Noise Study Report

Fresno County

November 2015

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Retrofit Sound Wall Study

Noise Study Report

Fresno County

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Summary

The Fresno Council of Governments (Fresno COG) is evaluating (1) potential traffic noise impacts to noise-sensitive areas along highways in the County of Fresno (County), and (2) the need for sound walls at five locations that would potentially be eligible for retrofit barrier funding under the Type 2 Retrofit Noise Abatement Program. These five locations were identified based on the findings summarized in the December 2014 *Retrofit Sound Wall Study – Monitoring Results and Modeling Recommendations Memorandum* (LSA Associates, Inc.), which is attached in Appendix C. These five locations are listed below:

- Project Site 1 – 2890 Huntington Boulevard, Fresno
- Project Site 2 – 2409 E. Cambridge Avenue, Fresno
- Project Site 3 – 4708 E. Donner Avenue, Fresno
- Project Site 4 – 4531 E. Cambridge Avenue and 4524 E. Weldon Avenue, Fresno
- Project Site 5 – 4538 E. Cornell Avenue, Fresno

The noise study areas were determined based noise-sensitive receptors adjacent to high volume roadways that bound the area. All identified noise-sensitive receptors within the project site location were evaluated in this report.

The study area at Project Site 1 includes multifamily residences on the west side of State Route 41 (SR-41) between R Street and Tulare Street. The study area at Project Site 2 includes single-family residences on the east side of SR-41 between N. Fresno Street and E. Clinton Avenue. The study area at Project Site 3 includes single-family residences on the east side of State Route 168 (SR-168) south of E. Gettysburg Avenue. The study area at Project Site 4 includes single-family residences on the east side of SR-168 between south of E. University Avenue and E. Clinton Avenue. The study area at Project Site 5 includes single-family residences on the east side of SR-168 between E. Clinton Avenue and E. Shields Avenue.

The purpose of this retrofit sound wall study is to address the need for sound walls in the County and to assist the Fresno COG and its member agencies in identifying traffic noise impacts and noise abatement measures that are eligible for federal funding, such as funding available through the State Transportation Improvement Program (STIP).

For purposes of this Noise Study Report, the Fresno COG has applied California Department of Transportation's (Caltrans) qualification criteria for Type 2 retrofit noise abatement projects and the Caltrans reasonable cost allowance calculation procedures for determining abatement to be reasonable. Impacted locations are those that are identified as being exposed to traffic noise levels that exceed the Noise Abatement Criteria (NAC). Under the qualification criteria, any proposed abatement must be designed to reduce traffic noise levels by 5 A-weighted decibels (dBA) or more at impacted receptor locations and should be reasonable. For an abatement to be reasonable, three required factors must be considered:

(1) the noise reduction design goal;

(2) the cost of noise abatement; and

(3) the viewpoints of benefited receptors.

The proposed project is considered a Type 2 project because noise abatement measures are being considered within State right-of-way on existing highways for Type 2 federal aid funds under Code of Federal Regulations Title 23, Part 772.

For Project Site 1, existing land uses in the project area include multifamily residences and recreational uses. Residences and recreational uses in this area are approximately 5 feet (ft) lower in elevation than SR-41 to 30 ft higher in elevation than SR-41. The primary source of noise in the project area is traffic on SR-41 and other roadways within the area.

For Project Site 2, existing land uses in the project area include single-family residences. These residences are located approximately 20 ft lower in elevation than SR-41. The primary source of noise in the project area is traffic on SR-41 and other roadways within the area.

For Project Site 3, existing land uses in the project area include single-family residences. These residences are located approximately 10 ft lower in elevation than SR-168 to 25 ft higher in elevation than SR-168. The primary source of noise in the project area is traffic on SR-168 and other roadways within the area.

For Project Site 4, existing land uses in the project area include single-family residences. These residences are located approximately 20 to 25 ft lower in elevation than SR-168. The primary source of noise in the project area is traffic on SR-168 and other roadways within the area.

For Project Site 5, existing land uses in the project area include single-family residences. These residences are located approximately 20 to 30 ft higher in elevation than SR-168. The primary source of noise in the project area is traffic on SR-168 and other roadways within the area.

To document the existing noise environment for the five project site locations, a total of 18 short-term noise level measurements were conducted at locations representative of noise-sensitive receptors. Table S-A shows the number of short-term noise level measurements for each project site. All 18 short-term noise level measurements were used to calibrate the noise prediction model with concurrent traffic counts and measured vehicle speeds.

A total of five long-term 24-hour noise level measurements were conducted to characterize the change in hourly noise levels over the course of a 24-hour period in the project area and to identify the peak traffic noise hour. As shown in Table S-A below, one long-term noise level measurement was conducted for each project site.

A total of 114 receptors were modeled for the five project sites. Table S-A shows the number of receptors modeled for each project site. The results of the modeled noise levels for the existing and future conditions at each project site are shown in Table B-1 in Appendix B.

Table S-A. Noise Study Summary Statistics

Project Site	Number of Short-Term Noise Level Measurements	Number of Long-Term Noise Level Measurements	Number of Modeled Receptors	Number of Impacted Receptors[1]	Number of Evaluated Noise Barriers
1	2	1	46	10	2
2	3	1	14	10	1
3	4	1	14	0	0
4	4	1	19	3	1
5	5	1	21	2	2

Source: LSA Associates, Inc. (August 2015).
[1] Under future traffic conditions.

When traffic noise impacts have been identified, noise abatement measures must be considered. Traffic noise impacts result from predicted noise levels exceeding the 67 dBA equivalent continuous sound level (L_{eq}) NAC. Noise levels at Project Site 3 did not exceed the 67 dBA sound level NAC. Therefore, no receptors were considered impacted at Project Site 3 and barriers were not evaluated for this location. Table S-A shows the total number of modeled receptors evaluated for each project site and the number of receptors that would exceed 67 dBA L_{eq} under the future worst-case traffic conditions.

Noise abatement measures were evaluated for all receptors that would be or would continue to be exposed to traffic noise exceeding 67 dBA L_{eq}. Table S-A shows the number of noise barriers evaluated at each project site. The results of the noise barrier modeling for each project site are shown in Table B-1 in Appendix B.

All noise barriers evaluated for Project Sites 1, 2, 4, and 5 were capable of reducing noise levels by 5 dBA or more, as required to be considered feasible. However, as shown in Table 7-8, all feasible noise barriers would not be considered reasonable NAC for Type 2 project standards because either the estimated construction cost would exceed the total reasonable allowance or the barrier would not achieve a noise level reduction of 7 dBA at one or more benefited receptors.

If noise barriers were constructed, the closest residences would be located within 50 ft of noise barrier construction areas. Therefore, these closest residences may be subject to short-term noise reaching 87 dBA maximum instantaneous noise level (L_{max}) or higher generated by construction activities within the project area. Compliance with the construction hours specified in the County of Fresno Ordinance, the City of Fresno Municipal Code, and Caltrans Standard Specifications in Section 14-8.02 would be required to minimize construction noise impacts on sensitive land uses adjacent to the project site.

Construction noise is regulated by Caltrans Standard Specifications in Section 14-8.02. Noise control shall conform to the provisions in Section 14-8.02. The noise level from the Contractor's operations, between the hours of 9:00 p.m. and 6:00 a.m., shall not exceed 86 dBA at a distance of 50 ft.

Conclusion

The results of this preliminary noise barrier analysis indicate the barriers at Project Sites 1, 2, 4 and 5 would provide a noise reduction benefit. Additionally, under Type 2 project standards, the following barriers were determined to be reasonable because the estimated noise barrier construction cost is within the reasonable allowance and the barrier would achieve a noise level reduction of 7 dBA at one or more benefited receptor location: NB No. 1-1 with a height of 16 ft, NB No. 2-1 with heights of 12 ft, 14 ft, and 16 ft, and NB No. 4-1 with heights of 14 ft and 16 ft. However, the remaining noise barriers were determined to be not reasonable because either the estimated noise barrier construction cost would exceed the total reasonable allowance or the barrier would not achieve a noise level reduction of 7 dBA at one or more benefited receptors.

For the reasonable noise barriers, a Priority Index was calculated based on the guidelines in Chapter 30 of the Caltrans Project Development Procedures Manual (PDPM). The priority index formula and priority index numbers are shown in Table 7-9.

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List of Abbreviated Terms

°F	degrees Fahrenheit
μPa	micro-Pascals
23 CFR 772	Title 23, Part 772 of the Code of Federal Regulations
Caltrans	California Department of Transportation
CFR	Code of Federal Regulations
CNEL	Community Noise Equivalent Level
County	County of Fresno
dB	decibels
dBA	A-weighted decibels
dBA L_{eq}	equivalent continuous sound level measured in A-weighted decibels
FHWA	Federal Highway Administration
Fresno COG	Fresno Council of Governments
ft	foot/feet
Hz	Hertz
kHz	kilohertz
L_{dn}	day-night level
L_{eq}	equivalent continuous sound level
L_{eq}(h)	1-hour A-weighted equivalent sound level
L_{max}	maximum sound level
LOS	level(s) of service

L_{xx}	percentile-exceeded sound level
mph	miles per hour
NAC	Noise Abatement Criteria
NB	Noise Barrier
NBSSR	Noise Barrier Scope Summary Report
NSR	Noise Study Report
PDPM	Caltrans Project Development Procedures Manual
PI	Priority Index
Protocol	*Traffic Noise Analysis Protocol for New Highway Construction, Reconstruction, and Retrofit Barrier Projects*
RTPAs	Regional Transportation Planning Agencies
SB	Senate Bill
SPL	sound pressure level
SR-41	State Route 41
SR-168	State Route 168
STIP	State Transportation Improvement Program
TeNS	Caltrans Technical Noise Supplement
TNM	Traffic Noise Model
vplph	vehicles per lane per hour

Chapter 1. Introduction

The Fresno Council of Governments (Fresno COG) is evaluating potential traffic noise impacts to nearby noise-sensitive areas and the need for sound walls at five locations that would potentially be eligible for retrofit barrier funding under the Type 2 Retrofit Noise Abatement Program. These five study locations were identified in the December 2014 *Retrofit Sound Wall Study – Monitoring Results and Modeling Recommendations Memorandum* (LSA Associates, Inc.). The December 2014 *Retrofit Sound Wall Study – Monitoring Results and Modeling Recommendations Memorandum* is provided in Appendix C. Below is a list of the five locations.

- Project Site 1 – 2890 Huntington Boulevard, Fresno
- Project Site 2 – 2409 E. Cambridge Avenue, Fresno
- Project Site 3 – 4708 E. Donner Avenue, Fresno
- Project Site 4 – 4531 E. Cambridge Avenue and 4524 E. Weldon Avenue, Fresno
- Project Site 5 – 4538 E. Cornell Avenue, Fresno

These five locations are identified by Project Sites 1 through 5 in this study. The project location and vicinity map for each of the five project sites are shown on Figures 1-1 through 1-5, respectively.

1.1. Purpose of the Noise Study Report

The purpose of Title 23, Part 772, of the Code of Federal Regulations (23 CFR 772), Procedures for Abatement of Highway Traffic Noise and Construction Noise, is to provide procedures to help protect public health and welfare, supply Noise Abatement Criteria (NAC), and establish requirements for information to be given to local officials for use in the planning and design of highways approved pursuant to 23 CFR 772.1. As such, 23 CFR 772 provides procedures for preparing operational and construction noise impact studies and evaluating noise abatement considered for federal and federal-aid highway projects. According to 23 CFR 772.3, all highway projects that are developed in conformance with this regulation are deemed to be in conformance with Federal Highway Administration (FHWA) noise standards.

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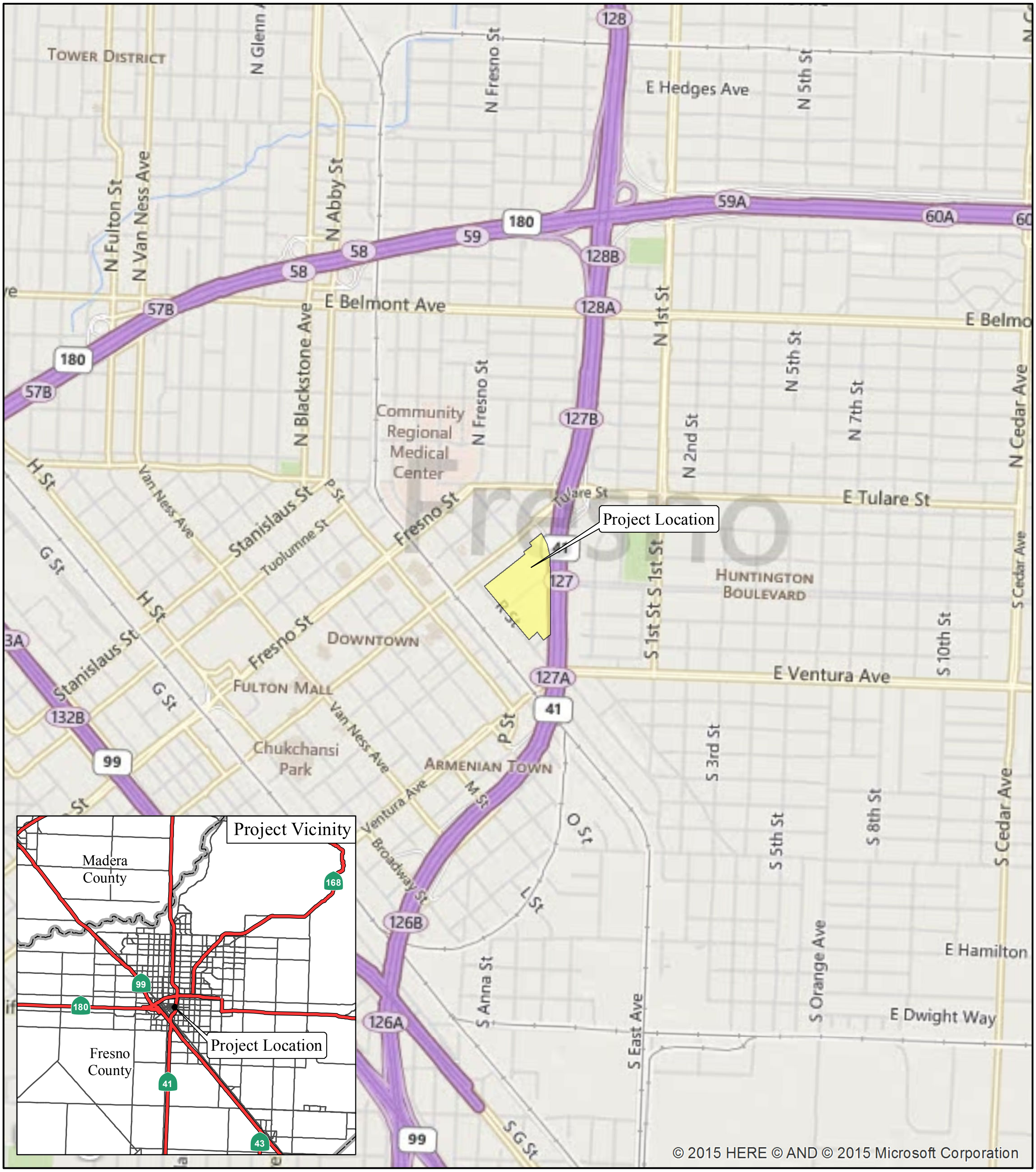

