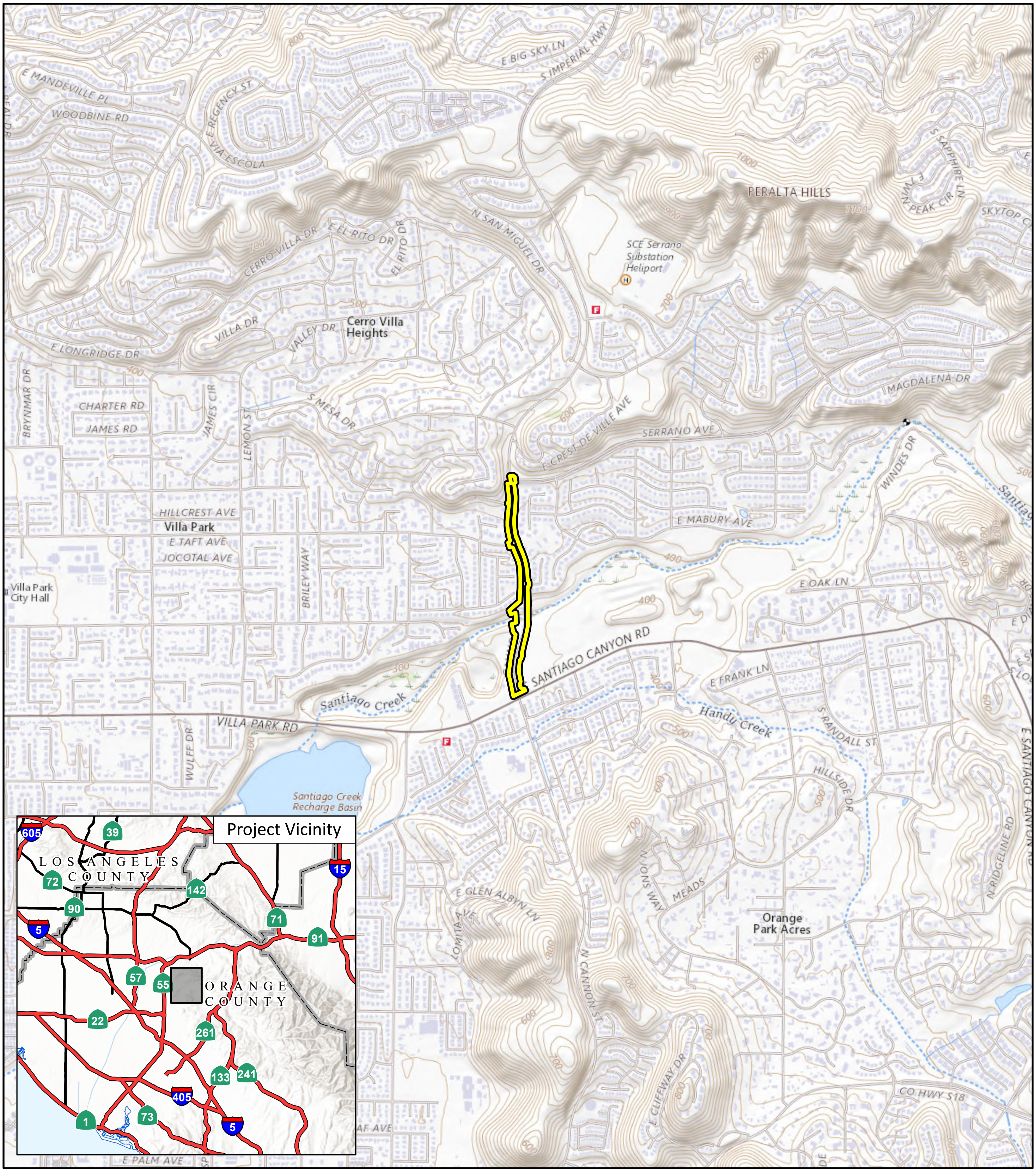
ATTACHMENT B

FIGURES



Project Location

FIGURE 1

LSA

0 1000 2000
FEET

SOURCE: USGS The National Map

Cannon Street Widening Project
Project Location

J:\20230893\GIS\Pro\Cannon Street Widening Project.aprx (10/18/2023)

