Environmental Noise & Vibration Assessment

East 18th Street Apartments

Antioch, California

BAC Job # 2018-148

Prepared For:

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CEQA Checklist

NOISE AND VIBRATION – **Would the Project Result in:**	**NA – Not Applicable**	**Potentially Significant Impact**	**Less than Significant with Mitigation Incorporated**	**Less Than Significant Impact**	**No Impact**
a) Exposure of persons to or generation of noise levels in excess of standards established in the local general plan or noise ordinance, or applicable standards of other agencies?			X		
b) Exposure of persons to or generation of excessive groundborne vibration or groundborne noise levels?				X	
c) A substantial permanent increase in ambient noise levels in the project vicinity above levels existing without the project?				X	
d) A substantial temporary or periodic increase in ambient noise levels in the project vicinity above level existing without the project?			X		
e) For a project located within an airport land use plan or, where such a plan has not been adopted, within two miles of a public airport or public use airport, would the project expose people residing or working in the project to excessive noise levels?					X
f) For a project within the vicinity of a private airstrip, would the project expose people residing or working in the project area to excessive noise levels?					X

Introduction

The proposed East 18th Street Apartments (project) is located west of California State Route 160 (SR 160) and south of East 18th Street in Antioch, California. The project proposes the development of a 394-unit apartment complex comprised of 11 buildings on a currently undeveloped parcel. Existing land uses in the project vicinity include residential to the west and northeast, church to the south, and vacant land to the north and east. The project area and site plan are shown on Figures 1 and 2, respectively.

Due to the proximity of the proposed residential development to SR 160, East 18th Street, and adjacent existing noise-sensitive uses, the City of Antioch has requested an environmental noise and vibration assessment to ensure that the applicable noise standards are satisfied. In response to this request, the project applicant has retained Bollard Acoustical Consultants, Inc. (BAC) to prepare this noise and vibration assessment. Specifically, this assessment focuses on the quantification of off-site traffic noise generation, on-site traffic noise levels associated with SR 160 and East 18th Street, and project-generated construction noise and vibration levels.

Noise and Vibration Fundamentals

Noise

Noise is simply described as unwanted sound. Sound is defined as any pressure variation in air that the human ear can detect. Discussing sound directly in terms of pressure would require a very large and awkward range of numbers. To avoid this, the decibel (dB) scale was devised. The decibel scale uses the hearing threshold (20 micropascals of pressure), as a point of reference, defined as 0 dB. Other sound pressures are compared to the reference pressure and the logarithm is taken to keep the numbers in a practical range. The dB scale allows a million-fold increase in pressure to be expressed as 120 dB.

To better relate overall sound levels and loudness to human perception, frequency-dependent weighting networks were developed. There is a strong correlation between the way humans perceive sound and A-weighted sound levels. For this reason, the A-weighted sound level has become the standard tool of environmental noise assessment for community exposures. All sound levels expressed as dB in this section are A-weighted sound levels, unless noted otherwise. Definitions of acoustical terminology are provided in Appendix A.

Community noise is commonly described in terms of the “ambient” noise level, which is defined as the all-encompassing noise level associated with a given noise environment. A common statistical tool to measure the ambient noise level is the average, or equivalent, sound level (L_{eq}), over a given time period (usually one hour). The L_{eq} is the foundation of the composite noise descriptors, day-night average level (L_{dn}) and the community noise equivalent level (CNEL), and shows very good correlation with community response to noise for the average person. The median noise level descriptor, denoted L_{50}, represents the noise level which is exceeded 50% of the hour. In other words, half of the hour ambient conditions are higher than the L_{50} and the other half are lower than the L_{50}.

The L_{dn} is based upon the average noise level over a 24-hour day, with a +10 dB weighting applied to noise occurring during nighttime (10:00 p.m. to 7:00 a.m.) hours. The nighttime penalty is based upon the assumption that people react to nighttime noise exposures as though they were twice as loud as daytime exposures. Because L_{dn} represents a 24-hour average, it tends to disguise short-term variations in the noise environment. Where short-term noise sources are an issue, noise impacts may be assessed in terms of maximum noise levels, hourly averages, or other statistical descriptors.

The perceived loudness of sounds and corresponding reactions to noise are dependent upon many factors, including sound pressure level, duration of intrusive sound, frequency of occurrence, time of occurrence, and frequency content. As mentioned above; however, within the usual range of environmental noise levels, perception of loudness is relatively predictable, and can be approximated by weighing the frequency response of a sound level meter by means of the standardized A-weighing network. Figure 3 shows examples of noise levels for several common noise sources and environments.

It is generally recognized that an increase of at least 3 dB of similar sources is usually required before most people will perceive a change in noise levels in the community, and an increase of 5 dB is required before the change will be clearly noticeable. A common practice is to assume that a minimally perceptible increase of 3 dB represents a significant increase in ambient noise levels. This approach is very conservative, however, when applied to noise conditions substantially below levels deemed acceptable in general plan noise elements or in noise ordinances.

Vibration

Vibration is like noise in that it involves a source, a transmission path, and a receiver. While vibration is related to noise, it differs in that noise is generally considered to be pressure waves transmitted through air, while vibration is usually associated with transmission through the ground or structures. As with noise, vibration consists of an amplitude and frequency. A person’s response to vibration will depend on their individual sensitivity as well as the amplitude and frequency of the source.

Vibration can be described in terms of acceleration, velocity, or displacement. A common practice is to monitor vibration measures in terms of velocity in inches per second or root-mean-square (RMS) in VdB. Standards pertaining to perception as well as damage to structures have been developed for vibration in terms of peak particle velocity as well as RMS velocities.

Legend

Project Border (Approximate)

(#) Long-Term Noise and Short-Term Vibration Level Measurement Locations

(T) Traffic Calibration Location

N

Scale (feet)

0 200 400

18th Street Apartments
Antioch, California

Project Area

Figure 1

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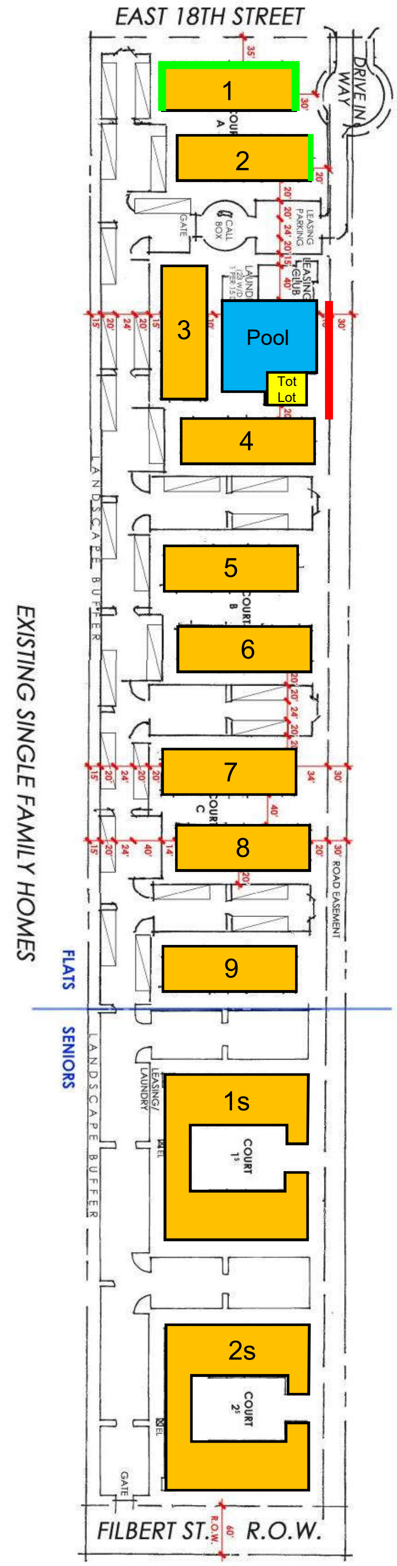

Legend

- Recommended 6-Foot Tall Solid Barrier
- Recommended Window Upgrades: STC 32 (Upper-Floors)
- Residential Buildings

N

Scale (Feet)

0 100 200

18th Street Apartments

Antioch, California

Project Site Plan

Figure 2

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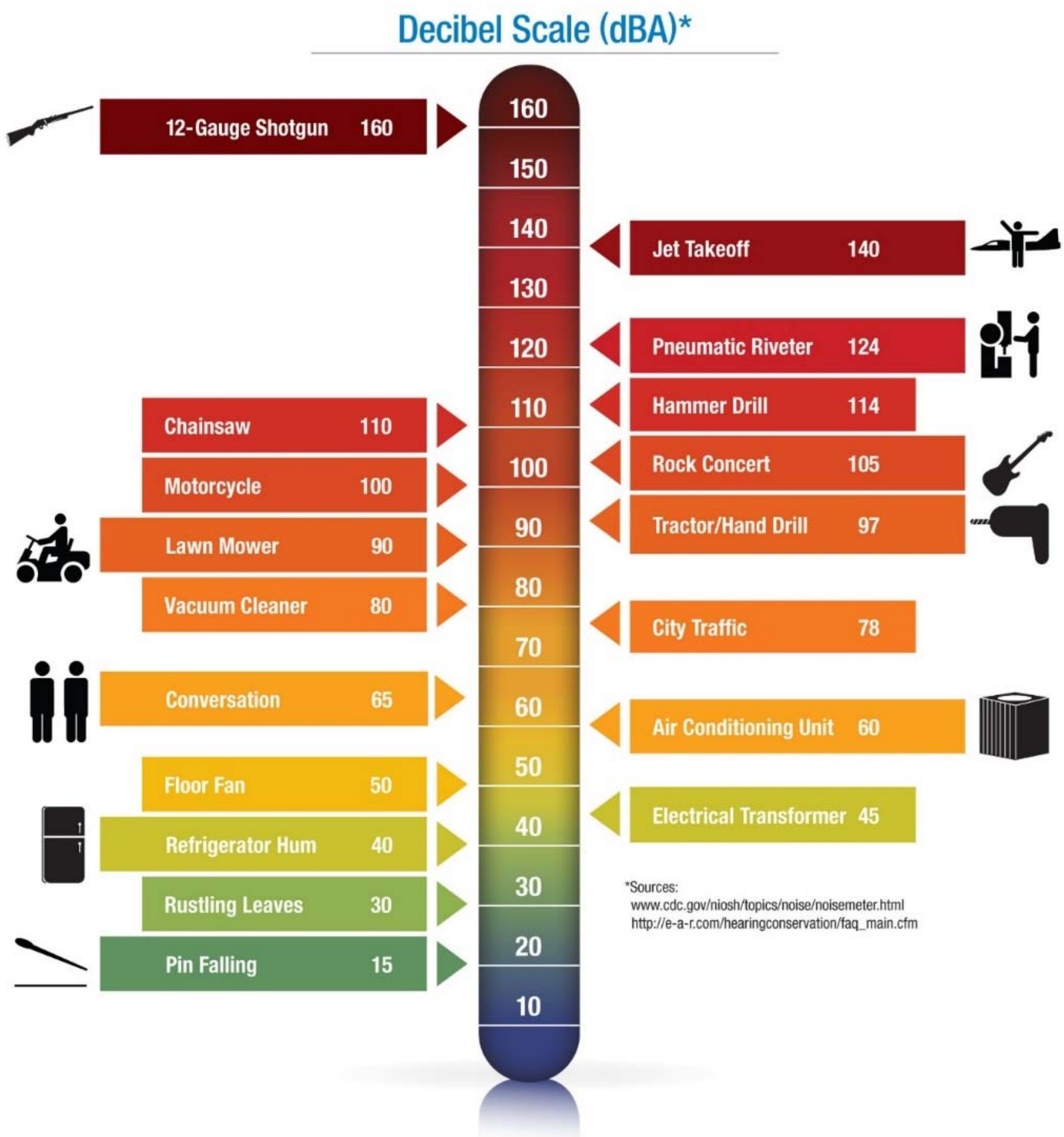
Figure 3
Typical A-Weighted Sound Levels of Common Noise Sources