LEGEND

Project Location

FIGURE 1-1

N

0 1000 2000
FEET

SOURCE: Bing (2013)

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Retrofit Sound Wall Study
Noise Study Report
Project Site 1
Project Location and Vicinity

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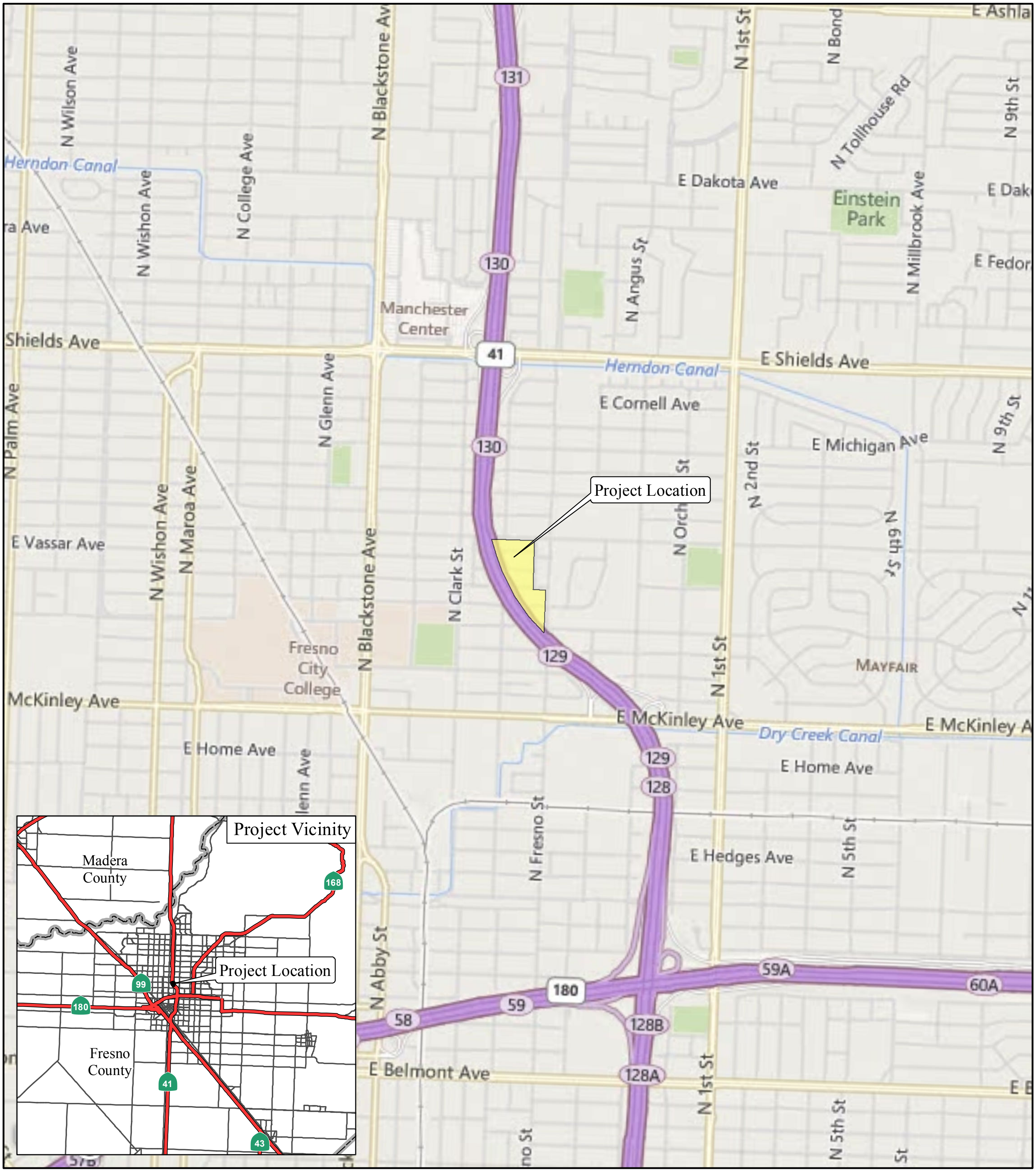

LEGEND

Project Location

FIGURE 1-2

N

0 1000 2000
FEET

SOURCE: Bing (2013)

Retrofit Sound Wall Study
Noise Study Report

Project Site 2
Project Location and Vicinity

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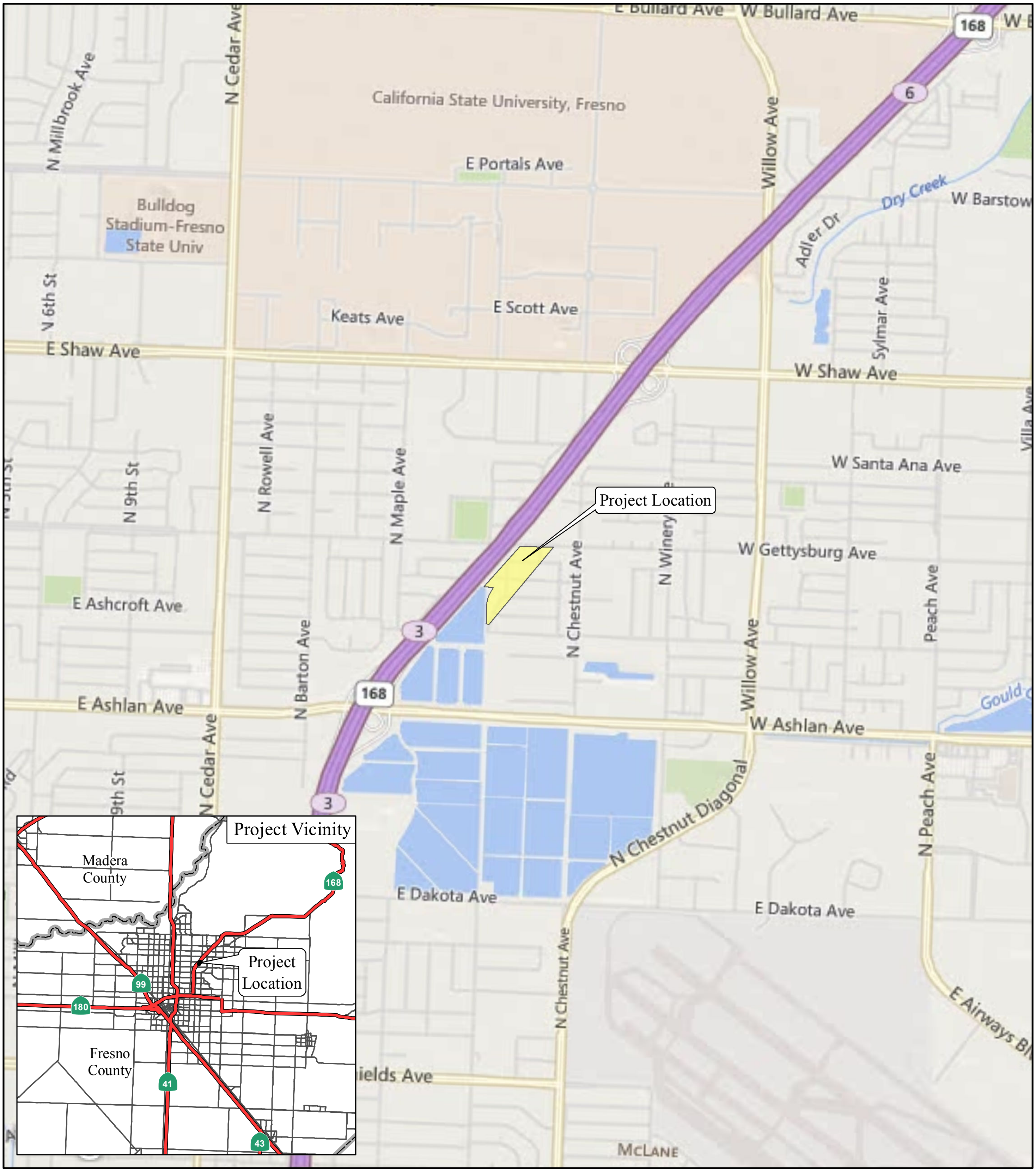

LEGEND

Project Location

FIGURE 1-3

N

0 1000 2000

FEET

Retrofit Sound Wall Study

Noise Study Report

Project Site 3

Project Location and Vicinity

SOURCE: Bing (2013)

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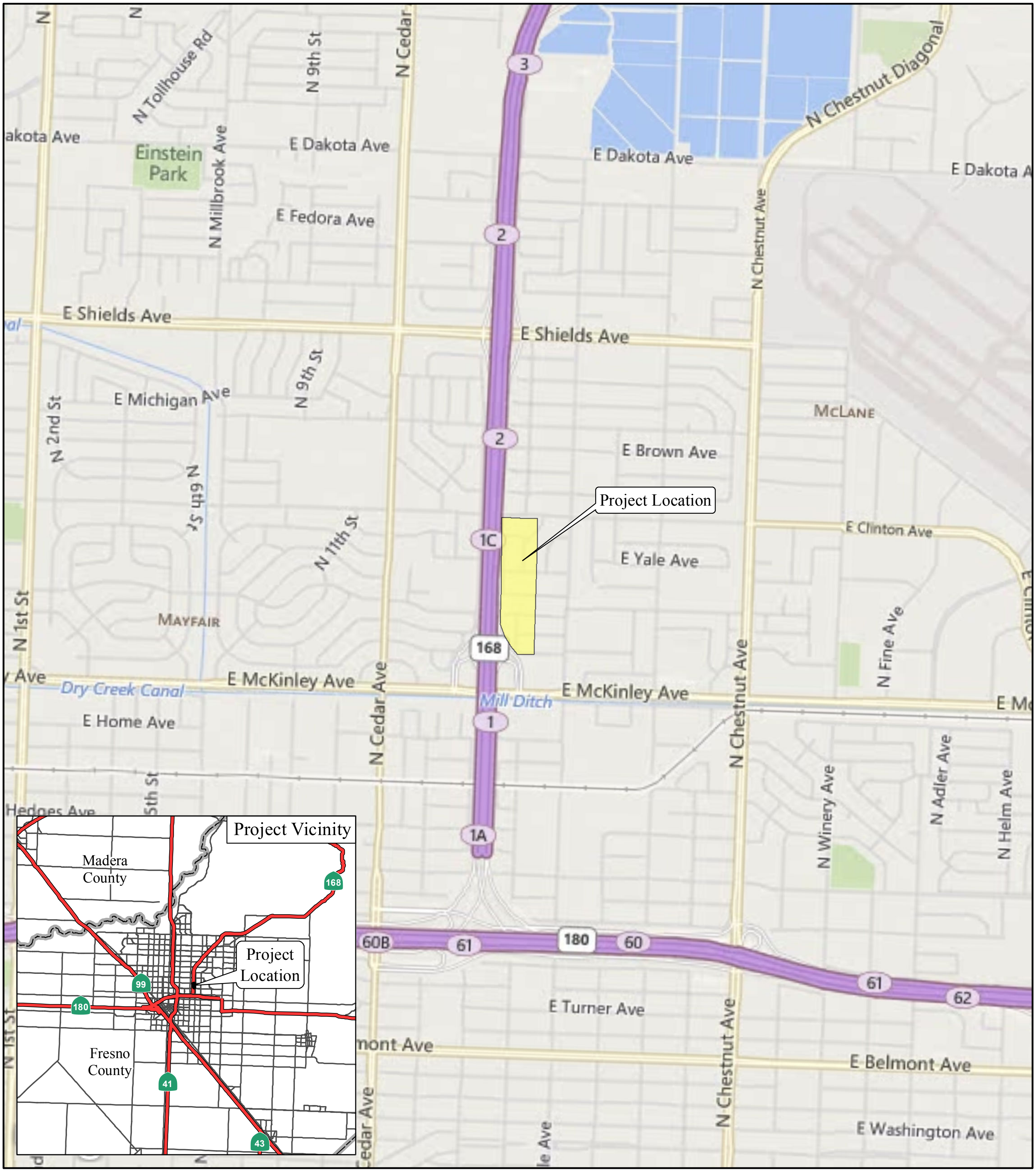

LEGEND

Project Location

FIGURE 1-4

0 1000 2000
FEET

SOURCE: Bing (2013)