LSA

Existing Pavement Edges

Proposed Lane Striping

City Boundaries

0 60 120

FEET

SOURCE: Nearmap (5/2023)

J:\20230893\GIS\Pro\Cannon Street Widening Project.aprx (3/14/2024)

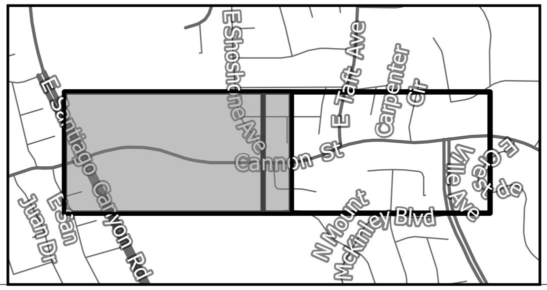


FIGURE 2

Sheet 1 of 2

Cannon Street Widening Project

Proposed Project Improvements

SOURCE: Nearmap (5/2023)

FIGURE 2

Sheet 2 of 2

Cannon Street Widening Project

Proposed Project Improvements

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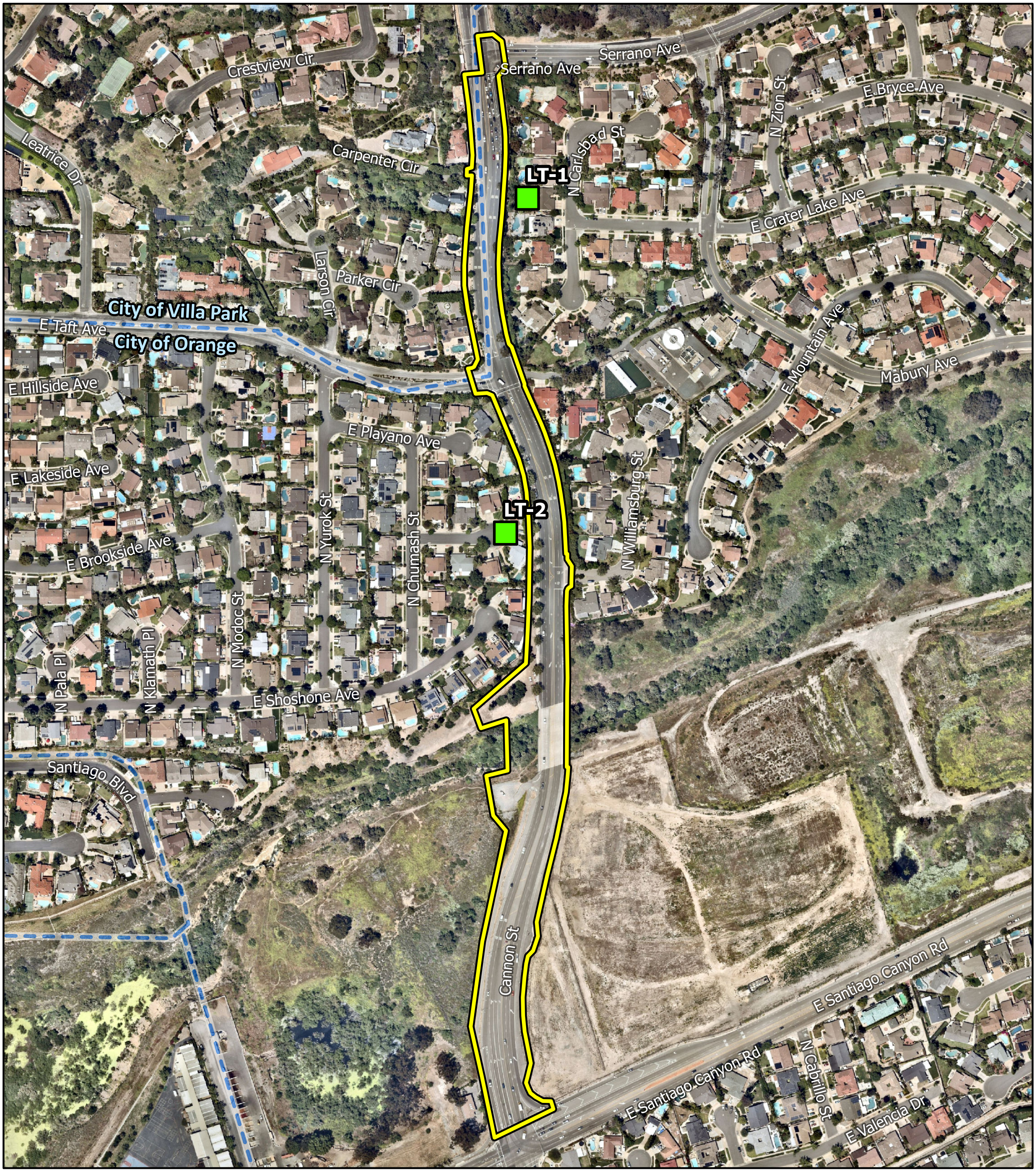