As vibrations travel outward from the source, they excite the particles of rock and soil through which they pass and cause them to oscillate. Differences in subsurface geologic conditions and distance from the source of vibration will result in different vibration levels characterized by different frequencies and intensities. In all cases, vibration amplitudes will decrease with increasing distance. The maximum rate, or velocity of particle movement, is the commonly accepted descriptor of the vibration "strength".

Human response to vibration is difficult to quantify. Vibration can be felt or heard well below the levels that produce any damage to structures. The duration of the event has an effect on human response, as does frequency. Generally, as the duration and vibration frequency increase, the potential for adverse human response increases.

According to the Transportation and Construction-Induced Vibration Guidance Manual (Caltrans, June 2004), operation of construction equipment and construction techniques generate ground vibration. Traffic traveling on roadways can also be a source of such vibration. At high enough amplitudes, ground vibration has the potential to damage structures and/or cause cosmetic damage. Ground vibration can also be a source of annoyance to individuals who live or work close to vibration-generating activities. However, traffic, rarely generates vibration amplitudes high enough to cause structural or cosmetic damage.

Regulatory Setting: Criteria for Acceptable Noise and Vibration Exposure

Federal

There are no federal noise or vibration criteria which would be directly applicable to this project.

State of California

California Environmental Quality Act (CEQA)

The State of California has established regulatory criteria that are applicable to this assessment. Specifically, Appendix G of the State of California Environmental Quality Act (CEQA) Guidelines are used to assess the potential significance of impacts pursuant to local General Plan policies, Municipal Code standards, or the applicable standards of other agencies. According to Appendix G of the CEQA guidelines, the project would result in a significant noise or vibration impact if the following occur:

A. exposure of persons to or generation of noise levels in excess of standards established in the local general plan or noise ordinance, or applicable standards of other agencies;

B. exposure of persons to or generation of excessive groundborne vibration or noise levels;

C. a substantial permanent increase in ambient noise levels in the project vicinity above levels existing without the project;

D. a substantial temporary or periodic increase in ambient noise levels in the project vicinity above levels existing without the project;

E. for a project located within an ALUP or, where such a plan has not been adopted, within 2 miles of a public airport or public use airport, the project would expose people residing or working in the project area to excessive noise levels;

F. or a project within the vicinity of a private airstrip, the project would expose people residing or working in the project area to excessive noise levels.

It should be noted that audibility is not a test of significance according to CEQA. If this were the case, any project which added any audible amount of noise to the environment would be considered unacceptable according to CEQA. Because every physical process creates noise, the use of audibility alone as significance criteria would be unworkable. CEQA requires a substantial increase in noise levels before noise impacts are identified, not simply an audible change.

California Department of Transportation (Caltrans)

The City of Antioch does not currently have adopted standards for groundborne vibration. As a result, vibration criteria established by the California Department of Transportation (Caltrans 2013) was applied to this project. The Caltrans publication, *Transportation and Construction Vibration Guidance Manual*, provides guidelines for acceptable vibration limits for transportation and construction projects in terms of the induced peak particle velocity (PPV). Human and structural response to different vibration levels is influenced by a number of factors, including ground type, distance between source and receptor, duration, and the number of perceived vibration events. The Caltrans criteria applicable to human responses to vibration are shown below in Table 1.

Table 1
Human Response to Transient Vibration

Human Response/Structure	Peak Particle Velocity (in/sec)
Barely Perceptible	0.04
Distinctly Perceptible	0.25
Strongly Perceptible	0.90
Severe	2.00
Residential Construction	1.0

Source: Caltrans Transportation and Construction Vibration Guidance Manual, September 2013

As shown in Table 1, a vibration level of 0.25 in/sec PPV is the level at which vibration becomes distinctly to strongly perceptible. As a result, the 0.25 threshold is considered to be a conservative benchmark against which project vibration levels are evaluated in this assessment.

Local

City of Antioch General Plan

Chapter 11 (Environmental Hazards) of the City of Antioch General Plan contains the City's noise-related objectives and policies. The specific objectives and policies which are generally applicable to this project are reproduced below:

11.6.1 Noise Objective

Achieve and maintain exterior noise levels appropriate to planned land uses throughout Antioch, as described below:

Single-Family Residential: 60 dBA CNEL within rear yards

Multi-Family Residential: 60 dBA CNEL within interior open space

School Classrooms: 65 dBA CNEL

School Play and Sports Areas: 70 dBA CNEL

Hospitals, Libraries: 60 dBA CNEL

Commercial/Industrial: 70 dBA CNEL at the front setback

11.6.2 Noise Policies

Noise Compatible Land Use and Circulation Patterns

a. Implementation of the noise objective contained in Section 11.6.1 and the policies contained in Section 11.6.2 of the Environmental Hazards Element shall be based on noise data contained in Section 4.9 of the General Plan EIR, unless a noise analysis conducted pursuant to the City's development and environmental review process provides more up-to-date and accurate noise projections, as determined by the City.

b. Maintain a pattern of land uses that separates noise-sensitive land uses from major noise sources to the extent possible, and guide noise-tolerant land uses into the noisier portions of the Planning Area.

Noise Analysis and Mitigation

d. Where new development (including construction and improvement of roadways) is proposed in areas exceeding the noise levels identified in the General Plan Noise Objective, or where the development of proposed uses could result in a significant increase in noise, require a detailed noise attenuation study to be prepared by a qualified acoustical engineer to determine appropriate mitigation and ways to incorporate such mitigation into project design and implementation.

f. In reviewing noise impacts, utilize site design and architectural design features to the extent feasible to mitigate impacts on residential neighborhoods and other uses that are sensitive to noise. In addition to sound barriers, design techniques to mitigate noise impacts may include, but are not limited to:

- Increased building setbacks to increase the distance between the noise source and sensitive receptor.
- Orient buildings which are compatible with higher noise levels adjacent to noise generators or in clusters to shield more noise sensitive areas and uses.
- Place noise tolerant use, such as parking areas, and noise tolerant structures, such as garages, between the noise source and sensitive receptor.
- Cluster office, commercial, or multi-family residential structures to reduce noise levels within interior open space areas.
- Provide double glazed and double paned windows on the side of the structure facing a major noise source, and place entries away from the noise source to the extent possible.

g. Where feasible, require the use of noise barriers (walls, berms, or a combination thereof) to reduce significant noise impacts.

- Noise barriers must have sufficient mass to reduce noise transmission and high enough to shield the receptor from the noise source.
- To be effective, the barrier needs to be constructed without cracks or openings.
- The barrier must interrupt the line of sight between the noise source and noise receptor.
- The effects of noise “flanking” the noise barrier should be minimized by bending the end of the barrier back from the noise source.
- Require appropriate landscaping treatment to be provided in conjunction with noise barriers to mitigate their potential aesthetic impacts.

h. Continue enforcement of California Noise Insulation Standards (Title 25, Section 1092, California Administrative Code).

<u>Temporary Construction</u>

i. Ensure that construction activities are regulated as to hours of operation in order to avoid or mitigate noise impacts on adjacent noise-sensitive land uses.

j. Require proposed development adjacent to occupied noise-sensitive land uses to implement a construction-related noise mitigation plan. This plan would depict the location of construction equipment storage and maintenance areas, and document noise impacts on adjacent noise-sensitive land uses.

k. Require that all construction equipment utilize noise reduction features (e.g., mufflers and engine shrouds) that are no less effective than those originally installed by the manufacturer.

m. Prior to the issuance of any grading plans, the City shall condition approval of subdivisions and non-residential development adjacent to any developed/occupied noise-sensitive land uses by requiring that applicants to submit a construction-related noise mitigation plan to the City for review and approval. The plan should depict the location of construction equipment and how the noise from this equipment will be mitigated during construction of the project through the use of such methods as:

- The construction contractor shall use temporary noise-attenuation fences, where feasible, to reduce construction noise impacts on adjacent noise-sensitive land uses.

- During all project site excavation and grading on-site, the construction contractors shall equip all construction equipment, fixed or mobile, with properly operating and maintained mufflers, consistent with manufacturers' standards. The construction contractor shall place all stationary equipment so that emitted noise is directed away from sensitive receptors nearest the project site.

- The construction contractor shall locate equipment staging in areas that will create the greatest distance between construction-related noise sources and noise-sensitive receptors nearest the project site during all project construction.