Retrofit Sound Wall Study
Noise Study Report

Project Site 4

Project Location and Vicinity

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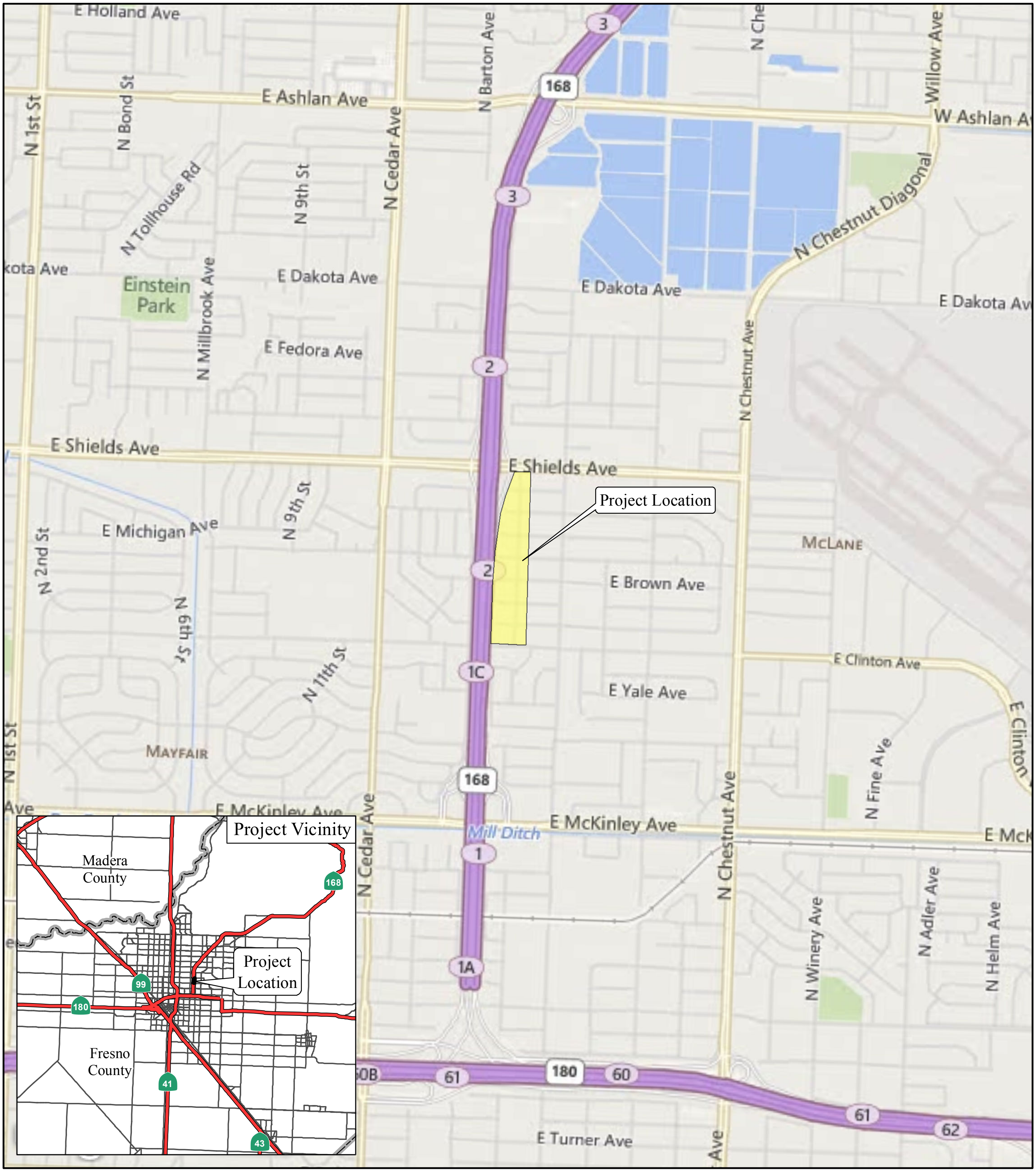

FIGURE 1-5

LEGEND

Project Location

0 1000 2000
FEET

SOURCE: Bing (2013)

Retrofit Sound Wall Study
Noise Study Report

Project Site 5
Project Location and Vicinity

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The California Department of Transportation (Caltrans) *Traffic Noise Analysis Protocol for New Highway Construction, Reconstruction, and Retrofit Barrier Projects* (Protocol) (Caltrans 2011) provides Caltrans policy for implementing 23 CFR 772 in California. The Protocol outlines the requirements for preparing Noise Study Reports (NSRs). The purpose of this NSR is to evaluate noise impacts and noise abatement consistent with the requirements of 23 CFR 772.

1.2. Project Purpose

1.2.1. Project Purpose

The purpose of this retrofit sound wall study is to address the need for sound walls in the County of Fresno (County) and to assist the Fresno COG and its member agencies in identifying traffic noise impacts and noise abatement measures that are eligible for federal funding, such as funding under the State Transportation Improvement Program (STIP). Under Senate Bill (SB) 45, the responsibility for prioritizing and programming noise reduction projects for the STIP was passed to local transportation planning agencies, such as the Fresno COG.

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Chapter 2. Project Description

The Fresno COG is evaluating potential traffic noise impacts to noise-sensitive areas along highways in the County and the need for sound walls at five locations that would potentially be eligible for retrofit barrier funding under the Type 2 Retrofit Noise Abatement Program. These five locations were identified in the December 2014 *Retrofit Sound Wall Study – Monitoring Results and Modeling Recommendations Memorandum*. Below is a list of the five locations.

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The noise study areas were determined based on noise-sensitive receptors adjacent to roadways that bound the study area. Noise-sensitive receptors within the project site location were evaluated. The study area at Project Site 1 includes multifamily residences on the west side of State Route 41 (SR-41) between R Street and Tulare Street. The study area at Project Site 2 includes single-family residences on the east side of SR-41 between N. Fresno Street and E. Clinton Avenue. The study area at Project Site 3 includes single-family residences on the east side of State Route 168 (SR-168) south of E. Gettysburg Avenue. The study area at Project Site 4 includes single-family residences on the east side of SR-168 between south of E. Weldon Avenue and E. University Avenue. The study area at Project Site 5 includes single-family residences on the east side of SR-168 between E. Clinton Avenue and E. Shields Avenue.

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Chapter 3. Fundamentals of Traffic Noise

The following is a brief discussion of fundamental traffic noise concepts. For a detailed discussion, refer to the Caltrans *Technical Noise Supplement* (TeNS) (September 2013), a technical supplement to the Protocol that is available on the Caltrans website.[1]

3.1. Sound, Noise, and Acoustics

Sound can be described as the mechanical energy of a vibrating object transmitted by pressure waves through a liquid or gaseous medium (e.g., air) to a hearing organ, such as a human ear. Noise is defined as loud, unexpected, or annoying sound.

In the science of acoustics, the fundamental model consists of a sound (or noise) source, a receptor, and the propagation path between the two. The loudness of the noise source and obstructions or atmospheric factors affecting the propagation path to the receptor determines the sound level and characteristics of the noise perceived by the receptor. The field of acoustics deals primarily with the propagation and control of sound.

3.2. Frequency and Hertz

Continuous sound can be described by frequency (pitch) and amplitude (loudness). A low-frequency sound is perceived as low in pitch. Frequency is expressed in terms of cycles per second, or Hertz (Hz) (e.g., a frequency of 250 cycles per second is referred to as 250 Hz. High frequencies are sometimes more conveniently expressed in kilohertz (kHz), or thousands of Hertz. The audible frequency range for humans is generally between 20 Hz and 20,000 Hz.

3.3. Sound Pressure Levels and Decibels

The amplitude of pressure waves generated by a sound source determines the loudness of that source. Sound pressure amplitude is measured in micro-Pascals (µPa). One µPa is approximately one hundred billionth (0.00000000001) of normal atmospheric pressure. Sound pressure amplitudes for different kinds of noise environments can range from less than 100 to 100,000,000 µPa. Because of this huge

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1 California Department of Transportation. Website: http://www.dot.ca.gov/hq/env/noise/pub/TeNS_Sept_2013B.pdf.

range of values, sound is rarely expressed in terms of µPa. Instead, a logarithmic scale is used to describe sound pressure level (SPL) in terms of decibels (dB). The threshold of hearing for young people is approximately 0 dB, which corresponds to 20 µPa.

3.4. Addition of Decibels

Because decibels are logarithmic units, SPL cannot be added or subtracted through ordinary arithmetic. Under the decibel scale, a doubling of sound energy corresponds to a 3 dB increase. In other words, when two identical sources are each producing sounds of the same loudness, the resulting sound level at a given distance would be 3 dB higher than one source under the same conditions. For example, if one automobile produces an SPL of 70 dB when it passes an observer, two cars passing simultaneously would not produce 140 dB—rather, they would combine to produce 73 dB, a difference of 3 dB. Under the decibel scale, three sources of equal loudness together produce a sound level 5 dB louder than one source.

3.5. A-Weighted Decibels

The decibel scale alone does not adequately characterize how humans perceive noise. The dominant frequencies of a sound have a substantial effect on the human response to that sound. Although the intensity (energy per unit of area) of the sound is a purely physical quantity, the loudness or human response is determined by the characteristics of the human ear.

Human hearing is limited in the range of audible frequencies as well as in the way it perceives the SPL in that range. In general, people are most sensitive to the frequency range of 1,000–8,000 Hz and perceive sounds within that range better than sounds of the same amplitude in higher or lower frequencies. To approximate the response of the human ear, sound levels of individual frequency bands are weighted, depending on the human sensitivity to those frequencies. An “A-weighted” sound level (expressed in units of A-weighted decibels [dBA]) can then be computed based on this information.

The A-weighting network approximates the frequency response of the average young ear when listening to most ordinary sounds. When people make judgments regarding the relative loudness or annoyance of a sound, their judgments correlate well with the A-scale sound levels of those sounds. Other weighting networks have been devised to address high noise levels or other special problems (e.g., B, C, and D scales), but these scales are rarely used in conjunction with highway traffic noise. Noise levels for traffic noise reports are typically reported in terms of dBA. Table 3-1 shows typical A-weighted noise levels.

Table 3-1. Typical A-Weighted Noise Levels

Common Outdoor Activities	Noise Level (dBA)	Common Indoor Activities
	— 110 —	Rock band
Jet fly-over at 1,000 ft		
	— 100 —	
Gas lawn mower at 3 ft		
	— 90 —	
Diesel truck at 50 ft at 50 mph		Food blender at 3 ft
	— 80 —	Garbage disposal at 3 ft
Noisy urban area, daytime		
Gas lawn mower, 100 ft	**— 70 —**	Vacuum cleaner at 10 ft
Commercial area		Normal speech at 3 ft
Heavy traffic at 300 ft	**— 60 —**	
		Large business office
Quiet urban daytime	**— 50 —**	Dishwasher next room
Quiet urban nighttime	**— 40 —**	Theater, large conference room (background)
Quiet suburban nighttime		
	— 30 —	Library
Quiet rural nighttime		Bedroom at night, concert
	— 20 —	
		Broadcast/recording studio
	— 10 —	
Lowest threshold of human hearing	**— 0 —**	Lowest threshold of human hearing

Source: California Department of Transportation *Technical Noise Supplement* (September 2013).
dBA = A-weighted decibels
ft = feet
mph = miles per hour

3.6. Human Response to Changes in Noise Levels

As discussed above, doubling sound energy results in a 3 dB increase in sound. However, given a sound level change measured with precise instrumentation, the subjective human perception of a doubling of loudness will usually be different than what is measured.

Under controlled conditions in an acoustical laboratory, the trained, healthy human ear is able to discern 1 dB changes in sound levels when exposed to steady, single-frequency (“pure-tone”) signals in the midfrequency range (1,000–8,000 Hz). In typical noisy environments, 1–2 dB changes in noise are generally not perceptible. However, it is widely accepted that people are able to begin to detect sound level increases of 3 dB in typical noisy environments. Further, a 5 dB increase is generally perceived as a distinctly noticeable increase, and a 10 dB increase is generally perceived as a doubling of loudness. Therefore, a doubling of sound energy (e.g., doubling the volume of traffic on a highway) that would result in a 3 dB increase in sound would generally be perceived as barely detectable.

3.7. Noise Descriptors

Noise in the daily environment fluctuates over time. Some fluctuations are minor, yet some are substantial. Some noise levels occur in regular patterns, yet others are random. Some noise levels fluctuate rapidly, yet others slowly. Some noise levels vary widely, yet others are relatively constant. Various noise descriptors have been developed to describe time-varying noise levels. The following are the noise descriptors most commonly used in traffic noise analysis:

- **Equivalent Continuous Sound Level (L_{eq}):** L_{eq} represents an average of the sound energy occurring over a specified period of time. In effect, L_{eq} is the steady-state sound level containing the same acoustical energy as the time-varying sound that actually occurs during the same period. The 1-hour A-weighted equivalent sound level (L_{eq}[h]) is the energy average of A-weighted sound levels occurring during a 1-hour period and is the basis for the NAC used by both Caltrans and the FHWA.
- **Percentile-Exceeded Sound Level (L_{xx}):** L_{xx} represents the sound level exceeded for a given percentage of a specified period of time (e.g., L_{10} is the sound level exceeded 10 percent of the time, and L_{90} is the sound level exceeded 90 percent of the time).
- **Maximum Sound Level (L_{max}):** L_{max} is the highest instantaneous sound level measured during a specified period.
- **Day-Night Level (L_{dn}):** L_{dn} is the energy average of A-weighted sound levels occurring over a 24-hour period, with a 10 dB penalty applied to A-weighted sound levels occurring during the nighttime hours between 10:00 p.m. and 7:00 a.m.
- **Community Noise Equivalent Level (CNEL):** Similar to L_{dn}, CNEL is the energy average of the A-weighted sound levels occurring over a 24-hour period, with a 10 dB penalty applied to A-weighted sound levels occurring during the nighttime hours between 10:00 p.m. and 7:00 a.m., and a 5 dB penalty applied to the A-weighted sound levels occurring during the evening hours between 7:00 p.m. and 10:00 p.m.

3.8. Sound Propagation

When sound propagates over a distance, it changes in level and frequency content. The manner in which noise reduces with distance depends on the following factors.

3.8.1. Geometric Spreading

Sound from a localized source (i.e., a point source) propagates uniformly outward in a spherical pattern. The sound level attenuates (or decreases) at a rate of 6 dB for each doubling of distance from a point source. Highways consist of several localized noise sources on a defined path and hence can be treated as a line source, which approximates the effect of several point sources. Noise from a line source propagates outward in a cylindrical pattern, often referred to as cylindrical spreading. Sound levels attenuate at a rate of 3 dB for each doubling of distance from a line source.

3.8.2. Ground Absorption

The propagation path of noise from a highway to a receptor is usually very close to the ground. Noise attenuation from ground absorption and reflective wave canceling, adds to the attenuation associated with geometric spreading. Traditionally, the excess attenuation has also been expressed in terms of attenuation per doubling of distance. This approximation is usually sufficiently accurate for distances of less than 200 feet (ft). For acoustically hard sites (i.e., sites with a reflective surface between the source and the receptor, such as a parking lot or body of water), no excess ground attenuation is assumed. For acoustically absorptive or soft sites (i.e., sites with an absorptive ground surface between the source and the receptor, such as soft dirt, grass, or scattered bushes and trees), an excess ground attenuation value of 1.5 dB per doubling of distance is normally assumed. When added to the cylindrical spreading, the excess ground attenuation results in an overall drop-off rate of 4.5 dB per doubling of distance.

3.8.3. Atmospheric Effects

Receptors located downwind from a source can be exposed to increased noise levels relative to calm conditions, whereas locations upwind can have lowered noise levels. Sound levels can be increased at large distances (e.g., more than 500 ft) from the highway due to atmospheric temperature inversion (i.e., increasing temperature with elevation). Other factors, such as air temperature, humidity, and turbulence, can also have significant effects.