LSA

Project Location

City Boundaries

Long-Term Noise Monitoring Locations

FIGURE 3

0 200 400
FEET

SOURCE: Nearmap (5/2023)

Cannon Street Widening Project

Noise Monitoring Locations

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ATTACHMENT C

NOISE SURVEY SHEETS

Noise Measurement Survey – 24 HR

Project Number: 20230893
Project Name: Cannon Street Widening

Test Personnel: Kevin Nguyendo
Equipment: Spark 706RC (SN:908)

Site Number: LT-1 Date: 2/22/24

Time: From 12:00 p.m. To 12:00 p.m.

Site Location: 1854 N Carlsbad Street, Orange, CA 92867. Near the center of a backyard. On a tree.

Primary Noise Sources: Traffic on Cannon Street.

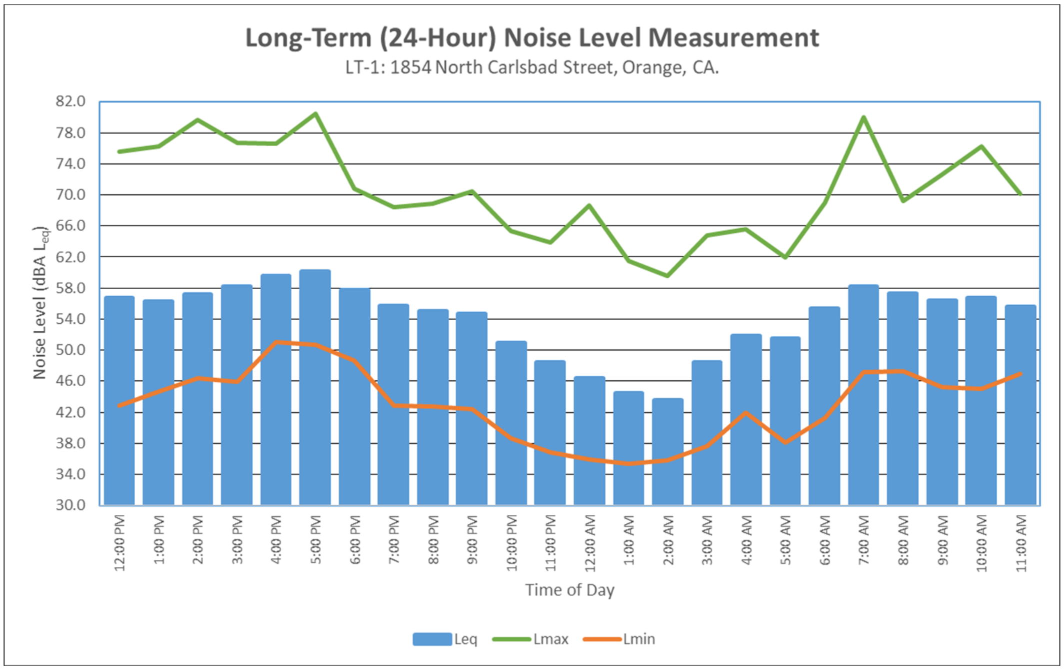
Comments: Existing 5 ft high property wall. The residence is located approximately 10 ft lower in elevation than Cannon Street.