- The construction contractor shall limit all construction-related activities that would result in high noise levels to between the hours of 7 am and 7 pm Monday through Saturday. No construction shall be allowed on Sundays and public holidays.

n. The construction-related noise mitigation plan required shall also specify that haul truck deliveries be subject to the same hours specified for construction equipment. Additionally, the plan shall denote any construction traffic haul routes where heavy trucks would exceed 100 daily trips (counting those both to and from the construction site). To the extent feasible, the plan shall denote haul routes that do not pass sensitive land uses or residential dwellings. Lastly, the construction-related noise mitigation plan shall incorporate any other restrictions imposed by the City.

City of Antioch Code

The City of Antioch Code provides noise level limits for non-transportation (stationary) and mobile noise sources in an effort to ensure that City residents live in an environment free of unnecessary, offensive and excessive noise. The noise level limits that are applicable to the project are provided below:

5-17.04 Heavy Construction Equipment Noise.

A. For the purposes of this chapter, the following definitions shall apply unless the context clearly indicates or requires a different meaning.

Heavy Construction Equipment. Equipment used in grading and earth moving, including diesel engine equipped machines used for that purpose, except pickup trucks of one ton or less.

Operate. Includes the starting, warming-up, and idling of heavy construction equipment engines or motors.

B. It shall be unlawful for any person to operate heavy construction equipment during the hours specified below:

1. On weekends prior to 7 am and after 6 pm.
2. On weekdays within 300 feet of occupied dwelling space, prior to 8 am and after 5 pm.
3. On weekends and holidays, prior to 9 am and after 5 pm, irrespective of the distance from the occupied dwelling.

5-17.05 Construction Activity Noise.

A. As used in this section, *construction activity* means the process or manner of constructing, building, refurbishing, remodeling, or demolishing a structure, delivering supplies thereto and includes, but is not limited to, hammering, sawing, drilling, and other construction activities when the noise or sound therefrom can be heard beyond the perimeter of the parcel where such work is being performed. The term *construction activity* also includes the testing of any audible device such as a burglar or fire alarm or loudspeaker. *Construction activity* does not include floor covering installation or painting when done with non-powered equipment.

B. It is unlawful for any person to be involved in construction activity during the hours specified below:

1. On weekdays prior to 7 am and after 6 pm.
2. On weekdays within 300 feet of occupied dwellings, prior to 8 am and after 5 pm.
3. On weekends and holidays, prior to 9 am and after 5 pm, irrespective of the distance from the occupied dwellings.

C. In addition to the penalties provided by this code, authorized employees may issue “Stop Work Orders” when a violation of this section or §§ 5-17-04 and 5-17.05 for a specific period of time.

Thresholds of Significance for Project-Related Noise Level Increases

The CEQA guidelines state that a project would result in a significant noise impact if it results in a substantial temporary increase in ambient noise levels above those present without the project. CEQA does not, however, define what constitutes a substantial increase. It is generally recognized that an increase of at least 3 dB for similar noise sources is usually required before most people will perceive a change in noise levels, and an increase of 6 dB is required before the change will be clearly noticeable (Egan, Architectural Acoustics, page 21, 1988, McGraw Hill).

The Federal Interagency Commission on Noise (FICON) has developed a graduated scale for use in the assessment of project-related noise level increases. Table 2 was developed by FICON as a means of developing thresholds for impact identification for project-related noise level increases. The FICON standards have been used extensively in recent years by the authors of this section in the preparation of the noise sections of Environmental Impact Reports that have been certified in many California Cities and Counties.

The rationale for the graduated scale used in the FICON standards is that test subjects' reactions to increases in noise levels varied depending on the starting level of noise. Specifically, with lower ambient noise environments, such as those below 60 dB L_{dn}, a larger increase in noise levels was required to achieve a negative reaction than was necessary in more elevated noise environments.

The use of the FICON standards are considered conservative relative to thresholds used by other agencies in the State of California. For example, the California Department of Transportation (Caltrans) requires a project-related traffic noise level increase of 12 dB for a finding of significance, and the California Energy Commission (CEC) considers project-related noise level increases between 5-10 dB significant, depending on local factors. Therefore, the use of the FICON standards, which set the threshold for finding of significant noise impacts as low as 1.5 dB, provides a very conservative approach to impact assessment for this project.

Table 2
Significance of Changes in Cumulative Noise Exposure

Ambient Noise Level Without Project, L_{dn}	Increase Considered Significant
<60 dB	+5.0 dB or more
60-65 dB	+3.0 dB or more
>65 dB	+1.5 dB or more

Source: Federal Interagency Committee on Noise (FICON)

Based on the FICON research, as shown in Table 2, a 5 dB increase in noise levels due to a project is required for a finding of significant noise impact where ambient noise levels without the project are less than 60 dB L_{dn}. Where pre-project ambient conditions are between 60 and 65 dB L_{dn}, a 3 dB increase is applied as the standard of significance. Finally, in areas already exposed to higher noise levels, specifically pre-project noise levels in excess of 65 dB L_{dn}, a 1.5 dB increase is considered by FICON as the threshold of significance.

This graduated scale indicates that in quieter noise environments, test subjects tolerated a higher increase in noise levels due to a project before the onset of adverse noise impacts than did test subjects in louder environments.

According to the FICON study, if screening analysis shows that noise-sensitive areas will be at or above DNL 65 dB and will have an increase of DNL 1.5 or more, further analysis should be conducted. The FICON study also reported the following: Every change in the noise environment does not necessarily impact public health and welfare.

As noted previously, audibility is not a test of significance according to CEQA. If this were the case, any project which added any audible amount of noise to the environment would be considered unacceptable according to CEQA. Because every physical process creates noise, whether by the addition of a single vehicle on a roadway, or a tractor in an agricultural field, the use of audibility alone as significance criteria would be unworkable. CEQA requires a substantial increase in noise levels before noise impacts are identified, not simply an audible change.

Environmental Setting – Existing Ambient Noise and Vibration Environment

Noise Environment

The existing ambient noise environment at the project site is primarily defined by traffic on East 18th Street, SR 160, and the SR 160 southbound ramp. To quantify the existing ambient noise environment at the project site, BAC conducted continuous (24-hour) noise level measurements at two (2) locations on the project site on August 15, 2018. The noise measurement locations are shown on Figure 1, identified as Sites 1 and 2.

Larson Davis Laboratories (LDL) Model 820 precision integrating sound level meters were used for the noise level measurement survey. The meter was calibrated before use with an LDL Model CA200 acoustical calibrator to ensure the accuracy of the measurements. The equipment used meets all specifications of the American National Standards Institute requirements for Type 1 sound level meters (ANSI S1.4). The results of the measurements are shown numerically and graphically in Appendices B and C, and are summarized in Table 3. Photographs of the noise measurement site are provided in Appendix D.

Table 3
Summary of Long-Term Ambient Noise Monitoring Results
East 18th Street Apartments – Antioch, California
August 15, 2018

		Average Measured Hourly Noise Levels (dB)					
		Daytime (7:00 a.m. to 10:00 p.m.)			Nighttime (10:00 p.m. to 7:00 a.m.)		
Site[1]	**L_{dn}, dB**	**L_{eq}**	**L_{50}**	**L_{max}**	**L_{eq}**	**L_{50}**	**L_{max}**
1	61	54	52	70	54	50	68
2	68	69	51	68	56	51	64

Notes:
[1] Long-term ambient noise monitoring site is identified on Figure 1.
Source: Bollard Acoustical Consultants, Inc. (2018)

Upon analysis of the collected noise level data at Site 2, BAC noted the occurrence of anomalous loud events that influenced measured maximum (L_{max}) noise levels during the 7:00 p.m. and 8:00 p.m. hours. During all other hours, measured maximum noise levels at Site 2 ranged from 56 dB to 73 dB while measured maximum noise levels during the 7:00 p.m. and 8:00 pm hours were 93 dB and 98 dB, respectively. The measured maximum noise levels during this period significantly contributed to elevated average hourly (L_{eq}) noise levels, which resulted in an artificially high day-night average level (L_{dn}) calculation of 68 dB L_{dn}. After correction for the anomalous data, the day-night average noise level for Site 2 was calculated to be approximately 62 dB L_{dn}.

The Table 3 data indicate that the existing ambient noise levels at the project site exceeded the City of Antioch 60 dB L_{dn} exterior traffic noise level standard for residential land uses, including the re-calculated L_{dn} value for Site 2. As a result, a detailed analysis of future traffic noise levels was conducted and that analysis is presented in the following section.

Vibration Environment

During a site visit on August 14, 2018, vibration levels were below the threshold of perception at the project site. Nonetheless, to quantify existing vibration levels at the project site, BAC conducted short-term (10-minute) vibration measurements at two (2) locations on the project site. The vibration measurement locations are shown on Figure 1. Photographs of the vibration measurement sites are provided in Appendix D.

A Larson-Davis Laboratories Model 831 precision integrating sound level meter equipped with a vibration transducer was used to complete the measurements. The results are summarized in Table 4.

Table 4
Short-Term Vibration Measurement Results
East 18th Street Apartments – Antioch, California
August 14, 2018

Site[1]	Time	Average Vibration Level, VdB RMS
1	10:34 a.m.	48
2	11:14 a.m.	54

Source: Bollard Acoustical Consultants, Inc. (2018)

The Table 4 data indicate that measured average vibration levels at Sites 1 and 2 ranged from 48-54 VdB RMS. The measured vibration levels at both sites are well below the threshold of perception, or below 0.1 inches per second if converted to Peak Particle Velocities (PPV).

Impacts and Mitigation Measures

Traffic Noise Prediction Methodology

The Federal Highway Administration Highway Traffic Noise Prediction Model (FHWA-RD-77-108) was used to predict traffic noise levels at the project site. The model is based upon the CALVENO noise emission factors for automobiles, medium trucks and heavy trucks, with consideration given to vehicle volume, speed, roadway configuration, distance to the receiver, and the acoustical characteristics of the site. The FHWA Model was developed to predict hourly L_{eq} values for free flowing traffic conditions, and is considered to be accurate within 1.5 dB in most situations.

Traffic Noise Prediction Model Calibration

The FHWA Model provides reasonably accurate traffic noise predictions under "ideal" roadway conditions. Ideal conditions are generally considered to be long straight roadway segments with uniform vehicle speeds, a flat roadway surface, good pavement conditions, a statistically large volume of traffic, and an unimpeded view of the roadway from the receiver location. Such conditions did not appear to be in effect at the project site due to nearby traffic lights. As a result, BAC conducted a calibration of the FHWA Model through site-specific traffic noise level measurements and concurrent traffic counts along East 18th Street.