3.8.4. Shielding by Natural or Human-Made Features

A large object or barrier in the path between a noise source and a receptor can substantially attenuate noise levels at the receptor. The amount of attenuation provided by shielding depends on the size of the object and the frequency content of the noise source. Natural terrain features (e.g., hills and dense woods) and human-made features (e.g., buildings and walls) can substantially reduce noise levels. Walls are often constructed between a source and a receptor specifically to reduce noise. A barrier that breaks the line of sight between a source and a receptor will typically result in at least 5 dB of noise reduction. Taller barriers provide increased noise reduction. Vegetation between the highway and a receptor is rarely effective in reducing noise because it does not create a solid barrier.

Chapter 4. Federal, State, and Local Policies and Procedures

This report focuses on the requirements of 23 CFR 772, as discussed below.

4.1. Federal Regulations

4.1.1. 23 CFR 772

23 CFR 772 provides procedures for preparing operational and construction noise studies and evaluating noise abatement considered for federal and federal-aid highway projects. Under 23 CFR 772.7, projects are categorized as Type 1, Type 2, or Type 3 projects. FHWA defines a Type 1 project as a proposed federal or federal-aid highway project for the construction of a highway on a new location, the physical alteration of an existing highway where there is either substantial horizontal or substantial vertical alteration (i.e., auxiliary lanes or new bridge), or a project that increases the number of through-traffic lanes. A Type 2 project is a noise barrier retrofit project that involves no changes to highway capacity or alignment. A Type 3 project is a project that does not meet the classifications of a Type 1 or Type 2 project. Type 3 projects do not require a noise analysis.

Under 23 CFR Part 772, noise abatement can be considered for a Type 2 project if traffic noise impacts have been identified. The FHWA defines retrofit noise abatement projects, or Type 2 projects, as federal or federal-aid highway projects for noise abatement on an existing highway. For a Type 2 project to be eligible for federal-aid funding, the retrofit noise barrier analysis must be performed in accordance with the State's adopted Type 2 program requirements.

For Type 2 projects, a traffic noise impact is considered to occur when the existing traffic noise levels at the exterior of dwelling unit areas exceed the NAC specified in the regulation.

Table 4-1 summarizes the NAC corresponding to various land use activity categories. Activity categories and related traffic noise impacts are determined based on the actual land use in a given area.

Table 4-1. Activity Categories and Noise Abatement Criteria

Activity Category	Activity $L_{eq}(h)$[1]	Evaluation Location	Description of Activities
A	57	Exterior	Lands on which serenity and quiet are of extraordinary significance, that serve an important public need, and where the preservation of those qualities is essential if the area is to continue to serve its intended purpose.
B[2]	67	Exterior	Residential
C[2]	67	Exterior	Active sport areas, amphitheaters, auditoriums, campgrounds, cemeteries, daycare centers, hospitals, libraries, medical facilities, parks, picnic areas, places of worship, playgrounds, public meeting rooms, public or nonprofit institutional structures, radio studios, recording studios, recreation areas, Section 4(f) sites, schools, television studios, trails, and trail crossings.
D	52	Interior	Auditoriums, daycare centers, hospitals, libraries, medical facilities, places of worship, public meeting rooms, public or nonprofit institutional structures, radio studios, recording studios, schools, and television studios.
E	72	Exterior	Hotels, motels, offices, restaurants/bars, and other developed lands, properties, or activities not included in A–D or F.
F	—	—	Agriculture, airports, bus yards, emergency services, industrial uses, logging, maintenance facilities, manufacturing, mining, railyards, retail facilities, shipyards, utilities (water resources, water treatment, electrical), and warehousing.
G	—	—	Undeveloped lands that are not permitted.

Source: Federal Highway Administration 23 CFR 772.
[1] The $L_{eq}(h)$ activity criteria values are for impact determination only and are not design standards for noise abatement measures. All values are in dBA.
[2] Includes undeveloped lands permitted for this activity category.
CFR = Code of Federal Regulations
dBA = A-weighted decibels
$L_{eq}(h)$ = equivalent continuous sound level per hour

In identifying noise impacts, primary consideration is given to exterior areas of frequent human use. In situations where there are no exterior activities, or where the exterior activities are far from the roadway or physically shielded in a manner that prevents an impact on exterior activities, the interior criterion (Activity Category D) is used as the basis for determining a noise impact.

4.2. State Regulations and Policies

4.2.1. Traffic Noise Analysis Protocol for Retrofit Noise Abatement Projects

The Traffic Noise Analysis Protocol addresses retrofit noise abatement on existing transportation facilities for projects proposed within the State right-of-way or projects proposed by any agency using Type 2 federal aid funds under 23 CFR 772. Qualification criteria for retrofit noise abatement projects include the following:

(1) activity area must have been developed before construction of the highway or before any expansion or alteration of the highway that would result in increased traffic noise at the residential area; (2) existing worst-hour noise level at the activity area must exceed the applicable noise abatement criterion; and (3) any other FHWA-approved criteria established and implemented by sponsoring Regional Transportation Planning Agencies (RTPAs) responsible for retrofit noise abatement program must be met.

The Caltrans TeNS (September 2013) and the Protocol provide detailed technical guidance for the evaluation of highway traffic noise. This includes field measurement methods, noise modeling methods, and report preparation guidance.

4.3. Local Regulations and Policies

4.3.1. County of Fresno

The County of Fresno Ordinance Section 8.40.060(C) limits noise associated with construction to the hours between 6:00 a.m. and 9:00 p.m. on weekdays and between the hours of 7:00 a.m. and 5:00 p.m. on Saturday or Sunday.

4.3.2. City of Fresno

The City of Fresno Municipal Code 10-109(a) limits construction, repair, or remodeling work accomplished pursuant to a building, electrical, plumbing, mechanical, or other construction permit issued by the City or other governmental agency, or to site preparation and grading to the hours between 7:00 a.m. and 10:00 p.m. on any day except Sunday.

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Chapter 5. Study Methods and Procedures

5.1. Methods for Identifying Land Uses and Selecting Noise Measurement and Modeling Receptor Locations

A field investigation was conducted to identify land uses that could be subject to traffic noise impacts from the existing highway. Noise-sensitive land uses in the study area include single and multifamily residences. As retrofit noise abatement projects are limited to residential areas, no receptors were modeled to represent hotels, retail, and commercial land uses. As stated in the Protocol, noise abatement is only considered for areas of frequent human use that would benefit from a lowered noise level. Accordingly, this noise impact analysis focuses on locations with defined outdoor activity areas, such as residential back yards and common-use areas at multifamily residences.

The geographical features of the project area relative to nearby existing land uses were also identified.

Short-term (15-mintue) noise level monitoring was conducted within each of the five project sites in locations selected to represent residential land uses. The short-term monitoring results were used to calibrate the noise model. Long-term (24-hour) measurements were conducted at each of the five sites to capture the diurnal traffic noise level patterns. Additional locations were selected to represent receptors in the noise model based on locations of existing residential uses.

5.2. Field Measurement Procedures

A field noise study was conducted in accordance with the recommended procedures in the TeNS (Caltrans 2013). The following is a summary of the procedures used to collect short-term and long-term sound level data.

5.2.1. Short-Term Measurements

Short-term noise level measurements at all five project sites were sampled during off-peak traffic hours when traffic was flowing freely. Short-term noise level measurements were made using Larson Davis Models 820 and 824 Type 1 sound level meters.

The following measurement procedures were utilized:

- Calibration of the sound level meter.
- Set up of the sound level meter at a height of 5 ft.
- Commencement of noise monitoring.
- Collection of site-specific data such as date, time, direction of traffic, vehicle speed, and the location of the sound level meter relative to any existing feature.
- Counting of passing vehicles for a period of 15 minutes during noise level measurement. Vehicles are divided into three categories for this procedure: automobiles, medium trucks, and heavy trucks.
- Stop measurement after 15 minutes.
- Calibration of the sound level meter.
- Proceed to the next monitoring site and repeat.

The traffic counts were expanded to hourly volumes (multiplied by four to normalize the results to hourly values) and entered into the FHWA Traffic Noise Model (TNM) 2.5 for each monitoring site. The monitoring results were used to calibrate the TNM noise model.

5.2.2. Long-Term Measurements

Five long-term noise level measurements were conducted using dosimeters for the five project sites (one long-term noise level measurement per project site). The purpose of the long-term measurements was to identify variations in sound levels throughout the day.

5.3. Traffic Noise Level Prediction Methods

Traffic noise levels were predicted using the FHWA TNM 2.5, a computer model based on two FHWA reports (FHWA-PD-96-009 [1998a], and FHWA-PD-96-010 [1998b]). Key inputs to the traffic noise model included the locations of roadways, shielding features (e.g., topography and buildings), existing noise barriers, ground types, and receptors.

The traffic volumes counted and the noise levels measured during the ambient noise monitoring were used to calibrate the TNM 2.5 model for the existing conditions at all modeled receptor locations. The TNM 2.5 program is the traffic noise model used to evaluate traffic noise impacts against the 67 dBA L_{eq} NAC. A summary of traffic counts during ambient noise level measurement is provided in Appendix A.

The existing traffic noise levels at all modeled receptor locations were then modeled using peak-hour traffic volumes obtained from the Caltrans Traffic Census.[1] The future worst-case traffic noise levels were modeled assuming 1,950 vehicles per lane per hour (vplph) on the highway mainline, 1,200 vplph on auxiliary lanes, and 1,000 vplph on the highway on-ramps. The worst-case traffic condition on the highway is assumed to be Level of Service (LOS) D/E and is generally loudest when vehicles on a given roadway travel at free-flowing traffic conditions. Accordingly, the worst-case traffic volume assumptions are based on the maximum number of vehicles that can typically travel in a given lane while still resulting in free-flowing traffic conditions. In addition, future traffic volumes on local roadways were assumed to be 100 vplph for Huntington Boulevard, 642 vplph for E. Clinton Avenue, 755 vplph for E. Gettysburg Avenue, and 855 for E. Shields Avenue. A summary of traffic data inputs for existing and future conditions is also provided in Appendix A.

TNM 2.5 is sensitive to the volume of trucks on the roadway because trucks contribute disproportionally to traffic noise. Vehicle distributions on SR-41 and SR-168 at the five project sites were based on traffic counts collected during ambient noise level measurements. Vehicle distributions for SR-41 and SR-168 were reviewed in the *Annual Average Daily Trucks on the California State Highway System* (Caltrans 2013), however it was determined that the vehicle distributions obtained from traffic counts collected during ambient noise level measurements contained higher truck percentages. Therefore, to represent a worse scenario the collected data was used in the analysis. Table 5-1 shows the vehicle distribution and vehicle speeds for each vehicle category and roadway within the project study area used to calculate existing and future traffic noise levels.

5.4. Methods for Identifying Traffic Noise Impacts and Consideration of Abatement

Traffic noise impacts are considered to occur at receptor locations where predicted future worst-hour noise levels exceed the NAC for the applicable noise abatement criterion. Where traffic noise impacts are identified, noise abatement must be considered for reasonableness and feasibility as required by 23 CFR 772 and the Protocol.

[1] California Department of Transportation. Website: http://www.dot.ca.gov/hq/traffops/saferesr/trafdata/.

Table 5-1. Vehicle Distribution

Roadway	Vehicle Distribution (%)			Vehicle Speed (mph)		
	Autos	Medium Trucks	Heavy Trucks	Autos	Medium Trucks	Heavy Trucks
SR-41	0.951	0.025	0.025	65	65	55
SR-168	0.966	0.021	0.013	65	65	55
SR-41 NB Off-Ramp at Tulare Avenue	0.956	0.033	0.011	45	45	45
SR-41 SB On-Ramp at Tulare Avenue	0.954	0.031	0.015	65	65	55
SR-168 NB On-Ramp from McKinley Avenue	0.981	0.014	0.005	65	65	55
SR-168 SB Off-Ramp to McKinley Avenue	0.989	0.011	0.000	45	45	45
Huntington Boulevard	1.000	0.000	0.000	30	30	30
E. Clinton Avenue	0.965	0.031	0.004	40	40	40
E. Gettysburg Avenue	0.970	0.018	0.012	40	40	40
E. Shields Avenue	0.979	0.021	0.000	40	40	40

Source: LSA Associates, Inc. (August 2015).
mph = miles per hour
NB = northbound
SB = southbound
SR-41 = State Route 41
SR-168 = State Route 168

According to the Protocol, an abatement measure is considered acoustically feasible if a minimum noise reduction of 5 dBA at impacted receptor locations is predicted with implementation of the abatement measure. In addition, barriers should be designed to intercept the line-of-sight from the exhaust stack of a truck to the first tier of receptors as required by the *Highway Design Manual*, Chapter 1100 (Caltrans 2012). Other factors that affect feasibility include topography, access requirements for driveways and ramps, presence of local cross-streets, utility conflicts, other noise sources in the area, and safety considerations. The overall reasonableness of noise abatement is determined by considering factors such as the construction cost of the barrier, the noise reduction design goal (a noise level reduction of 7 dBA or more at one or more benefited receptors), and the viewpoints of benefited receptors (including property owners and residents of the benefited receptors).

The Protocol defines the procedure for assessing the reasonableness of noise barriers from a cost perspective. A cost-per-residence allowance is calculated for each benefited residence (i.e., residences that receive at least 5 dBA of noise reduction from a noise barrier). The 2015 allowance is $71,000 per benefited residence. The allowance in previously years was $55,000. Total allowances are calculated by multiplying the allowance per residence by the number of benefited residences.

Chapter 6. Existing Noise Environment

6.1. Existing Land Uses

Developed land uses in the project vicinity were identified through land use maps, aerial photography, and site inspection for each of the five project sites. Existing land uses under study include single-family and multifamily residences and recreational uses. The study area and the existing land uses at each project site are described in further detail below:

- **Project Site 1:** The study area includes multifamily residences and recreational uses on the west side of SR-41 between R Street and Tulare Street. Multifamily residences and recreational uses in this area are located approximately 5 ft lower to 30 ft higher in elevation than SR-41. Currently, there is an existing 3.3 to 5.3 ft high wall along the property line/State right-of-way that shields multifamily residences and recreational uses located south of Huntington Boulevard while there are no existing walls within the State right-of-way that shield multifamily residences and recreational uses located north of Huntington Boulevard. In addition, multifamily residences located south of Huntington Boulevard have a wood fence or masonry block wall that surrounds some of the ground floor patios. Multifamily residences were evaluated under Activity Category B, which has an exterior NAC of 67 dBA L_{eq}. Recreational uses were evaluated under Activity Category C, which has an exterior NAC of 67 dBA L_{eq}.
- **Project Site 2:** The study area includes single-family residences on the east side of SR-41 between N. Fresno Street and E. Clinton Avenue. Single-family residences in this area are approximately 20 ft lower in elevation than SR-41. Currently, there is an existing 5 ft high barrier along the edge of shoulder that runs approximately 350 ft north and south of E. Clinton Avenue and partially shields these residences. In addition, some residences have a wood fence or masonry block wall along the property line. Single-and multifamily residences were evaluated under Activity Category B, which has an exterior NAC of 67 dBA L_{eq}.
- **Project Site 3:** The study area includes single-family residences on the east side of SR-168 south of E. Gettysburg Avenue. Single-family residences in this area are approximately 20 to 25 ft lower in elevation than SR-168. Currently, there is an existing 2.6 ft high barrier along the edge of shoulder that runs approximately 100 ft south of E. Gettysburg Avenue and 260 ft north of E. Gettysburg Avenue, and partially shields these residences. In addition, some residences have a wood

fence along the property line. Single-and multifamily residences were evaluated under Activity Category B, which has an exterior NAC of 67 dBA L_{eq}.