Photo:

Long-Term (24-Hour) Noise Level Measurement Results at LT-1

Start Time	Date	Noise Level (dBA)		
		L_{eq}	L_{max}	L_{min}
12:00 PM	2/22/24	56.7	75.6	42.8
1:00 PM	2/22/24	56.2	76.2	44.7
2:00 PM	2/22/24	57.2	79.7	46.4
3:00 PM	2/22/24	58.2	76.7	45.9
4:00 PM	2/22/24	59.5	76.6	51.0
5:00 PM	2/22/24	60.1	80.5	50.7
6:00 PM	2/22/24	57.8	70.8	48.7
7:00 PM	2/22/24	55.7	68.4	42.9
8:00 PM	2/22/24	55.1	68.9	42.7
9:00 PM	2/22/24	54.7	70.5	42.4
10:00 PM	2/22/24	51.0	65.4	38.6
11:00 PM	2/22/24	48.4	63.9	36.8
12:00 AM	2/23/24	46.3	68.6	35.9
1:00 AM	2/23/24	44.5	61.5	35.4
2:00 AM	2/23/24	43.5	59.5	35.8
3:00 AM	2/23/24	48.4	64.8	37.6
4:00 AM	2/23/24	51.8	65.6	42.0
5:00 AM	2/23/24	51.5	61.9	38.1
6:00 AM	2/23/24	55.4	69.0	41.3
7:00 AM	2/23/24	58.2	80.0	47.2
8:00 AM	2/23/24	57.2	69.2	47.3
9:00 AM	2/23/24	56.3	72.6	45.2
10:00 AM	2/23/24	56.7	76.2	45.0
11:00 AM	2/23/24	55.6	70.1	47.0

Source: Compiled by LSA (2024).
dBA = A-weighted decibel
L_{eq} = equivalent continuous sound level
L_{max} = maximum instantaneous noise level
L_{min} = minimum measured sound level



Noise Measurement Survey – 24 HR

Project Number: 20230893
Project Name: Cannon Street Widening

Test Personnel: Kevin Nguyendo
Equipment: Spark 706RC (SN:632)

Site Number: LT-2 Date: 3/19/24

Time: From 2:00 p.m. To 2:00 p.m.

Site Location: 1732 N Williamsburg Street, Orange, CA 92867. In the backyard.

Primary Noise Sources: Traffic on Cannon Street.