The calibration process was performed at the project site on August 14, 2018. The measurements were conducted at a height of 5 feet above existing grade to quantify traffic noise levels at the future building facades of residences proposed nearest to East 18th Street. The location of the traffic calibration site is shown on Figure 1. Photographs of the traffic calibration site are provided in Appendix D. Detailed results of the traffic calibration procedure are provided in Appendix E.

A Larson Davis Laboratories (LDL) Model 831 precision integrating sound level meter and real-time frequency analyzer was used to conduct the traffic calibration noise level survey. The meter was calibrated before use with an LDL Model CAL200 acoustical calibrator to ensure the accuracy of the measurements. The equipment used meets all pertinent specifications of the American National Standards Institute for Type 1 sound level meters (ANSI S1.4).

As indicated in Appendix E, the FHWA Model was found to over-predict East 18th Street traffic noise levels by 2.5 dB. Nonetheless, no calibration offset was applied to the model in order to provide a conservative assessment of future East 18th Street traffic noise levels at the project site.

Evaluation of Exterior Traffic Noise Levels at Project Site

The FHWA Model was used with future (Cumulative Plus Project) traffic data obtained from the project traffic study (Hexagon Transportation Consultants, Inc., 2018) to predict future traffic noise levels from East 18th Street and the SR 160 southbound ramp at the proposed residential uses of the project site. In addition, the FHWA Model was used with traffic data from Caltrans 2016 Traffic Counts to predict future SR 160 traffic noise level exposure at the project site. Specifically, future SR 160 traffic volumes were conservatively estimated by increasing the existing traffic volume by a factor of 1.5 to account for regional growth in the next 20 years. The FHWA Model inputs and predicted future traffic noise levels at the noise-sensitive locations on the project site are shown in Appendix F. The results are summarized in Table 5.

The predicted future East 18th Street traffic noise levels at the common outdoor area of the development (pool/tot lot) takes into consideration the screening provided by proposed intervening buildings, and have been conservatively adjusted by -7 dB to account for this shielding. No shielding offset was applied to SR 160 or SR 160 southbound ramp traffic noise levels at the common outdoor area.

Table 5
Predicted Future Exterior Traffic Noise Levels[1]
East 18th Street Apartments – Antioch, California

Roadway	Building	Location	Distance, ft.	Offset, dB[2]	L_{dn}, dB
East 18th Street	1	Common outdoor area	430	-7	48
		First-floor facades	80		66
		Upper-floor facades	80	+3	69
SR 160	2s	Common outdoor area	810		59
		First-floor facades	490		63
		Upper-floor facades	490	+3	66
SR 160 Southbound Ramp	2	Common outdoor area	475		56
		First-floor facades	375		57
		Upper-floor facades	375	+3	60

Notes:

1 A complete listing of FHWA Model inputs and results are provided in Appendix F.

2 A +3 dB offset was applied to the upper-floor facades due to reduced ground absorption at elevated floor levels. A -7 dB offset was applied to predicted future East 18th Street traffic noise levels at the common outdoor area (pool/tot lot) to account for the shielding provided by proposed intervening buildings.

Source: Bollard Acoustical Consultants, Inc. (2018)

Evaluation of Interior Traffic Noise Levels at Project Site

The worst-case interior traffic noise exposure at the proposed development would occur within the residences proposed closest to East 18th Street, SR 160, and the SR 160 southbound ramp. According to Table 5, the future L_{dn} values at the first-floor facades of the residences nearest to these roadways are predicted to range from 57 to 66 dB L_{dn}. Due to reduced ground absorption at elevated positions, upper-level traffic noise levels from these roadways could range from 60 to 69 dB L_{dn}. In addition, standard residential construction (stucco siding, STC-27 windows, door weather-stripping, exterior wall insulation, composition plywood roof), results in an exterior to interior noise reduction of at least 25 dB with windows closed and approximately 15 dB with windows open.

Evaluation of Off-Site Traffic Noise Level Increases in the Project Vicinity

Construction of this project would result in increased traffic on the local roadway network. BAC utilized the FHWA Model with the project traffic study prepared by Hexagon Transportation Consultants, Inc. to determine whether traffic noise impacts (relative to the FICON impact significance criteria) would occur as a result of this project. The FHWA Model inputs are provided in Appendix G, and the results are shown below in Tables 6 and 7.

Table 6
Existing vs. Existing Plus Project Traffic Noise Levels, dB L_{dn}
East 18th Street Apartments – Antioch, California

Roadway	Segment	Existing	Existing + Project	Change	Substantial Increase?
East 18th Street	West of Viera Avenue	63.8	63.9	0.1	No
East 18th Street	Viera Avenue to Phillips Lane	63.4	63.6	0.2	No
East 18th Street	Phillips Lane to Holub Lane	63.2	63.3	0.1	No
East 18th Street	Holub Lane to SR 160 SB Ramps	63.1	63.6	0.5	No
East 18th Street	SR 160 SB Ramps to NB Ramps	64.8	65.1	0.3	No
East 18th Street	East of SR 160 NB Ramps	67.0	67.1	0.1	No
Viera Avenue	North of East 18th Street	51.0	51.2	0.2	No
Viera Avenue	South of East 18th Street	49.8	50.0	0.2	No
Phillips Lane	South of East 18th Street	50.3	50.6	0.3	No
Holub Lane	South of East 18th Street	31.6	49.7	18.1	Yes
Drive-In Lane	North of East 18th Street	48.7	48.7	0.0	No
SR 160 SB Ramps	South of East 18th Street	64.6	64.7	0.1	No
SR 160 NB Ramps	South of East 18th Street	66.8	67.0	0.2	No

Sources: FHWA-RD-77-108, project traffic study, and Bollard Acoustical Consultants, Inc. (2018)

Table 7
Cumulative vs. Cumulative Plus Project Traffic Noise Levels, dB L_{dn}
East 18th Street Apartments – Antioch, California

Roadway	Segment	Cumulative	Cumulative + Project	Change	Substantial Increase?
East 18th Street	West of Viera Avenue	64.9	65.0	0.1	No
East 18th Street	Viera Avenue to Phillips Lane	64.0	64.2	0.2	No
East 18th Street	Phillips Lane to Holub Lane	64.6	64.7	0.1	No
East 18th Street	Holub Lane to SR 160 SB Ramps	64.5	64.8	0.3	No
East 18th Street	SR 160 SB Ramps to NB Ramps	65.8	66.0	0.2	No
East 18th Street	East of SR 160 NB Ramps	68.3	68.4	0.1	No
Viera Avenue	North of East 18th Street	53.6	53.7	0.1	No
Viera Avenue	South of East 18th Street	55.6	55.8	0.2	No
Phillips Lane	South of East 18th Street	53.5	53.7	0.2	No
Holub Lane	South of East 18th Street	31.6	49.5	17.9	Yes
Drive-In Lane	North of East 18th Street	48.7	48.7	0.0	No
SR 160 SB Ramps	South of East 18th Street	65.6	65.7	0.1	No
SR 160 NB Ramps	South of East 18th Street	68.6	68.6	0.0	No

Sources: FHWA-RD-77-108, project traffic study, and Bollard Acoustical Consultants, Inc. (2018)

The data shown in Tables 6 and 7 indicate that the project-related increase in traffic noise levels on the local roadway network would be substantial along one of the analyzed roadway segments (Holub Lane, south of East 18th Street).

Evaluation of Project Construction Noise at Existing Residences

During project construction, heavy equipment would be used for grading excavation, paving, and building construction, which would increase ambient noise levels when in use. Noise levels would vary depending on the type of equipment used, how it is operated, and how well it is maintained. Noise exposure at any single point outside the project site would also vary depending on the proximity of construction activities to that point. Standard construction equipment, such as graders, backhoes, loaders, and trucks, would be used for this work.

The range of maximum noise levels for various types of construction equipment at a distance of 50 feet is depicted in Table 8. The noise values represent maximum noise generation, or full-power operation of the equipment. As one increases the distance between equipment, or increases separation of areas with simultaneous construction activity, dispersion and distance attenuation reduce the effects of combining separate noise sources.

Table 8
Construction Equipment Noise Emission Levels

Equipment	Typical Sound Level (dBA) 50 Feet from Source
Air compressor	81
Backhoe	80
Compactor	82
Concrete mixer	85
Concrete pump	82
Concrete vibrator	76
Crane, mobile	83
Dozer	85
Generator	81
Grader	85
Impact wrench	85
Jackhammer	88
Loader	85
Paver	89
Pneumatic tool	85
Pump	76
Roller	74
Saw	76
Truck	88

Source: Transit Noise and Vibration Impact Assessment, Federal Transit Administration, Table 12-1. (May 2006)

The nearest existing noise-sensitive receptors to the project site are single-family residential developments located to the northeast and west. The nearest residences are located approximately 25 feet from construction activities which would occur on the project site. As shown in Table 8, construction activities typically generate noise levels ranging from approximately 75 to 90 dB L_{max} at a reference distance of 50 feet from the construction activities. The noise levels from construction operations decrease at a rate of approximately 6 dB per doubling of distance from the source. As a result, worst-case maximum construction noise levels would range from approximately 81 to 96 dB L_{max} at the nearest residences.

Evaluation of Project Construction Vibration Levels at Existing Residences

During project construction heavy equipment would be used for grading excavation, paving, and building construction, which would generate localized vibration in the immediate vicinity of the construction. The nearest residence is located approximately 25 feet from construction activities which would occur on the project site.

The range of vibration source levels for construction equipment commonly used in similar projects are shown in Table 9. The vibration levels depicted in Table 8 are representative of measurements at a distance of 25 feet from the equipment source.

Table 9
Vibration Levels of Construction Equipment – 25 Foot Reference Distance

Source	Peak Particle Velocity (PPV) inches/second
Vibratory Roller	0.210
Loaded Truck	0.076
Excavator	0.051
Front Loader	0.035
Water Truck	0.001

Source: FTA and FHWA

The vibration data shown in Table 9 indicate that heavy equipment-generated vibration levels would be at or below distinctly perceptible levels, and well below levels considered severe, at the nearest residences to the project site.