- **Project Site 4:** The study area includes single-family residences on the east side of SR-168 between south of E. Weldon Avenue and E. University Avenue. Single-family residences in this area are approximately 10 ft lower in elevation than SR-168 to 25 ft higher in elevation than SR-168. Currently, there are no existing walls within the State right-of-way that shield these residences. However, some residences have a wood fence or masonry wall along the property line. Single-family residences were evaluated under Activity Category B, which has an exterior NAC of 67 dBA L_{eq}.
- **Project Site 5:** The study area includes single-family residences on the east side of SR-168 between E. Clinton Avenue and E. Shields Avenue. Single-family residences in this area are approximately 20 to 30 ft higher in elevation than SR-168. Currently, there are no existing walls within the State right-of-way that shield these residences. However, some residences have a wood fence or masonry wall along the property line. Single-family residences were evaluated under Activity Category B, which has an exterior NAC of 67 dBA L_{eq}.

6.2. Noise Measurement Results

The existing noise environment in the project area is based on short-term and long-term 24-hour noise level measurements.

6.2.1. Short-Term Monitoring

The primary source of noise in the project areas is traffic on the adjacent freeways. For Project Sites 1 and 2, the primary source of noise is traffic on SR-41. For Project Sites 3, 4, and 5, the primary source of noise is traffic on SR-168. Short-term (15-minute) noise measurements were conducted to document existing noise levels at 18 representative sensitive receptor locations for the five project sites. Short-term (15-minute) noise level measurements were conducted using Larson Davis Models 820 and 824 Type 1 sound level meters. Table 6-1 contains the results of the short-term noise level measurements along with a description of the physical location at each monitoring site. These short-term noise measurements were used to calibrate the noise model and to predict the noise levels at all modeled receptors for the five project sites. The short-term monitoring locations are shown on Figures 6-1, 6-2, 6-3, 6-4, and 6-5. The noise monitoring results are included in Appendix C while the concurrent traffic counts and measured vehicle speeds for each monitoring site are included in Appendix A.

Table 6-1. Short-Term Ambient Noise Monitoring Results

Monitor No.	Date	Start Time	Duration	dBA L_{eq}	Location Description	Noise Sources	Comments
ST-1.1	5/12/2015	10:33 AM	15 minutes	68.6	2890 Huntington Boulevard, Fresno. At the tennis court of the Huntington Park Condominium on the east side of the complex. Located on the west side of SR-41 and the south side of Huntington Boulevard.	Traffic on SR-41.	Approximately 5 ft high wall located along the property line of the residential complex. Buildings are two stories each with 5 units.
ST-1.2	5/12/2015	10:33 AM	15 minutes	68.0	2881 Huntington Boulevard, Fresno. At the parking lot of the Villa Borgata Condominium on the east side of the complex. Located on the west side of SR-41 and the north side of Huntington Boulevard.	Traffic on SR-41.	Chain-link fence along the property line on the east side of the complex. Buildings are two stories each with 8 units.
ST-2.1	5/12/2015	11:25 AM	15 minutes	68.6	2409 E. Cambridge Avenue, Fresno. In the front yard. Located on the east side of SR-41.	Traffic on SR-41.	No wall, only chain-link fence. Residence has a 6 ft high wood back fence.
ST-2.2	5/12/2015	11:25 AM	15 minutes	67.2	2325 E. Berkeley Avenue, Fresno. In the backyard. Located on the east side of SR-41.	Traffic on SR-41.	Chain-link fence.
ST-2.3	5/12/2015	11:50 AM	15 minutes	66.1	2308 E. Vassar Avenue, Fresno. In the backyard approximately 15 ft from the wood fence. Located on the east side of SR-41.	Traffic on SR-41 and some aircraft noise.	Approximately 5 ft high wood fence with gaps. Noise meter has line of sight to SR-41.
ST-3.1	5/12/2015	2:12 PM	15 minutes	60.8	4481 N. Sierra Vista Avenue, Fresno. In the backyard. Located on the east side of SR-168.	Traffic on SR-168.	Approximately 5 ft high fence with large gaps. Portions of the fence have fallen down.
ST-3.2	5/12/2015	2:12 PM	15 minutes	65.1	At the cul-de-sac between 4708 and 4715 E. Donner Avenue, Fresno. Located on the east side of SR-168.	Traffic on SR-168.	Chain-link fence along the property line.
ST-3.3	5/12/2015	2:40 PM	15 minutes	63.2	4720 E. Norwich Avenue, Fresno. In the backyard. Located on the east side of SR-168.	Traffic on SR-168.	Approximately 5 ft high wood fence. The pad is approximately 1 ft higher than sidewalk.
ST-3.4	5/12/2015	2:40 PM	15 minutes	64.2	4727 E. Norwich Avenue, Fresno. In the backyard. Located on the east side of SR-168.	Traffic on SR-168.	Wood fence is 6 ft high and in good condition with no holes or damage.

Table 6-1. Short-Term Ambient Noise Monitoring Results

Monitor No.	Date	Start Time	Duration	dBA L_{eq}	Location Description	Noise Sources	Comments
ST-4.1	5/13/2015	9:34 AM	15 minutes	61.5	1905 Jackson Drive, Fresno. In the backyard. Located on the east side of SR-168.	Traffic on SR-168.	Partially shielded by adjacent home. Approximately 5 ft high wood fence with gaps.
ST-4.2	5/13/2015	9:33 AM	15 minutes	69.0	On Haystan Avenue adjacent to Yale Avenue; on the side of backyard at 4528 Yale Avenue.	Traffic on SR-168.	Approximately 5 ft high wood fence along the property line. Chain-link fence located along the State right-of-way.
ST-4.3	5/13/2015	10:07 AM	15 minutes	64.3	2218 N. Hayston Avenue, Fresno. In the front yard. Located on the east side of SR-168.	Traffic on SR-168.	This residence has side yards on both sides that are usable spaces.
ST-4.4	5/13/2015	10:07 AM	15 minutes	65.9	4528 E. Clinton Avenue, Fresno. In the backyard. Located on the east side of SR-168 and the south side of E. Clinton Avenue.	Traffic on SR-168.	Rear wood fence is approximately 5 ft high and dilapidated. Side fence (facing freeway) is chain link.
ST-5.1	5/13/2015	10:43 AM	15 minutes	57.1	4536 E. Terrace Avenue, Fresno. In the backyard. Located along the east side of SR-168.	Traffic on SR-168 and some bird noise.	A 5 ft high wood fence and chain-link fence along the property line. In an area full of bamboo trees.
ST-5.2	5/13/2015	10:43 AM	15 minutes	66.1	4530 E. Harvard Avenue, Fresno. In the backyard. Located on the east side of SR-168.	Traffic on SR-168.	Chain-link fence along the property line. Freeway is lower in elevation than the home.
ST-5.3	5/13/2015	11:20 AM	15 minutes	66.5	4533 E. Princeton Avenue, Fresno. Near the front/side yard of the house. Located on the east side of SR-168.	Traffic on SR-168 and some bird noise.	Chain link fence along the property line.
ST-5.4	5/13/2015	11:20 AM	15 minutes	64.7	At the cul-de-sac near 4638 East Cornell Avenue, Fresno CA. Located on the east side of SR-126.	Traffic on SR-168.	4538 E. Cornell Avenue has an approximately 7 ft high wooden fence along the property line.
ST-5.5	5/13/2015	11:51 AM	15 minutes	60.6	4545 E. Simpson Avenue, Fresno. In the front/side yard. Located on the east side of SR-168.	Traffic on SR-168.	Chain-link fence. The adjacent property is vacant.

Source: LSA Associates, Inc. (August 2015).
dBA L_{eq} = equivalent continuous sound level measured in A-weighted decibels
ft = foot/feet
SR-41 = State Route 41
SR-168 = State Route 168

Table 6-2 shows the meteorological conditions during the short-term noise measurements.

Table 6-2. Meteorological Conditions During Noise Monitoring

Date	Temperature (°F)	Average Wind Speed (mph)
5/12/2015	68.7–82.3	0.8–1.7
5/13/2015	64.7–70.6	0.7–1.4

Source: LSA Associates, Inc. (August 2015).
°F = degrees Fahrenheit mph = miles per hour

6.2.2. Long-Term Monitoring

A total of five long-term traffic noise level measurements were conducted. One long-term noise level measurement was conducted at each of the five project sites to document the peak traffic noise hour. Long-term ambient noise monitoring was conducted using a dosimeter. The long-term noise level measurement at LT-1 was performed at Huntington Boulevard from 11:00 a.m. on Tuesday, May 12, 2015, to 10:00 a.m. on Wednesday, May 13, 2015. The long-term noise level measurement at LT-2 was performed at 2424 E. Cambridge Avenue from 12:00 p.m. on Tuesday, May 12, 2015, to 11:00 a.m. on Wednesday, May 13, 2015. The long-term noise level measurement at LT-3 was performed at 4720 Norwich Avenue from 3:00 p.m. on Tuesday, May 13, 2015, to 2:00 p.m. on Wednesday, May 13, 2015. The long-term noise level measurement at LT-4 was performed at Cambridge Avenue from 3:00 p.m. on Tuesday, May 12, 2015, to 2:00 p.m. on Wednesday, May 13, 2015. The long-term noise level measurement at LT-5 was performed at E. Cornell Avenue from 8:00 a.m. on Tuesday, May 12, 2015, to 7:00 a.m. on Wednesday, May 13, 2015. The long-term noise monitoring locations at LT-1 through LT-5 are shown on Figures 6-1, 6-2, 6-3, 6-4, and 6-5, respectively.

Tables 6-3 through 6-7 (along with the associated graph representations) show that traffic noise peaks during the 7:00 a.m. to 8:00 a.m. hour at LT-1 through LT-5, respectively. To determine existing peak traffic noise levels in the project area, the difference between the hour in which the short-term ambient noise measurements were conducted and the peak traffic noise hour was added to the monitored noise levels. For example, monitoring location ST-1 was conducted during the 10:00 a.m. hour. Table 6-3 shows that the noise level during this hour is 3.0 dB lower than the level during the peak traffic noise hour. Therefore, 3.0 dB is added to the measured noise level at ST-1 to determine the existing peak traffic noise level.

Table 6-3. Long-Term 24-Hour Noise Level Measurement Results at Huntington Boulevard, Fresno, CA (LT-1)

	Start Time	Date	Noise Level (dBA L_{eq})
1	11:00 AM	5/12/15	77.4
2	12:00 PM	5/12/15	77.7
3	1:00 PM	5/12/15	78.1
4	2:00 PM	5/12/15	78.3
5	3:00 PM	5/12/15	78.7
6	4:00 PM	5/12/15	78.9
7	5:00 PM	5/12/15	78.8
8	6:00 PM	5/12/15	77.6
9	7:00 PM	5/12/15	76.6
10	8:00 PM	5/12/15	75.7
11	9:00 PM	5/12/15	75.2
12	10:00 PM	5/12/15	73.5
13	11:00 PM	5/12/15	70.9
14	12:00 AM	5/13/15	68.9
15	1:00 AM	5/13/15	66.3
16	2:00 AM	5/13/15	67.0
17	3:00 AM	5/13/15	68.6
18	4:00 AM	5/13/15	73.5
19	5:00 AM	5/13/15	77.7
20	6:00 AM	5/13/15	79.4
21	7:00 AM	5/13/15	**80.2**[1]
22	8:00 AM	5/13/15	78.8
23	9:00 AM	5/13/15	77.5
24	10:00 AM	5/13/15	77.2

Source: LSA Associates, Inc. (August 2015).