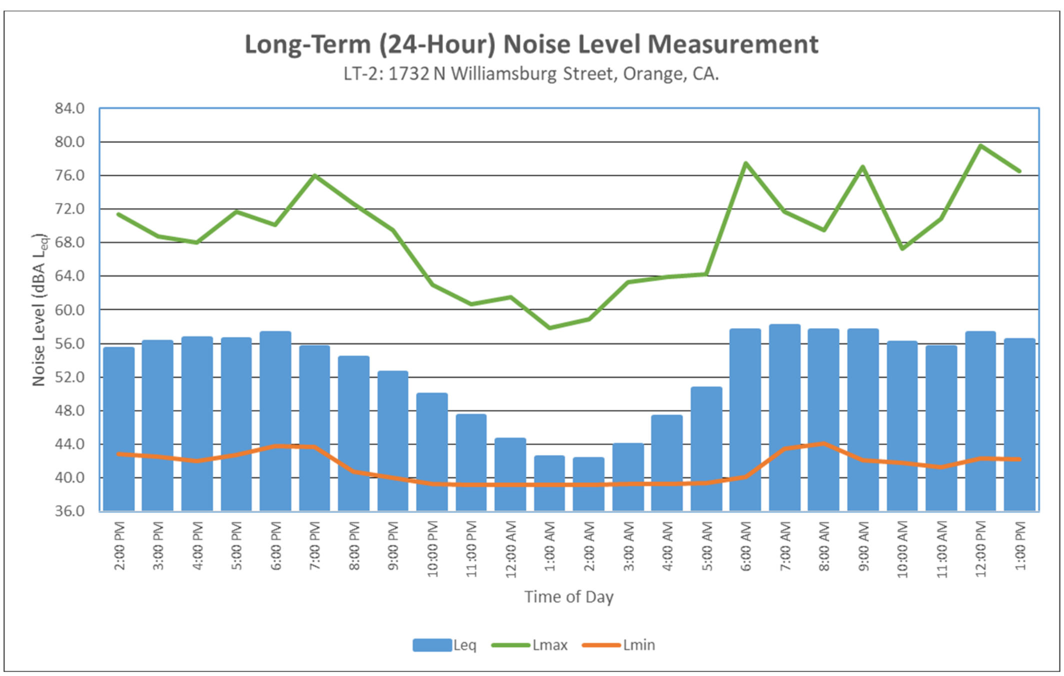
Comments:

Photo:

Long-Term (24-Hour) Noise Level Measurement Results at LT-2

Start Time	Date	Noise Level (dBA)		
		L_{eq}	L_{max}	L_{min}
2:00 PM	3/19/24	55.3	71.4	42.9
3:00 PM	3/19/24	56.1	68.8	42.5
4:00 PM	3/19/24	56.6	68.0	42.0
5:00 PM	3/19/24	56.5	71.7	42.7
6:00 PM	3/19/24	57.2	70.1	43.8
7:00 PM	3/19/24	55.6	76.0	43.7
8:00 PM	3/19/24	54.3	72.6	40.8
9:00 PM	3/19/24	52.5	69.5	40.0
10:00 PM	3/19/24	49.9	63.0	39.3
11:00 PM	3/19/24	47.4	60.7	39.2
12:00 AM	3/20/24	44.6	61.5	39.2
1:00 AM	3/20/24	42.5	57.8	39.2
2:00 AM	3/20/24	42.3	58.9	39.2
3:00 AM	3/20/24	44.0	63.3	39.3
4:00 AM	3/20/24	47.2	63.9	39.3
5:00 AM	3/20/24	50.6	64.2	39.4
6:00 AM	3/20/24	57.6	77.5	40.1
7:00 AM	3/20/24	58.1	71.7	43.5
8:00 AM	3/20/24	57.6	69.5	44.1
9:00 AM	3/20/24	57.5	77.0	42.1
10:00 AM	3/20/24	56.1	67.3	41.8
11:00 AM	3/20/24	55.5	70.8	41.3
12:00 PM	3/20/24	57.2	79.6	42.3
1:00 PM	3/20/24	56.4	76.5	42.2

Source: Compiled by LSA (2024).
dBA = A-weighted decibel
L_{eq} = equivalent continuous sound level
L_{max} = maximum instantaneous noise level
L_{min} = minimum measured sound level



ATTACHMENT D

FHWA TRAFFIC NOISE MODEL PRINTOUTS

TABLE Existing (2023)-01
FHWA ROADWAY NOISE LEVEL ANALYSIS

RUN DATE: 03/15/2024
ROADWAY SEGMENT: Cannon Street Between Serrano Avenue and Taft Avenue
NOTES: Cannon Street Widening - Existing (2023)