Evaluation of Vibration Levels at Project Site

The project proposes the development of residential units, community clubhouse buildings, and offices. It is the experience of BAC that these uses do not typically have equipment that generates appreciable vibration. In addition, it is our understanding that the proposed development does not propose equipment that will produce appreciable vibration.

As indicated in Table 4, measured ambient vibration levels at the project site ranged from 48-54 VdB RMS. As noted previously, the measured vibration levels at the project site are well below the threshold of perception (below 0.1 inches/second peak particle velocity).

Evaluation of Impacts Relative to CEQA Criteria

Criteria A: Exposure of persons to or generation of noise levels in excess of standards established in the local general plan or noise ordinance, or applicable standards of other agencies.

Exterior Traffic Noise Levels at the Project Site

As indicated in Table 5, the proposed common use area of the development (pool/ tot lot) would be exposed to a future (Cumulative Plus Project) East 18th Street traffic noise level of 48 dB L_{dn}, including the -7 dB offset to account for the shielding provided by the proposed buildings. The Table 5 data also indicates that the common use area will be exposed to future SR 160 and SR160 southbound ramp noise levels of 59 and 56 dB L_{dn}, respectively. Although not shown in Table 5, the combined future traffic noise level exposure from both SR 160 and the SR 160 ramp at the common use area is calculated to be 61 dB L_{dn}. Because combined SR 160 and SR 160 ramp traffic noise levels could exceed the City of Antioch 60 dB L_{dn} at the common outdoor use area of the development, this impact is considered to be ***potentially significant***.

Mitigation for Criteria A: Exterior Traffic Noise Levels

In order to reduce SR 160 and SR 160 southbound ramp traffic noise level exposure to a state of compliance with the City of Antioch 60 dB L_{dn} exterior noise level standard at the proposed common use area of the development (pool/tot lot), the following noise mitigation options could be employed by the project developer:

MM-1: A solid noise barrier measuring a minimum of 6-feet in height relative to common use area elevation should be constructed at the location identified on Figure 2. Barrier insertion loss calculation worksheets are provided as Appendix H.

Suitable materials for the traffic noise barrier include masonry and precast concrete panels. Glass can also be an effective barrier material in areas where preservation of views is desired. Other materials may be acceptable but should be reviewed by an acoustical consultant prior to use.

OR

MM-2: The project developer re-design the development such that the proposed common use area (pool/tot lot) is shielded from view of SR 160 and the SR 160 southbound ramp by intervening buildings.

Significance after Mitigation: *Less than Significant*

Interior Traffic Noise Levels at the Project Site

According to Table 5, the future L_{dn} values at the first-floor facades of the residences nearest to East 18th Street, SR 160, and the SR 160 southbound ramp are predicted to range from 57 to 66 dB L_{dn}. Due to reduced ground absorption at elevated positions, upper-level traffic noise levels from these roadways are expected to range from 60 to 69 dB L_{dn}. However, when taking into consideration the combined traffic noise exposure from the adjacent roadways, it is possible that that future traffic noise levels could be higher at these locations.

Standard residential construction (stucco siding, STC-27 windows, door weather-stripping, exterior wall insulation, composition plywood roof), results in an exterior to interior noise reduction of at least 25 dB with windows closed and approximately 15 dB with windows open. Based on this information, and after accounting for the combined roadway noise exposure at the project site, it is expected that standard residential construction would be acceptable for all level rooms of the development. However, in order to satisfy the City of Antioch 45 dB L_{dn} interior noise level criteria with a margin of safety, it is recommended that a portion of the upper-floor bedrooms of Buildings 1 and 2 be upgraded to a minimum STC rating of 32. The locations of the recommended window upgrades are shown on Figure 2. In addition, mechanical ventilation (air conditioning) should be provided for all residences within this development to allow the occupants to close doors and windows as desired for additional acoustical isolation.

Future interior traffic noise levels are predicted to satisfy the applicable City of Antioch interior noise level criteria. In addition, after implementation of the identified mitigation measures, future exterior traffic noise levels are expected to satisfy the applicable City of Antioch exterior noise level criteria. As a result, this impact is considered to be ***less-than significant.***

Criteria B: Exposure of persons to or generation of excessive groundborne vibration or groundborne noise levels.

At the nearest existing residences to the proposed project area, construction-generated vibration levels are predicted to be less than the 0.25 in/sec PPV threshold at which vibration levels become distinctly perceptible. Because construction-generated vibration levels at nearby existing receptors would satisfy the California Department of Transportation (Caltrans) vibration criteria (Table 1), project construction would not result in the exposure of persons to or generation of excessive groundborne vibration levels.

As indicated in Table 4, the measured average vibration levels at the project site are well below the threshold of perception, or below 0.1 inches per second if converted to Peak Particle Velocities (PPV). Therefore, the project would not result in the exposure of persons to or generation of excessive groundborne vibration levels at the project site.

Because vibration levels due to and upon the proposed project will satisfy the applicable Caltrans vibration criteria, this impact is considered to be ***less than significant.***

Criteria C: A substantial permanent increase in ambient noise levels in the project vicinity above levels existing without the project.

The following FICON criteria was used to determine the significance of impacts due to the project relative to CEQA (Table 2):

- Where existing traffic noise levels are less than 60 dB L_{dn} at the outdoor activity areas of noise-sensitive uses, a +5 dB L_{dn} increase in roadway noise levels will be considered significant;
- Where existing traffic noise levels range between 60 and 65 dB L_{dn} at the outdoor activity areas of noise-sensitive uses, a +3 dB L_{dn} increase in roadway noise levels will be considered significant; and

- Where existing traffic noise levels are greater than 65 dB L_{dn} at the outdoor activity areas of noise-sensitive uses, a +1.5 dB L_{dn} increase in roadway noise levels will be considered significant.

The results from the analysis of 13 roadway segments shown in Tables 6 and 7 indicate that the project-related increases in traffic noise levels on the local roadway network would be substantial along one roadway segment, Holub Lane, south of East 18th Street. Holub Lane south of East 18th Street is a proposed stub extension of Drive-In Way that will provide access to the project site. The existing roadway segment currently provides access to a single existing single-family residence located immediately east of the project site. Given the very low traffic volumes experienced on this roadway segment, the traffic noise model predicts a significant increase in traffic noise due to the project because it only considers the noise generation of traffic volumes on Drive-In Way/Holub Lane. The traffic noise model predicts an existing traffic noise level of 32 dB L_{dn} at a distance of 100 feet from the centerline of the roadway segment. However, as discussed in the Environment Setting section, the existing noise environment at the project site is primarily defined by traffic on SR 160. Therefore, the existing noise environment along the subject roadway segment would be expected to be consistent with measured ambient noise levels at Sites 1 and 2 of 61 and 62 dB L_{dn}, respectively.

Exiting Plus Project conditions along Holub Lane were calculated by summing the project only traffic on Holub Lane to the measured ambient noise levels at the project site. Cumulative Plus Project conditions along Holub Lane were similarly calculated. The actual increases in traffic noise due to the project on Holub Lane were then calculated for both conditions. The results of that analysis are summarized below in Table 10.

Table 10
Project-Generated Noise Level Increases Based on Measured Conditions
L_{dn} @ 100 feet from Centerline of Holub Lane

Existing[1]	Project Only[2]	Existing Plus Project	Increase	Cumulative[1]	Project Only[2]	Cumulative Plus Project	Increase
60.6	49.7	60.9	0.3	60.6	49.5	60.9	0.3

Notes:
1 Based on measured ambient noise level at Site 1 – 60.6 dB L_{dn}.
2 Based on predicted FHWA Model traffic noise level for Holub Lane, project only.
Source: FHWA and BAC Analysis (2018)

As indicated in Table 10, traffic noise level increases along Holub Lane were calculated to be 0.3 dB. Therefore, based on the measured ambient noise level environment, project-related changes in traffic noise levels on the local roadway network would not result in any significant increases, and would not exceed the

FICON standards of significance. As a result, this impact is considered to be ***less than significant***.

Criteria D: A substantial temporary or periodic increase in ambient noise levels in the project vicinity above levels existing without the project.

As shown in Table 8, exterior noise levels at a residence 50 feet from the noise sources could reach as high as 90 dB L_{max}. As a result, maximum construction noise levels could temporarily exceed 90 dB L_{max} at the nearest existing noise-sensitive receptors (residences). Thus, depending on the distances from the construction areas to nearby residences, construction activities associated with the project could result in substantial temporary and periodic increases in ambient noise levels at nearby receptors. As a result, this impact is considered ***potentially significant***.

Mitigation for Criteria D: Construction Noise Control Measures

MM-3: To the maximum extent practical, the following measures should be incorporated into the project construction operations:

- Pursuant to City of Antioch Code Section 5-17.04 (Heavy Construction Equipment Noise) it shall be unlawful for any person to operate heavy construction equipment on weekends prior to 7:00 a.m. and after 6:00 p.m., within 300 feet of occupied dwelling space prior to 8:00 a.m. and after 5:00 p.m. on weekdays, and on weekends/holidays prior to 9:00 a.m. and after 5:00 p.m.
- Pursuant to City of Antioch Code Section 5-17.05 (Construction Activity Noise) it is unlawful for any person to be involved in construction activity on weekdays prior to 7:00 a.m. and after 6:00 p.m., within 300 feet of occupied dwellings prior to 8:00 a.m. and after 5:00 p.m. on weekdays, and on weekends/holidays prior to 9:00 a.m. and after 5:00 p.m.
- Noise-generating construction activities shall occur pursuant to the criteria identified in the City of Antioch General Plan Policy 11.6.2 (Noise Policies, Temporary Construction).

Significance after Mitigation: *Less than Significant*

Criteria E: For a project located within an airport land use plan or, where such a plan has not been adopted, within two miles of a public airport or public use airport, would the project expose people residing or working in the project area to excessive noise levels?

Because the project site is not located within 2 miles of a public airport, ***no noise impact*** is identified relative to this significance criteria.

Criteria F: For a project within the vicinity of a private airstrip, would the project expose people residing or working in the project area to excessive noise levels?

Because the project site is not located in the vicinity of a private airstrip, ***no noise impact*** is identified relative to this significance criteria.