[1] **Bold** number represents the peak traffic noise hour.

dBA L_{eq} = equivalent continuous sound level measured in A-weighted decibels

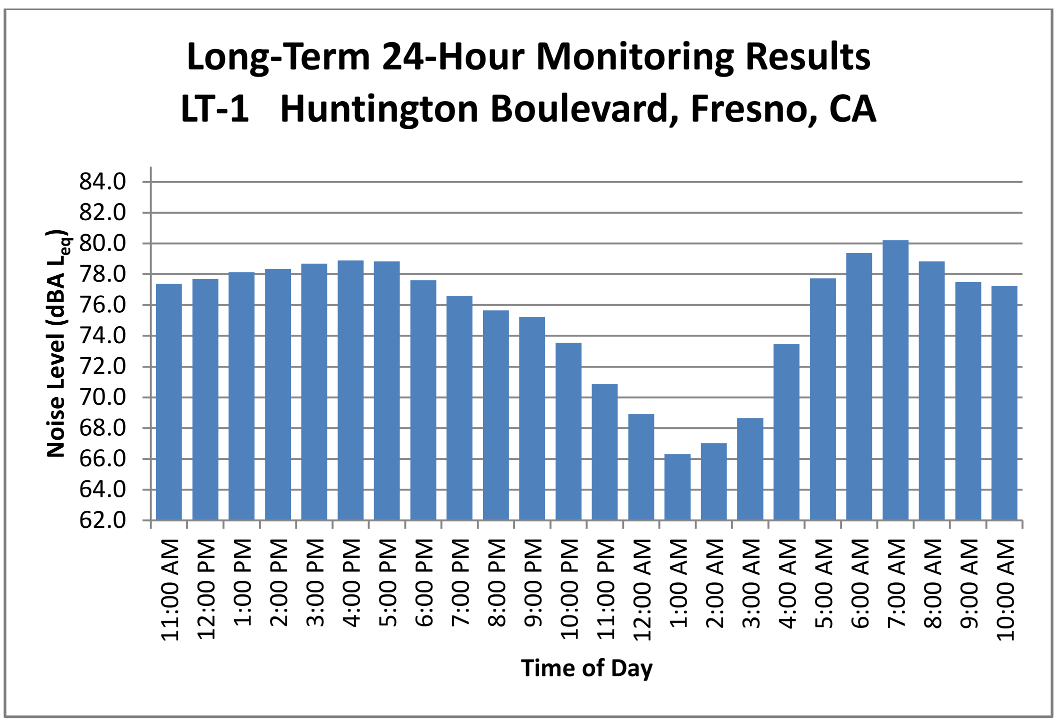


Table 6-4. Long-Term 24-Hour Noise Level Measurement Results at 2424 E. Cambridge Avenue, Fresno, CA (LT-2)

	Start Time	Date	Noise Level (dBA L_{eq})
1	12:00 PM	5/12/15	67.9
2	1:00 PM	5/12/15	67.3
3	2:00 PM	5/12/15	68.2
4	3:00 PM	5/12/15	68.1
5	4:00 PM	5/12/15	66.9
6	5:00 PM	5/12/15	69.1
7	6:00 PM	5/12/15	69.8
8	7:00 PM	5/12/15	69.7
9	8:00 PM	5/12/15	68.8
10	9:00 PM	5/12/15	68.0
11	10:00 PM	5/12/15	67.2
12	11:00 PM	5/12/15	65.8
13	12:00 AM	5/13/15	63.6
14	1:00 AM	5/13/15	61.2
15	2:00 AM	5/13/15	60.1
16	3:00 AM	5/13/15	60.0
17	4:00 AM	5/13/15	62.7
18	5:00 AM	5/13/15	67.0
19	6:00 AM	5/13/15	70.4
20	7:00 AM	5/13/15	**71.8**[1]
21	8:00 AM	5/13/15	71.1
22	9:00 AM	5/13/15	69.6
23	10:00 AM	5/13/15	68.6
24	11:00 AM	5/13/15	68.3

Source: LSA Associates, Inc. (August 2015).
[1] **Bold** number represents the peak traffic noise hour.
dBA L_{eq} = equivalent continuous sound level measured in A-weighted decibels

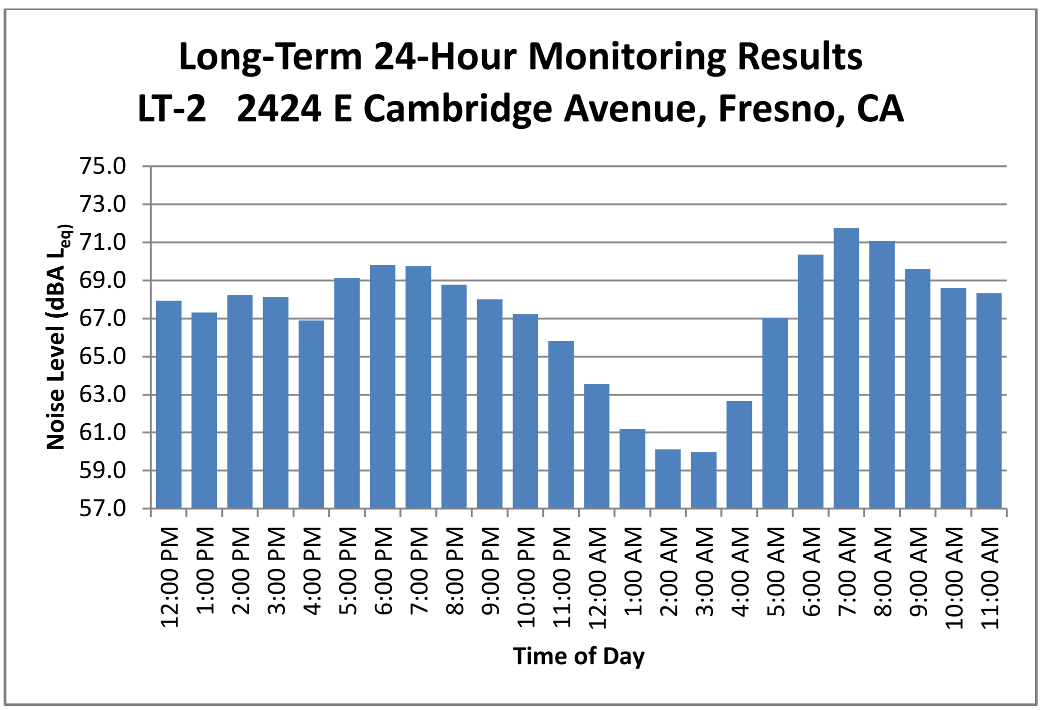


Table 6-5. Long-Term 24-Hour Noise Level Measurement Results at 4720 Norwich Avenue, Fresno, CA (LT-3)

	Start Time	Date	Noise Level (dBA L_{eq})
1	3:00 PM	5/12/15	64.1
2	4:00 PM	5/12/15	64.5
3	5:00 PM	5/12/15	64.9
4	6:00 PM	5/12/15	63.7
5	7:00 PM	5/12/15	63.6
6	8:00 PM	5/12/15	62.4
7	9:00 PM	5/12/15	60.4
8	10:00 PM	5/12/15	61.1
9	11:00 PM	5/12/15	60.0
10	12:00 AM	5/13/15	57.0
11	1:00 AM	5/13/15	56.2
12	2:00 AM	5/13/15	55.8
13	3:00 AM	5/13/15	54.4
14	4:00 AM	5/13/15	56.5
15	5:00 AM	5/13/15	59.9
16	6:00 AM	5/13/15	63.0
17	7:00 AM	5/13/15	**65.0**[1]
18	8:00 AM	5/13/15	64.0
19	9:00 AM	5/13/15	62.2
20	10:00 AM	5/13/15	61.8
21	11:00 AM	5/13/15	61.4
22	12:00 PM	5/13/15	60.7
23	1:00 PM	5/13/15	60.7
24	2:00 PM	5/13/15	60.8

Source: LSA Associates, Inc. (August 2015).
[1] **Bold** number represents the peak traffic noise hour.
dBA L_{eq} = equivalent continuous sound level measured in A-weighted decibels

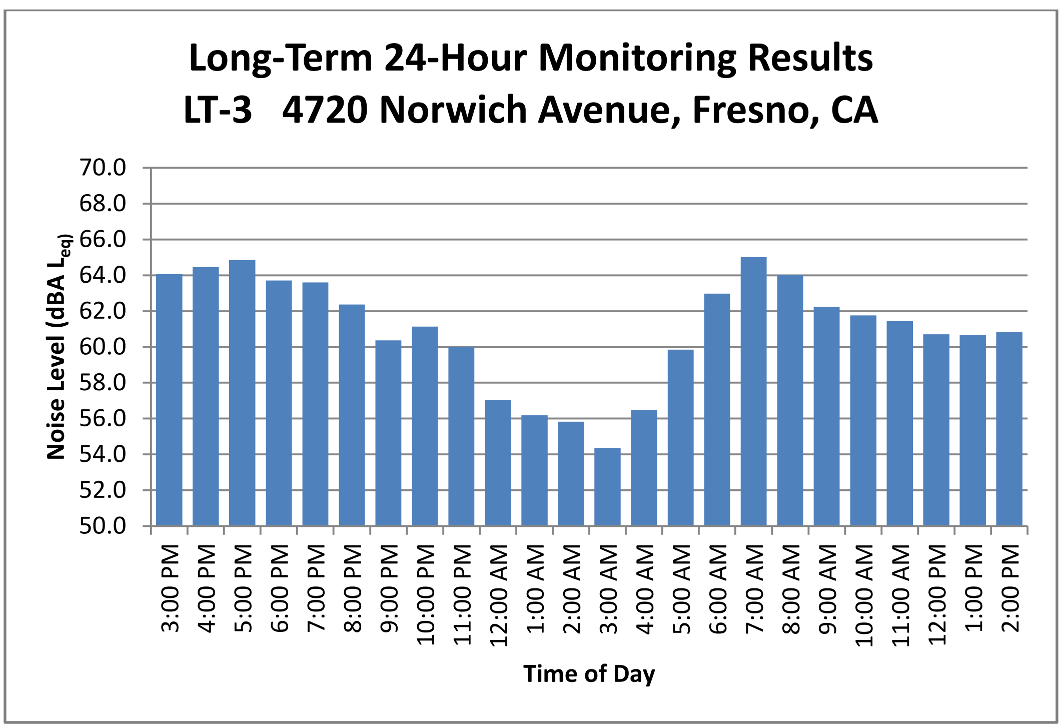


Table 6-6. Long-Term 24-Hour Noise Level Measurement Results at E. Cambridge Avenue, Fresno, CA (LT-4)

	Start Time	Date	Noise Level (dBA L_{eq})
1	3:00 PM	5/12/15	69.0
2	4:00 PM	5/12/15	69.5
3	5:00 PM	5/12/15	70.4
4	6:00 PM	5/12/15	70.1
5	7:00 PM	5/12/15	69.9
6	8:00 PM	5/12/15	68.9
7	9:00 PM	5/12/15	67.9
8	10:00 PM	5/12/15	67.2
9	11:00 PM	5/12/15	65.9
10	12:00 AM	5/13/15	63.7
11	1:00 AM	5/13/15	61.3
12	2:00 AM	5/13/15	60.9
13	3:00 AM	5/13/15	60.1
14	4:00 AM	5/13/15	62.7
15	5:00 AM	5/13/15	67.2
16	6:00 AM	5/13/15	70.4
17	7:00 AM	5/13/15	**72.3**[1]
18	8:00 AM	5/13/15	70.7
19	9:00 AM	5/13/15	68.3
20	10:00 AM	5/13/15	67.6
21	11:00 AM	5/13/15	66.6
22	12:00 PM	5/13/15	66.8
23	1:00 PM	5/13/15	66.9
24	2:00 PM	5/13/15	66.8

Source: LSA Associates, Inc. (August 2015).

[1] **Bold** number represents the peak traffic noise hour.

dBA L_{eq} = equivalent continuous sound level measured in A-weighted decibels

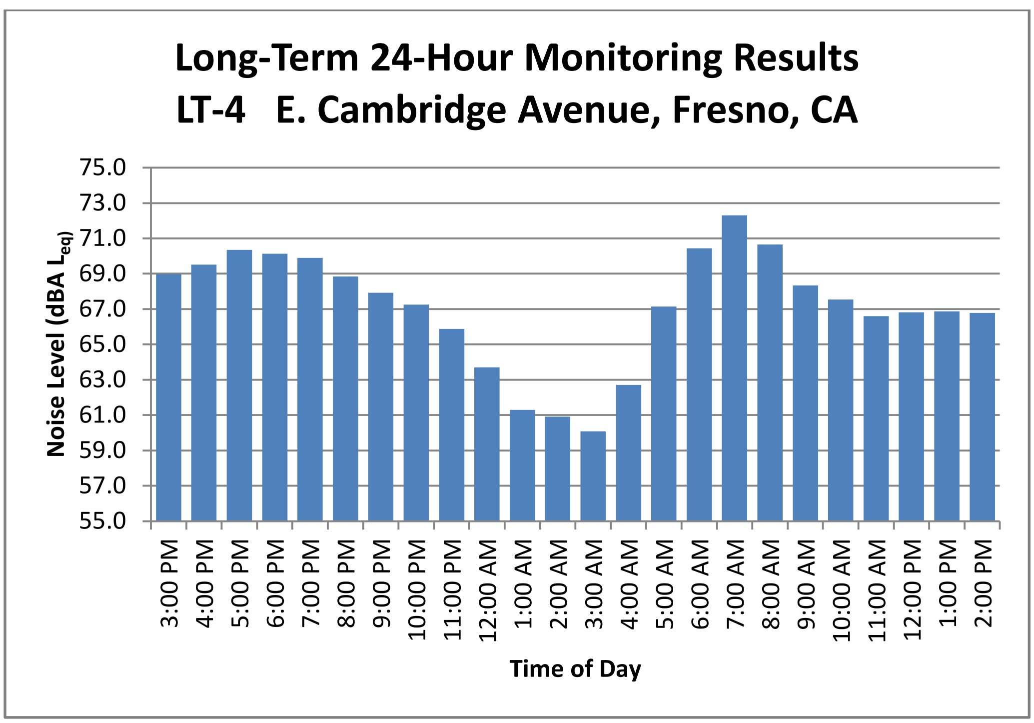


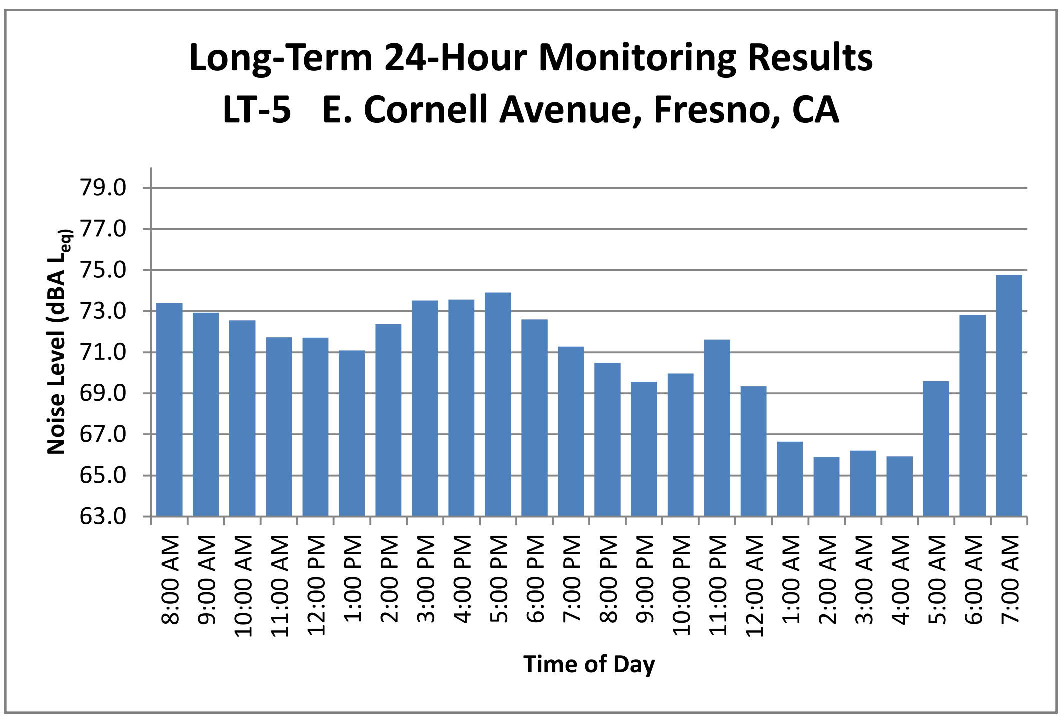
Table 6-7. Long-Term 24-Hour Noise Level Measurement Results at E. Cornell Avenue, Fresno, CA (LT-5)

	Start Time	Date	Noise Level (dBA L_{eq})
1	8:00 AM	5/12/15	73.4
2	9:00 AM	5/12/15	72.9
3	10:00 AM	5/12/15	72.6
4	11:00 AM	5/12/15	71.7
5	12:00 PM	5/12/15	71.7
6	1:00 PM	5/12/15	71.1
7	2:00 PM	5/12/15	72.4
8	3:00 PM	5/12/15	73.5
9	4:00 PM	5/12/15	73.6
10	5:00 PM	5/12/15	73.9
11	6:00 PM	5/12/15	72.6
12	7:00 PM	5/12/15	71.3
13	8:00 PM	5/12/15	70.5
14	9:00 PM	5/12/15	69.6
15	10:00 PM	5/12/15	70.0
16	11:00 PM	5/12/15	71.6
17	12:00 AM	5/13/15	69.3
18	1:00 AM	5/13/15	66.7
19	2:00 AM	5/13/15	65.9
20	3:00 AM	5/13/15	66.2
21	4:00 AM	5/13/15	65.9
22	5:00 AM	5/13/15	69.6
23	6:00 AM	5/13/15	72.8
24	7:00 AM	5/13/15	**74.8**[1]

Source: LSA Associates, Inc. (August 2015).