---

* * ASSUMPTIONS * *

AVERAGE DAILY TRAFFIC: 33096 SPEED (MPH): 45 GRADE: .5

TRAFFIC DISTRIBUTION PERCENTAGES

	DAY	EVENING	NIGHT
AUTOS	75.51	12.57	9.34
M-TRUCKS	1.56	0.09	0.19
H-TRUCKS	0.64	0.02	0.08

ACTIVE HALF-WIDTH (FT): 26 SITE CHARACTERISTICS: SOFT

---

* * CALCULATED NOISE LEVELS * *

CNEL AT 50 FT FROM NEAR TRAVEL LANE CENTERLINE (dB) = 70.45

DISTANCE (FEET) FROM ROADWAY CENTERLINE TO CNEL

70 CNEL	65 CNEL	60 CNEL	55 CNEL
80.8	166.7	355.7	764.6

TABLE Existing (2023)-02
FHWA ROADWAY NOISE LEVEL ANALYSIS

RUN DATE: 03/15/2024
ROADWAY SEGMENT: Cannon Street Between Taft Avenue and Santiago Canyon Road
NOTES: Cannon Street Widening - Existing (2023)

---

* * ASSUMPTIONS * *

AVERAGE DAILY TRAFFIC: 30297   SPEED (MPH): 45   GRADE: .5

TRAFFIC DISTRIBUTION PERCENTAGES

	DAY	EVENING	NIGHT
AUTOS	75.51	12.57	9.34
M-TRUCKS	1.56	0.09	0.19
H-TRUCKS	0.64	0.02	0.08

ACTIVE HALF-WIDTH (FT): 25   SITE CHARACTERISTICS: SOFT

---

* * CALCULATED NOISE LEVELS * *

CNEL AT 50 FT FROM NEAR TRAVEL LANE CENTERLINE (dB) = 70.13

DISTANCE (FEET) FROM ROADWAY CENTERLINE TO CNEL

70 CNEL	65 CNEL	60 CNEL	55 CNEL
76.3	157.3	335.4	721.0

TABLE Existing With Project (2023)-01

FHWA ROADWAY NOISE LEVEL ANALYSIS

RUN DATE: 03/15/2024
ROADWAY SEGMENT: Cannon Street Between Serrano Avenue and Taft Avenue
NOTES: Cannon Street Widening - Existing With Project (2023)

---

* * ASSUMPTIONS * *

AVERAGE DAILY TRAFFIC: 33096   SPEED (MPH): 45   GRADE: .5

TRAFFIC DISTRIBUTION PERCENTAGES

	DAY	EVENING	NIGHT
AUTOS	75.51	12.57	9.34
M-TRUCKS	1.56	0.09	0.19
H-TRUCKS	0.64	0.02	0.08

ACTIVE HALF-WIDTH (FT): 30   SITE CHARACTERISTICS: SOFT

---

* * CALCULATED NOISE LEVELS * *

CNEL AT 50 FT FROM NEAR TRAVEL LANE CENTERLINE (dB) = 70.20

DISTANCE (FEET) FROM ROADWAY CENTERLINE TO CNEL

70 CNEL	65 CNEL	60 CNEL	55 CNEL
82.1	167.4	355.9	764.5

TABLE Existing With Project (2023)-02

FHWA ROADWAY NOISE LEVEL ANALYSIS

RUN DATE: 03/15/2024

ROADWAY SEGMENT: Cannon Street Between Taft Avenue and Santiago Canyon Road

NOTES: Cannon Street Widening - Existing With Project (2023)

---

* * ASSUMPTIONS * *

AVERAGE DAILY TRAFFIC: 30297   SPEED (MPH): 45   GRADE: .5

TRAFFIC DISTRIBUTION PERCENTAGES

	DAY	EVENING	NIGHT
AUTOS	75.51	12.57	9.34
M-TRUCKS	1.56	0.09	0.19
H-TRUCKS	0.64	0.02	0.08

ACTIVE HALF-WIDTH (FT): 29   SITE CHARACTERISTICS: SOFT

---

* * CALCULATED NOISE LEVELS * *

CNEL AT 50 FT FROM NEAR TRAVEL LANE CENTERLINE (dB) = 69.88

DISTANCE (FEET) FROM ROADWAY CENTERLINE TO CNEL

70 CNEL	65 CNEL	60 CNEL	55 CNEL
77.7	157.9	335.6	720.9