Conclusions and Recommendations

This analysis concludes that with implementation of feasible noise mitigation measures, all potentially significant impacts at residences of the proposed development can be mitigated to a less than significant level. In addition, with implementation of feasible noise mitigation measures, all potentially significant noise impacts at the nearest existing residences can be mitigated to a less than significant level. Finally, this analysis concludes that project-generated vibration will not result in adverse impacts at the nearest existing residences.

This concludes BAC's noise assessment for the proposed East 18th Street Apartments project in Antioch, California. Please contact BAC at (916) 663-0500 or paulb@bacnoise.com with any questions regarding this assessment.

Appendix A
Acoustical Terminology

Acoustics	The science of sound.
Ambient Noise	The distinctive acoustical characteristics of a given space consisting of all noise sources audible at that location. In many cases, the term ambient is used to describe an existing or pre-project condition such as the setting in an environmental noise study.
Attenuation	The reduction of an acoustic signal.
A-Weighting	A frequency-response adjustment of a sound level meter that conditions the output signal to approximate human response.
Decibel or dB	Fundamental unit of sound, A Bell is defined as the logarithm of the ratio of the sound pressure squared over the reference pressure squared. A Decibel is one-tenth of a Bell.
CNEL	Community Noise Equivalent Level. Defined as the 24-hour average noise level with noise occurring during evening hours (7 - 10 p.m.) weighted by a factor of three and nighttime hours weighted by a factor of 10 prior to averaging.
Frequency	The measure of the rapidity of alterations of a periodic signal, expressed in cycles per second or hertz.
Ldn	Day/Night Average Sound Level. Similar to CNEL but with no evening weighting.
Leq	Equivalent or energy-averaged sound level.
Lmax	The highest root-mean-square (RMS) sound level measured over a given period of time.
Loudness	A subjective term for the sensation of the magnitude of sound.
Masking	The amount (or the process) by which the threshold of audibility is for one sound is raised by the presence of another (masking) sound.
Noise	Unwanted sound.
Peak Noise	The level corresponding to the highest (not RMS) sound pressure measured over a given period of time. This term is often confused with the Maximum level, which is the highest RMS level.
RT_{60}	The time it takes reverberant sound to decay by 60 dB once the source has been removed.
Sabin	The unit of sound absorption. One square foot of material absorbing 100% of incident sound has an absorption of 1 sabin.
SEL	A rating, in decibels, of a discrete event, such as an aircraft flyover or train passby, that compresses the total sound energy of the event into a 1-s time period.
Threshold of Hearing	The lowest sound that can be perceived by the human auditory system, generally considered to be 0 dB for persons with perfect hearing.
Threshold of Pain	Approximately 120 dB above the threshold of hearing.

Appendix B-1
Ambient Noise Monitoring Results - Site 1
East 18th Street Apartments - Antioch
Wednesday, August 15, 2018

Hour	Leq	Lmax	L50	L90
0:00	48	65	45	41
1:00	47	59	44	39
2:00	48	66	45	39
3:00	54	63	53	48
4:00	58	70	57	52
5:00	57	68	56	53
6:00	58	71	57	54
7:00	57	66	56	53
8:00	55	71	54	50
9:00	53	66	52	49
10:00	52	67	50	47
11:00	53	68	51	48
12:00	53	69	52	49
13:00	54	69	53	50
14:00	54	69	53	49
15:00	55	69	53	50
16:00	54	67	53	50
17:00	56	79	53	49
18:00	55	77	52	49
19:00	55	76	52	48
20:00	53	68	51	47
21:00	50	62	48	45
22:00	50	75	47	44
23:00	50	71	47	43

	Statistical Summary					
	Daytime (7 a.m. - 10 p.m.)			Nighttime (10 p.m. - 7 a.m.)		
	High	Low	Average	High	Low	Average
Leq (Average)	57	50	54	58	47	54
Lmax (Maximum)	79	62	70	75	59	68
L50 (Median)	56	48	52	57	44	50
L90 (Background)	53	45	49	54	39	46

Computed Ldn, dB	61
% Daytime Energy	62%
% Nighttime Energy	38%

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Appendix B-2
Ambient Noise Monitoring Results - Site 2
East 18th Street Apartments - Antioch
Wednesday, August 15, 2018

Hour	Leq	Lmax	L50	L90
0:00	49	60	47	41
1:00	50	64	47	40
2:00	50	61	47	39
3:00	56	66	54	46
4:00	59	70	58	53
5:00	59	69	58	55
6:00	60	73	60	56
7:00	58	68	57	53
8:00	58	67	57	52
9:00	54	66	53	48
10:00	53	61	51	47
11:00	51	67	49	46
12:00	50	68	49	46
13:00	50	60	49	46
14:00	50	62	49	46
15:00	50	62	49	47
16:00	51	60	51	48
17:00	50	58	49	47
18:00	50	63	50	48
19:00	80	93	51	48
20:00	66	98	59	45
21:00	45	61	44	41
22:00	46	60	44	41
23:00	43	56	42	40

	Statistical Summary					
	Daytime (7 a.m. - 10 p.m.)			Nighttime (10 p.m. - 7 a.m.)		
	High	Low	Average	High	Low	Average
Leq (Average)	80	45	69	60	43	56
Lmax (Maximum)	98	58	68	73	56	64
L50 (Median)	59	44	51	60	42	51
L90 (Background)	53	41	47	56	39	46

Computed Ldn, dB	68
% Daytime Energy	97%
% Nighttime Energy	3%

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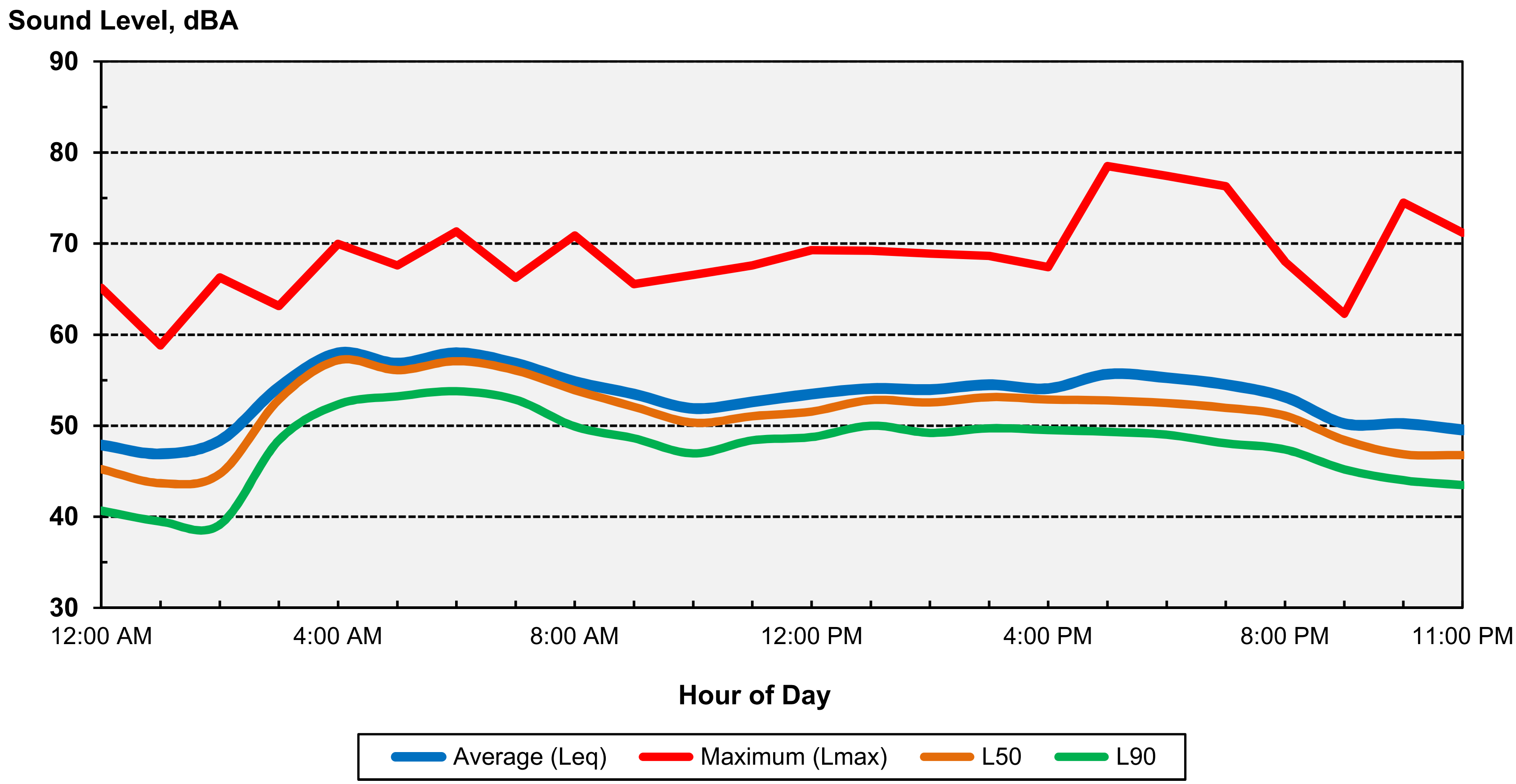
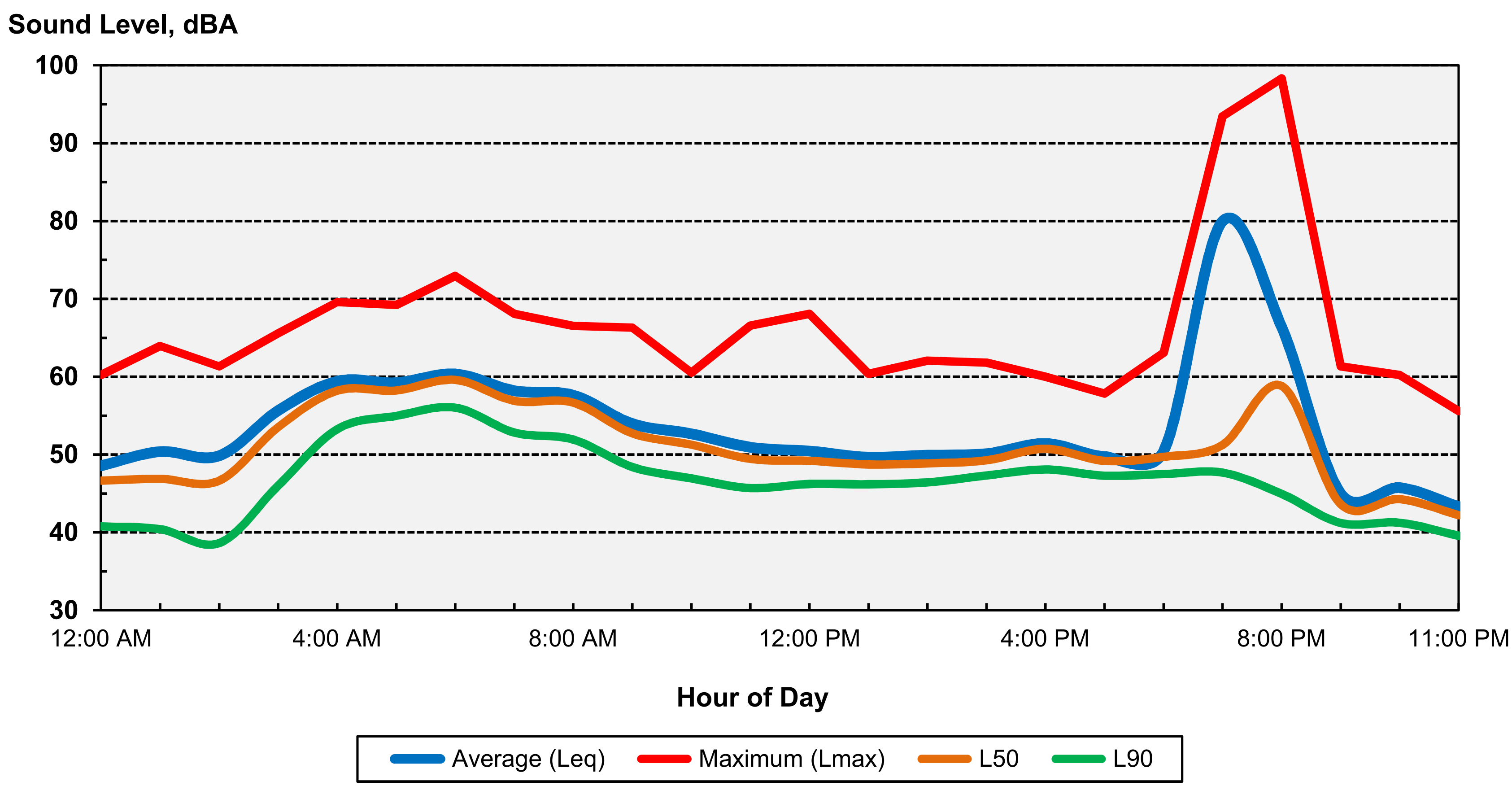
Appendix C-1
Ambient Noise Monitoring Results - Site 1
East 18th Street Apartments - Antioch
Wednesday, August 15, 2018