[1] **Bold** number represents the peak traffic noise hour.

dBA L_{eq} = equivalent continuous sound level measured in A-weighted decibels



6.2.3. Noise Model Calibration

A total of 10 separate model runs were conducted using the traffic counts and measured vehicle speeds collected during the ambient noise monitoring. The results of these model runs were compared to the measured ambient noise levels to ensure the accuracy of TNM 2.5. Correction factors known as K-factors were applied to each of the modeled receptor locations so that the monitored and modeled noise levels were the same. Table 6-8 shows the measured ambient noise level, the modeled noise levels using traffic counts and measured vehicle speeds during noise monitoring, and the K-factor at each of the 18 monitoring locations. As shown in Table 6-8, none of the K-factors are greater than 3 dBA. Therefore, K-factors shown in Table 6-8 were used to calibrate the noise model.

Table 6-8. Model Calibration

Monitor No.	Measured Noise Level (dBA L_{eq})	Modeled Noise Level (dBA L_{eq})	K-Factor (dBA)
ST-1.1	68.6	66.7	1.9
ST-1.2	68.0	70.0	-2.0
ST-2.1	68.6	67.7	0.9
ST-2.2	67.2	67.4	-0.2
ST-2.3	66.1	66.2	-0.1
ST-3.1	60.8	62.8	-2.0
ST-3.2	65.1	65.1	0.0
ST-3.3	63.2	63.8	-0.6
ST-3.4	64.2	65.4	-1.2
ST-4.1	61.5	64.0	-2.5
ST-4.2	69.0	69.6	-0.6
ST-4.3	64.3	63.7	0.6
ST-4.4	65.9	65.8	0.1
ST-5.1	57.1	56.6	0.5
ST-5.2	66.1	66.8	-0.7
ST-5.3	66.5	66.0	0.5
ST-5.4	64.7	65.9	-1.2
ST-5.5	60.6	60.2	0.4

Source: LSA Associates, Inc. (August 2015).
dBA = A-weighted decibels
L_{eq} = equivalent continuous sound level

6.3. Existing Noise Levels

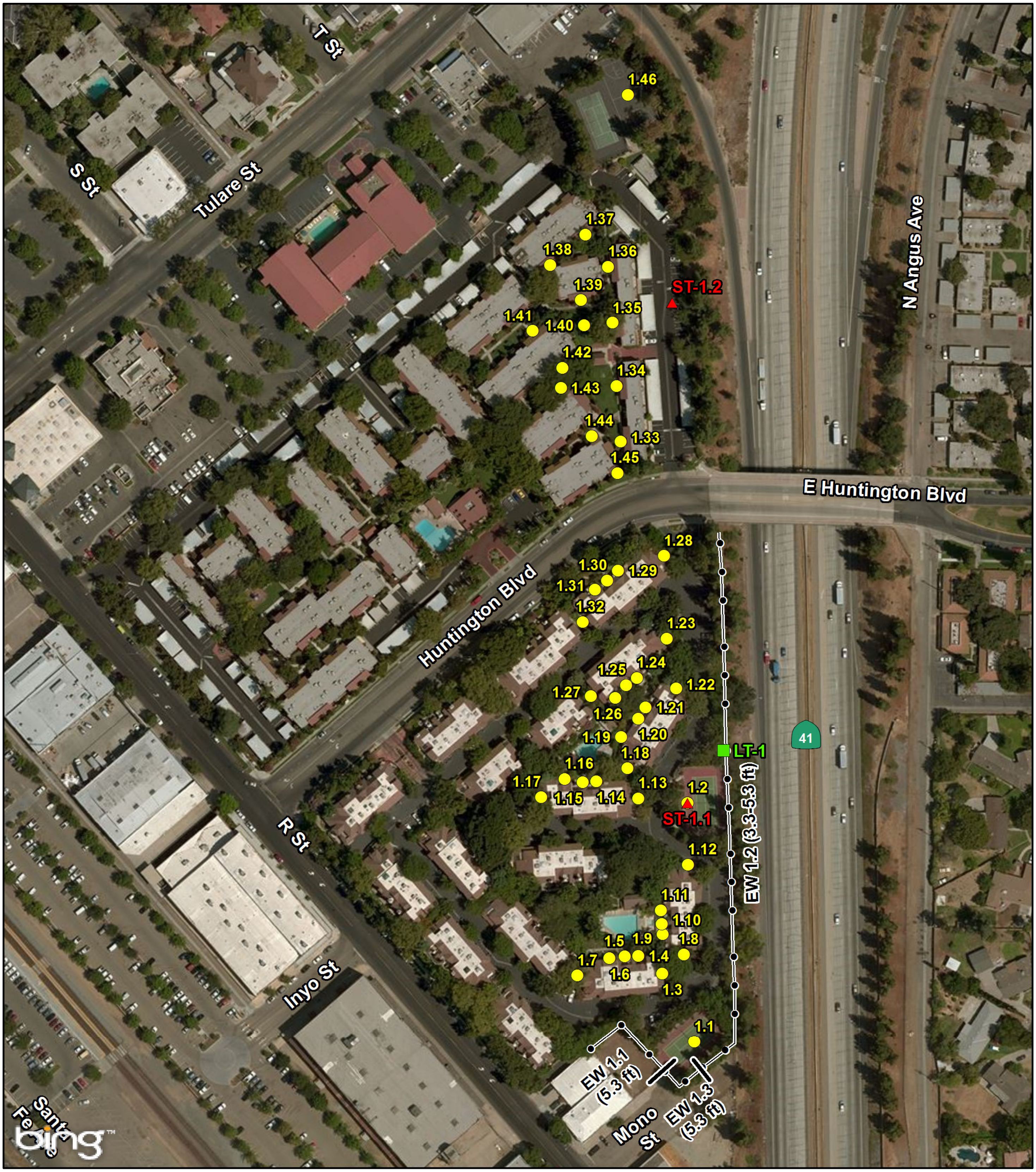
The existing peak-hour traffic volumes obtained from the Caltrans Traffic Census was coded into TNM 2.5 with existing roadway conditions, as described in Section 5.3. The results of the existing traffic noise modeling are shown in Table B-1 in Appendix B. Table 6-9 shows the number of modeled receptors for each project site, the number of receptors that would exceed the 67 dBA L_{eq} NAC, and the number of receptors/residential units that are impacted. Figures 6-1, 6-2, 6-3, 6-4, and 6-5 show the locations of the modeled receptors for each project site.

Table 6-9. Modeled Receptor Statistics

Project Site	Number of Modeled Receptors	Number of Impacted Receptors[1]	Number of Receptors/Residential Units Impacted
1	46	8	8
2	14	8	10
3	14	0	0
4	19	3	4
5	21	1	2

Source: LSA Associates, Inc. (August 2015).

[1] Under existing traffic conditions.



LEGEND

▲ Short-Term Monitoring Location

● Modeled Receptor Location

■ Long-Term Monitoring Location

•—• Existing Wall

N

0 100 200
FEET

SOURCE: Bing (2013)

FIGURE 6-1

Retrofit Sound Wall Study
Noise Study Report

Project Site 1
Monitoring and Modeled Receptor Locations

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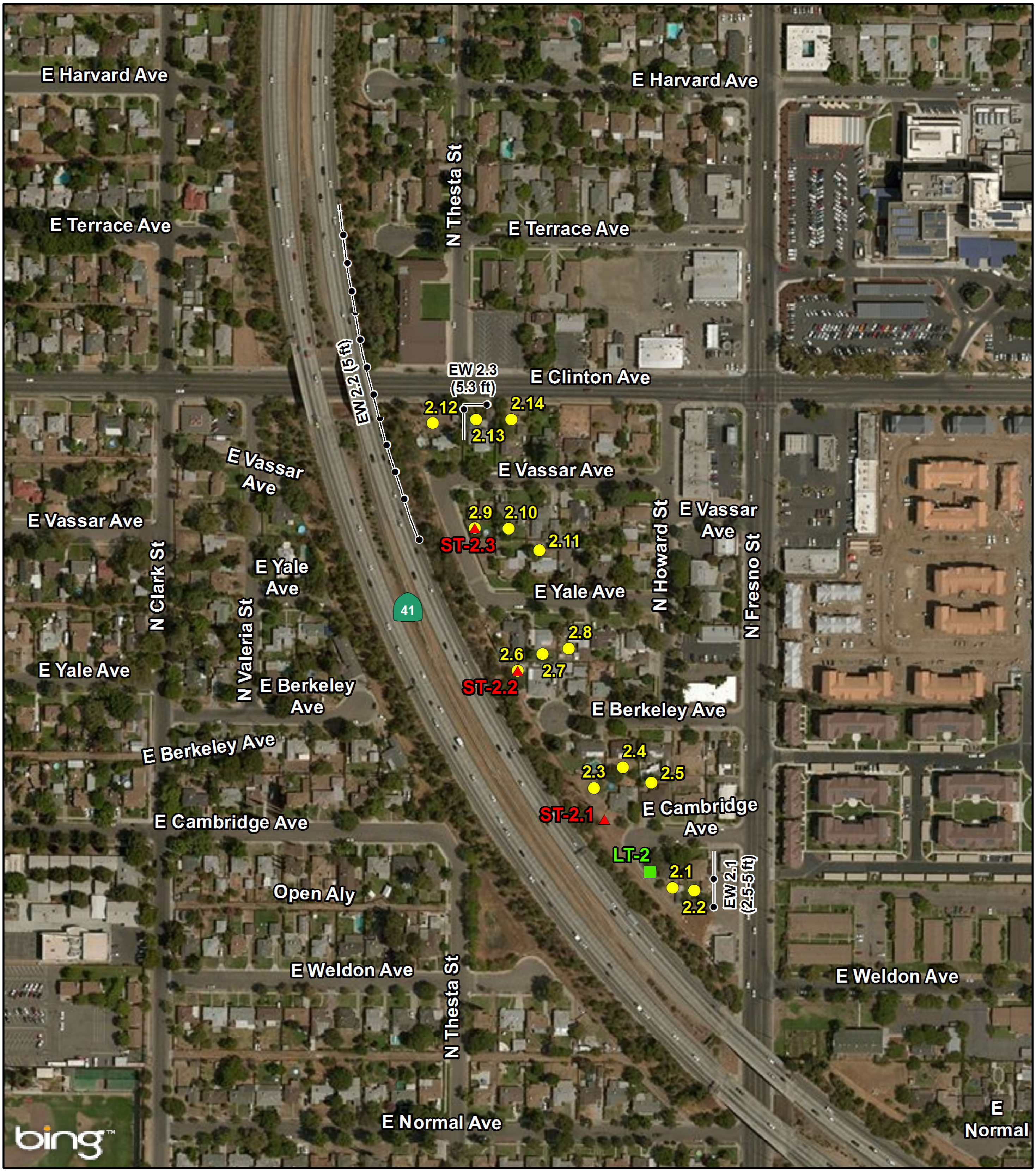

FIGURE 6-2

LEGEND

- Short-Term Monitoring Location
- Modeled Receptor Location
- Long-Term Monitoring Location
- Existing Wall

N

0 150 300
FEET

SOURCE: Bing (2013)

Retrofit Sound Wall Study
Noise Study Report

Project Site 2
Monitoring and Modeled Receptor Locations

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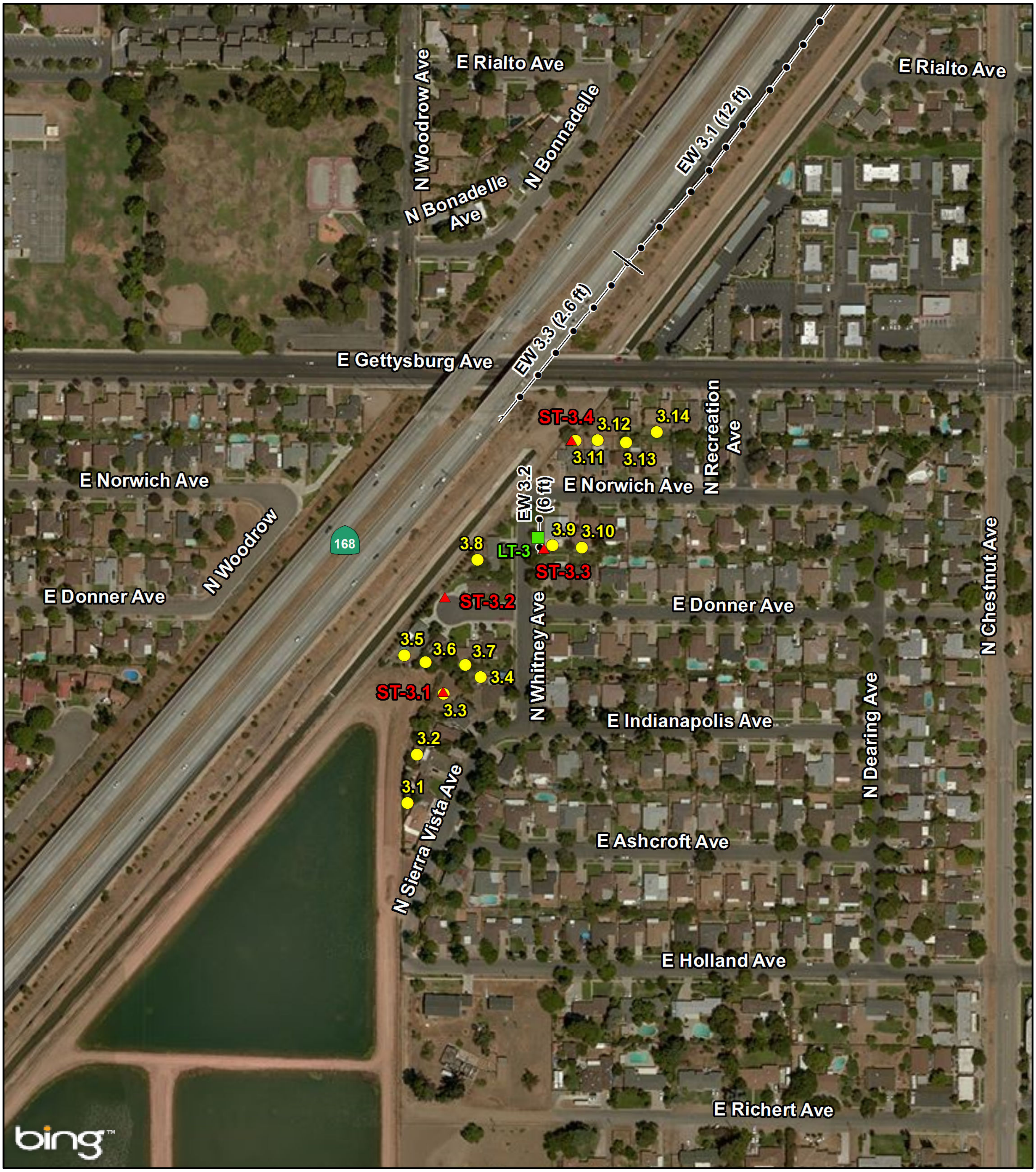