Ldn: 61 dB

Appendix C-2
Ambient Noise Monitoring Results - Site 2
East 18th Street Apartments - Antioch
Wednesday, August 15, 2018



Ldn: 68 dB

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Notes:

Upper-Left: Long-term noise measurement location Site 1, facing south.
Upper-Right: Short-term vibration measurement location Site 1.
Lower-Left: Long-term noise and short-term vibration measurement location Site 2.
Lower-Right: Traffic calibration measurement location Site T, facing north towards East 18th Street.

18th Street Apartments
Antioch, California

Noise & Vibration Measurement Site Photos

Appendix D

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Appendix E

FHWA Traffic Noise Prediction Model (FHWA-RD-77-108)
Calibration Worksheet

Project Information:	Job Number:	2018-148
	Project Name:	East 18th Street Apartments
	Roadway Tested:	East 18th Street
	Test Location:	Site T
	Test Date:	August 14, 2018
Weather Conditions:	Temperature (Fahrenheit):	74
	Relative Humidity:	53%
	Wind Speed and Direction:	W 13 mph
	Cloud Cover:	Partly Cloudy
Sound Level Meter:	Sound Level Meter:	LDL Model 831 (BAC #2)
	Calibrator:	LDL Model CAL200
	Meter Calibrated:	Immediately before
	Meter Settings:	A-weighted, slow response
Microphone:	Microphone Location:	On project site
	Distance to Centerline (feet):	130
	Microphone Height:	5 feet above ground
	Intervening Ground (Hard or Soft):	**Soft**
	Elevation Relative to Road (feet):	5
Roadway Condition:	Pavement Type	Asphalt
	Pavement Condition:	Good
	Number of Lanes:	4
	Posted Maximum Speed (mph):	45
Test Parameters:	Test Time:	11:21 PM
	Test Duration (minutes):	15
	Observed Number Automobiles:	99
	Observed Number Medium Trucks:	4
	Observed Number Heavy Trucks:	3
	Observed Average Speed (mph):	40
Model Calibration:	Measured Average Level (L_{eq}):	55.1
	Level Predicted by FHWA Model:	57.6
	Difference:	***2.5 dB***

Conclusions:

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Appendix F-1

FHWA Traffic Noise Prediction Model (FHWA-RD-77-108)
Noise Prediction Worksheet

Project Information:

Job Number: 2018-148
Project Name: East 18th Street Apartments
Roadway Name: East 18th Street

Traffic Data:

Year: Future (2040)
Average Daily Traffic Volume[1]: 11,410
Percent Daytime Traffic: 75
Percent Nighttime Traffic: 25
Percent Medium Trucks (2 axle): 2
Percent Heavy Trucks (3+ axle): 1
Assumed Vehicle Speed (mph): 45
Intervening Ground Type (hard/soft): **Soft**

Traffic Noise Levels:

Location	Description	Distance	Offset (dB)[2]	L_{dn}, dB Autos	Medium Trucks	Heavy Trucks	Total
1	Common outdoor area (pool/tot lot)	430	-7	47	38	40	48
2	Building 1 - First-floor facades	80	0	65	56	58	66
3	Building 1 - Upper-floor facades	80	3	68	59	61	69

Traffic Noise Contours (No Calibration Offset):

L_{dn} Contour, dB	Distance from Centerline, (ft)
75	21
70	44
65	96
60	206

Notes:

[1] Future average daily traffic volume (Cumulative Plus Project Conditions - 2040) for East 18th Street was calculated by using peak hour traffic volume data obtained from the 3530-3560 East 18th Street Residential Development Traffic Impact Analysis prepard by Hexagon Transportation Consultants, Inc. (2018). Future peak hour traffic volumes were estimated by conservatively multiplying peak hour conditions by a factor of 10.

[2] A +3 dB offset was applied at upper-level facades to account for reduced ground absorption at elevated locations. To account for the shielding provided by proposed intervening buildings, a -7 dB offset was conservatively applied at the common outdoor area (pool).

Appendix F-2

FHWA Traffic Noise Prediction Model (FHWA-RD-77-108)
Noise Prediction Worksheet

Project Information:

Job Number:	2018-148
Project Name:	East 18th Street Apartments
Roadway Name:	SR 160

Traffic Data:

Year:	Future (2040)
Average Daily Traffic Volume[1]:	16,050
Percent Daytime Traffic:	75
Percent Nighttime Traffic:	25
Percent Medium Trucks (2 axle):	3
Percent Heavy Trucks (3+ axle):	10
Assumed Vehicle Speed (mph):	70
Intervening Ground Type (hard/soft):	**Soft**

Traffic Noise Levels:

				L_{dn}, dB			
Location	**Description**	**Distance**	**Offset (dB)[2]**	**Autos**	**Medium Trucks**	**Heavy Trucks**	**Total**
1	Common outdoor area (pool/tot lot)	810	0	56	47	56	59
2	Building 2s - First-floor facades	490	0	60	50	59	63
3	Building 2s - Upper-floor facades	490	3	63	53	62	66

Traffic Noise Contours (No Calibration Offset):

L_{dn} Contour, dB	Distance from Centerline, (ft)
75	74
70	159
65	343
60	739

Notes:

[1] Future (2040) average daily traffic volume for SR 160 was conservatively estimated by multiplying existing traffic volumes by 1.5. Existing traffic counts were obtained from the 2016 Caltrans Traffic Volumes

[2] A +3 dB offset was applied at upper-level facades to account for reduced ground absorption at elevated locations.

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Appendix F-3

FHWA Traffic Noise Prediction Model (FHWA-RD-77-108)
Noise Prediction Worksheet

Project Information:

Job Number: 2018-148
Project Name: East 18th Street Apartments
Roadway Name: SR 160 Southbound Ramp

Traffic Data:

Year: Future (2040)
Average Daily Traffic Volume[1]: 8,600
Percent Daytime Traffic: 75
Percent Nighttime Traffic: 25
Percent Medium Trucks (2 axle): 2
Percent Heavy Trucks (3+ axle): 1
Assumed Vehicle Speed (mph): 55
Intervening Ground Type (hard/soft): **Soft**

Traffic Noise Levels:

				----------------- L_{dn}, dB -----------------			
Location	**Description**	**Distance**	**Offset (dB)[2]**	**Autos**	**Medium Trucks**	**Heavy Trucks**	**Total**
1	Common outdoor area (pool/tot lot)	475	0	55	45	46	56
2	Building 2 - First-floor facades	375	0	56	46	47	57
3	Building 2 - Upper-floor facades	375	3	59	49	50	60

Traffic Noise Contours (No Calibration Offset):

L_{dn} Contour, dB	Distance from Centerline, (ft)
75	24
70	51
65	111
60	239

Notes:

[1] Future average daily traffic volume (Cumulative Plus Project Conditions - 2040) for SR 160 SB Ramp was calculated by using peak hour traffic volume data obtained from the 3530-3560 East 18th Street Residential Development Traffic Impact Analysis prepard by Hexagon Transportation Consultants, Inc. (2018). Future peak hour traffic volumes were estimated by conservatively multiplying peak hour conditions by a factor of 10.

[2] A +3 dB offset was applied at upper-level facades to account for reduced ground absorption at elevated locations.

Appendix G-1

FHWA-RD-77-108 Highway Traffic Noise Prediction Model
Data Input Sheet

Project #: 2018-148 East 18th Street Apartments
Description: Existing
Ldn/CNEL: Ldn
Hard/Soft: Soft

Segment	Roadway Name	Segment Description	ADT	Day %	Eve %	Night %	% Med. Trucks	% Hvy. Trucks	Speed	Distance	Offset (dB)
1	East 18th Street	West of Viera Avenue	9,180	75		25	2	1	45	100	
2	East 18th Street	Viera Avenue to Phillips Lane	8,480	75		25	2	1	45	100	
3	East 18th Street	Phillips Lane to Holub Lane	8,050	75		25	2	1	45	100	
4	East 18th Street	Holub Lane to SR 160 SB Ramps	7,840	75		25	2	1	45	100	
5	East 18th Street	SR 160 SB Ramps to NB Ramps	11,640	75		25	2	1	45	100	
6	East 18th Street	East of SR 160 NB Ramps	19,200	75		25	2	1	45	100	
7	Viera Avenue	North of East 18th Street	1,730	75		25	1	1	25	100	
8	Viera Avenue	South of East 18th Street	1,310	75		25	1	1	25	100	
9	Phillips Lane	South of East 18th Street	1,470	75		25	1	1	25	100	
10	Holub Lane	South of East 18th Street	20	75		25	1	1	25	100	
11	Drive In Way	North of East 18th Street	1,030	75		25	1	1	25	100	
12	SR 160 SB Ramps	South of East 18th Street	6,720	75		25	2	1	55	100	
13	SR 160 NB Ramps	South of East 18th Street	11,260	75		25	2	1	55	100	

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Appendix G-2

FHWA-RD-77-108 Highway Traffic Noise Prediction Model
Data Input Sheet

Project #: 2018-148 East 18th Street Apartments
Description: Existing+Project
Ldn/CNEL: Ldn
Hard/Soft: Soft

Segment	Roadway Name	Segment Description	ADT	Day %	Eve %	Night %	% Med. Trucks	% Hvy. Trucks	Speed	Distance	Offset (dB)
1	East 18th Street	West of Viera Avenue	9,380	75		25	2	1	45	100	
2	East 18th Street	Viera Avenue to Phillips Lane	8,820	75		25	2	1	45	100	
3	East 18th Street	Phillips Lane to Holub Lane	8,290	75		25	2	1	45	100	
4	East 18th Street	Holub Lane to SR 160 SB Ramps	8,880	75		25	2	1	45	100	
5	East 18th Street	SR 160 SB Ramps to NB Ramps	12,440	75		25	2	1	45	100	
6	East 18th Street	East of SR 160 NB Ramps	19,700	75		25	2	1	45	100	
7	Viera Avenue	North of East 18th Street	1,800	75		25	1	1	25	100	
8	Viera Avenue	South of East 18th Street	1,380	75		25	1	1	25	100	
9	Phillips Lane	South of East 18th Street	1,570	75		25	1	1	25	100	
10	Holub Lane	South of East 18th Street	1,300	75		25	1	1	25	100	
11	Drive In Way	North of East 18th Street	1,030	75		25	1	1	25	100	
12	SR 160 SB Ramps	South of East 18th Street	6,960	75		25	2	1	55	100	
13	SR 160 NB Ramps	South of East 18th Street	11,560	75		25	2	1	55	100	

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Appendix G-3

FHWA-RD-77-108 Highway Traffic Noise Prediction Model
Data Input Sheet

Project #: 2018-148 East 18th Street Apartments
Description: Cumulative
Ldn/CNEL: Ldn
Hard/Soft: Soft

Segment	Roadway Name	Segment Description	ADT	Day %	Eve %	Night %	% Med. Trucks	% Hvy. Trucks	Speed	Distance	Offset (dB)
1	East 18th Street	West of Viera Avenue	11,920	75		25	2	1	45	100	
2	East 18th Street	Viera Avenue to Phillips Lane	9,740	75		25	2	1	45	100	
3	East 18th Street	Phillips Lane to Holub Lane	11,090	75		25	2	1	45	100	
4	East 18th Street	Holub Lane to SR 160 SB Ramps	10,880	75		25	2	1	45	100	
5	East 18th Street	SR 160 SB Ramps to NB Ramps	14,770	75		25	2	1	45	100	
6	East 18th Street	East of SR 160 NB Ramps	25,930	75		25	2	1	45	100	
7	Viera Avenue	North of East 18th Street	3,130	75		25	1	1	25	100	
8	Viera Avenue	South of East 18th Street	5,050	75		25	1	1	25	100	
9	Phillips Lane	South of East 18th Street	3,110	75		25	1	1	25	100	
10	Holub Lane	South of East 18th Street	20	75		25	1	1	25	100	
11	Drive In Way	North of East 18th Street	1,030	75		25	1	1	25	100	
12	SR 160 SB Ramps	South of East 18th Street	8,420	75		25	2	1	55	100	
13	SR 160 NB Ramps	South of East 18th Street	16,740	75		25	2	1	55	100	

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Appendix G-4

FHWA-RD-77-108 Highway Traffic Noise Prediction Model
Data Input Sheet

Project #: 2018-148 East 18th Street Apartments
Description: Cumulative+Project
Ldn/CNEL: Ldn
Hard/Soft: Soft

Segment	Roadway Name	Segment Description	ADT	Day %	Eve %	Night %	% Med. Trucks	% Hvy. Trucks	Speed	Distance	Offset (dB)
1	East 18th Street	West of Viera Avenue	12,120	75		25	2	1	45	100	
2	East 18th Street	Viera Avenue to Phillips Lane	10,160	75		25	2	1	45	100	
3	East 18th Street	Phillips Lane to Holub Lane	11,410	75		25	2	1	45	100	
4	East 18th Street	Holub Lane to SR 160 SB Ramps	11,770	75		25	2	1	45	100	
5	East 18th Street	SR 160 SB Ramps to NB Ramps	15,480	75		25	2	1	45	100	
6	East 18th Street	East of SR 160 NB Ramps	26,430	75		25	2	1	45	100	
7	Viera Avenue	North of East 18th Street	3,200	75		25	1	1	25	100	
8	Viera Avenue	South of East 18th Street	5,200	75		25	1	1	25	100	
9	Phillips Lane	South of East 18th Street	3,210	75		25	1	1	25	100	
10	Holub Lane	South of East 18th Street	1,230	75		25	1	1	25	100	
11	Drive In Way	North of East 18th Street	1,030	75		25	1	1	25	100	
12	SR 160 SB Ramps	South of East 18th Street	8,600	75		25	2	1	55	100	
13	SR 160 NB Ramps	South of East 18th Street	16,950	75		25	2	1	55	100	

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Appendix H-1

FHWA Traffic Noise Prediction Model (FHWA-RD-77-108)
Noise Barrier Effectiveness Prediction Worksheet

Project Information:

Job Number: 2018-148
Project Name: East 18th Street Apartments
Roadway Name: SR 160
Location(s): Common outdoor area (pool/tot lot)

Noise Level Data:

Year: Future (2040)
Auto L_{dn}, dB: 56
Medium Truck L_{dn}, dB: 47
Heavy Truck L_{dn}, dB: 56

Site Geometry:

Receiver Description: Common outdoor area (pool/tot lot)
Centerline to Barrier Distance (C_1): 715
Barrier to Receiver Distance (C_2): 95
Automobile Elevation: 64
Medium Truck Elevation: 66
Heavy Truck Elevation: 72
Pad/Ground Elevation at Receiver: 40
Receiver Elevation[1]: 45
Base of Barrier Elevation: 40
Starting Barrier Height 6

Barrier Effectiveness:

Top of Barrier Elevation (ft)	Barrier Height[2] (ft)	L_{dn}, dB				Barrier Breaks Line of Sight to…		
		Autos	Medium Trucks	Heavy Trucks	Total	Autos?	Medium Trucks?	Heavy Trucks?
46	6	51	42	51	**55**	No	No	No
47	7	51	42	51	**55**	No	No	No
48	8	51	42	51	**54**	Yes	Yes	No
49	9	51	42	51	**54**	Yes	Yes	Yes
50	10	51	42	51	**54**	Yes	Yes	Yes
51	11	51	41	50	**54**	Yes	Yes	Yes
52	12	50	41	50	**53**	Yes	Yes	Yes
53	13	50	40	50	**53**	Yes	Yes	Yes
54	14	49	40	49	**52**	Yes	Yes	Yes

Notes: 1.Standard receiver elevation is five feet above grade/pad elevations at the receiver location(s)

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Appendix H-2

FHWA Traffic Noise Prediction Model (FHWA-RD-77-108)
Noise Barrier Effectiveness Prediction Worksheet

Project Information:

Job Number: 2018-148
Project Name: East 18th Street Apartments
Roadway Name: SR 160 Southbound Ramp
Location(s): Common outdoor area (pool/tot lot)

Noise Level Data:

Year: Future (2040)
Auto L_{dn}, dB: 55
Medium Truck L_{dn}, dB: 45
Heavy Truck L_{dn}, dB: 46

Site Geometry:

Receiver Description: Common outdoor area (pool/tot lot)
Centerline to Barrier Distance (C_1): 380
Barrier to Receiver Distance (C_2): 95
Automobile Elevation: 43
Medium Truck Elevation: 45
Heavy Truck Elevation: 51
Pad/Ground Elevation at Receiver: 40
Receiver Elevation[1]: 45
Base of Barrier Elevation: 40
Starting Barrier Height 6

Barrier Effectiveness:

Top of Barrier Elevation (ft)	Barrier Height[2] (ft)	L_{dn}, dB Autos	Medium Trucks	Heavy Trucks	Total	Barrier Breaks Line of Sight to… Autos?	Medium Trucks?	Heavy Trucks?
46	6	49	40	41	**50**	Yes	Yes	No
47	7	49	40	41	**50**	Yes	Yes	Yes
48	8	49	39	41	**50**	Yes	Yes	Yes
49	9	48	39	40	**49**	Yes	Yes	Yes
50	10	48	38	40	**49**	Yes	Yes	Yes
51	11	47	38	39	**48**	Yes	Yes	Yes
52	12	47	37	39	**48**	Yes	Yes	Yes
53	13	46	37	38	**47**	Yes	Yes	Yes
54	14	46	36	38	**47**	Yes	Yes	Yes

Notes: 1.Standard receiver elevation is five feet above grade/pad elevations at the receiver location(s)

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