LEGEND

- Short-Term Monitoring Location
- Modeled Receptor Location
- Long-Term Monitoring Location
- Existing Wall

N

0 150 300
FEET

SOURCE: Bing (2013)

FIGURE 6-3

Retrofit Sound Wall Study
Noise Study Report

Project Site 3
Monitoring and Modeled Receptor Locations

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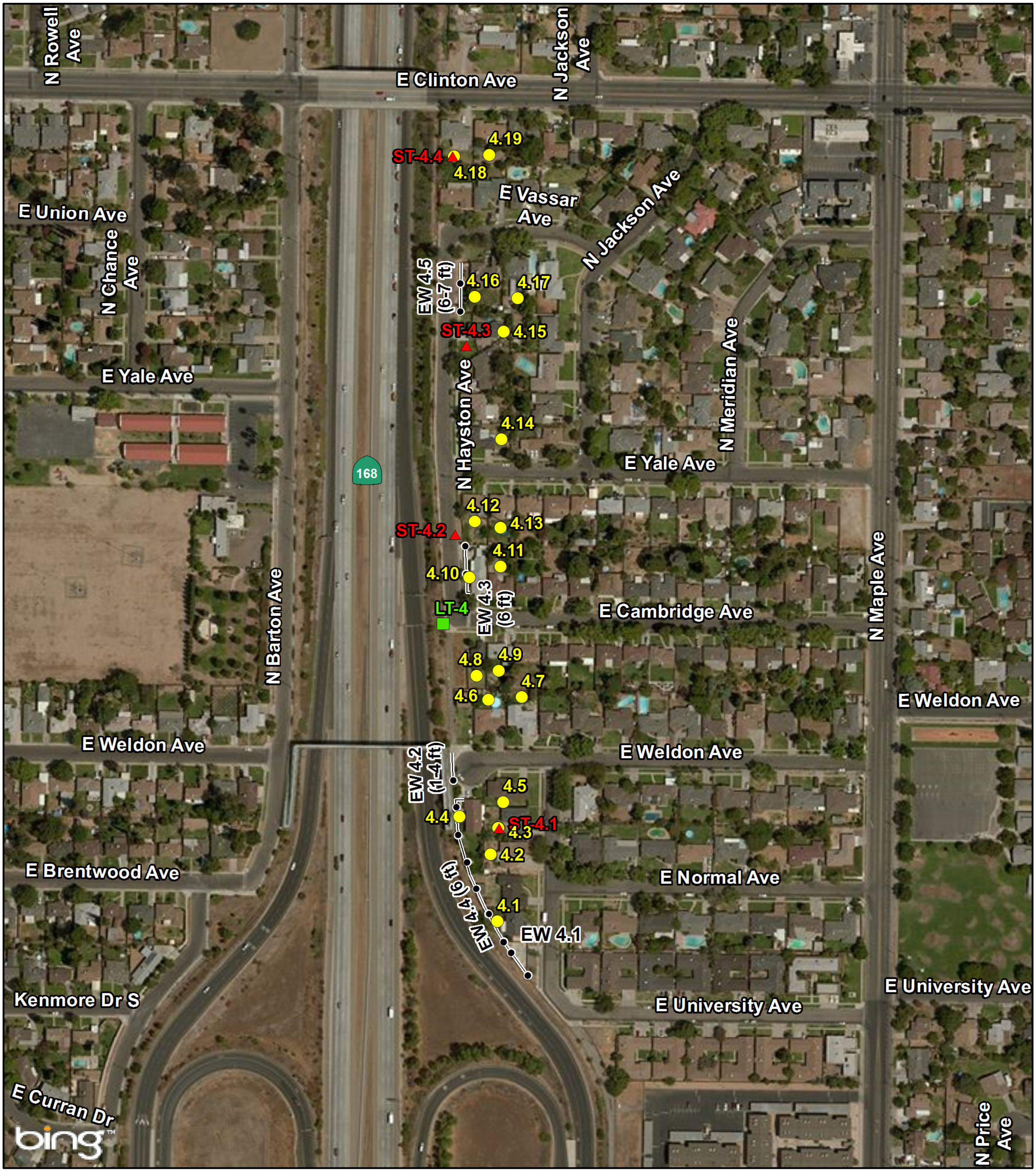

LEGEND

FIGURE 6-4

- Short-Term Monitoring Location
- Modeled Receptor Location
- Long-Term Monitoring Location
- Existing Wall

0 150 300
FEET

SOURCE: Bing (2013)

Retrofit Sound Wall
Noise Study Report
Project Site 4
Monitoring and Modeled Receptor Locations

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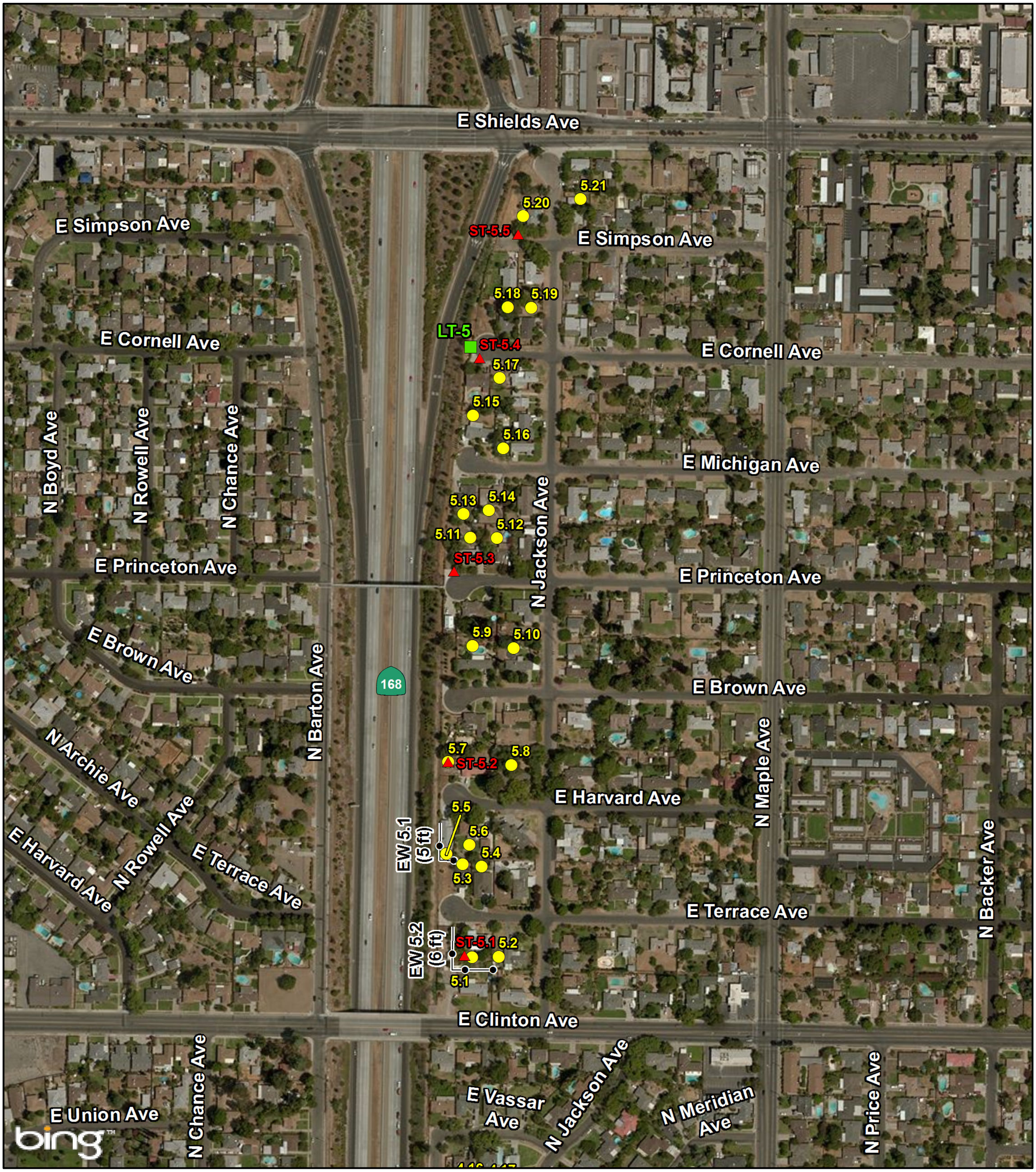

LEGEND

FIGURE 6-5

- Short-Term Monitoring Location
- Modeled Receptor Location
- Long-Term Monitoring Location
- Existing Wall

0 200 400
FEET

SOURCE: Bing (2013)

Retrofit Sound Wall Study
Noise Study Report
Project Site 5
Monitoring and Modeled Receptor Locations

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Chapter 7. Future Noise Environment, Impacts, and Considered Abatement

7.1. Future Noise Environment and Impacts

The noise study was conducted to determine the future traffic noise impacts at sensitive receptors along SR-41 and SR-168 at five project sites in Fresno County. Traffic noise was evaluated for the worst-case traffic condition to generate the worst-hour noise levels. Using coordinates obtained from the topographic maps, receptor locations associated with existing single-family and multifamily residences and recreational uses were evaluated in the model.

Future traffic noise levels were determined with existing walls using the worst-case traffic volumes (as described in Section 5.3): the worst-case traffic volume of 1,950 vplph for highway mainline, 1,200 vplph on auxiliary lanes, and 1,000 vplph on the highway on-ramps. The worst-case traffic condition on highway mainline is assumed to be LOS D/E and is generally loudest when vehicles on a given roadway travel at free-flowing traffic conditions. In addition, future traffic volumes on local roadways were assumed to the worst-case traffic condition of 642 vplph for E. Clinton Avenue, 755 vplph for E. Gettysburg Avenue, and 855 for E. Shields Avenue. Huntington Boulevard traffic volume was modeled at 100 vplph. Table B-1 in Appendix B summarizes the traffic noise modeling results for existing and future conditions. The modeled future noise levels were compared to the 67 dBA L_{eq} NAC to determine whether a traffic noise impact would occur.

Traffic noise impacts occur when the traffic noise level at a sensitive receptor location is predicted to exceed 67 dBA L_{eq} NAC. When traffic noise impacts occur, noise abatement measures must be considered. Project Site 3 did not have any receptor locations that would exceed the criteria.

The following receptor locations would be or would continue to be exposed to noise levels that exceed the 67 dBA L_{eq} NAC at Project Site 1:

- **Receptors R-1.1 through R-1.3, R-1.7, R-1.8, R-1.12, R-1.22, R-1.23, and R-1.28:** These receptor locations represent existing multifamily residences and recreational areas on the west side of SR-41 south of Huntington Boulevard. Currently, there is a 3.3 to 5.3 ft high existing wall located along the property line/State right-of-way that partially shields these residences and the recreational area. One noise barrier (NB No. 1-1) was modeled along the State right-of-way to shield these residences and the recreational area.

- **Receptor R-1.46:** This receptor location represents a recreational area associated with multifamily residences on the west side of SR-41 north of Huntington Boulevard. Currently, there are no existing walls that shield the recreational area. One noise barrier (NB No. 1-2) was modeled along the State right-of-way to shield the recreational area.

The following receptor locations would be or would continue to be exposed to noise levels that exceed the 67 dBA L_{eq} NAC at Project Site 2:

- **Receptors R-2.1 through R-2.7 and R-2.12 through R-2.14:** These receptor locations represent single-family residences on the east side of SR-41. Currently, there is an existing 5 ft high barrier along the edge of shoulder that partially shields these residences. One noise barrier (NB No. 2-1) was modeled along the edge of shoulder to shield these receptors.

The following receptor locations would be or would continue to be exposed to noise levels that exceed the 67 dBA L_{eq} NAC at Project Site 4:

- **Receptors R-4.8, 4.12, and R-4.18:** These receptor locations represent single-family residences on the east side of SR-168. Currently, there are no existing walls that shield these residences. One noise barrier (NB No. 4-1) was modeled along the State right-of-way to shield these receptors.

The following receptor locations would be or would continue to be exposed to noise levels that exceed the 67 dBA L_{eq} NAC at Project Site 5:

- **Receptor R-5.7:** This receptor location represents an existing single-family residence on the east side of SR-168. Currently, there are no existing walls that shield these residences. One noise barrier (NB No. 5-1) was modeled along the State right-of-way to shield this receptor.
- **Receptor R-5.15:** This receptor location represents single-family residences on the east side of SR-168. Currently, there are no existing walls that shield these residences. One noise barrier (NB No. 5-2) was modeled along the State right-of-way to shield this receptor.

7.2. Preliminary Noise Abatement Analysis

7.2.1. Noise Barrier Modeling

In accordance with 23 CFR 772, noise abatement is considered where noise impacts are predicted in areas of frequent human use that would benefit from a lowered noise level. Potential noise abatement measures identified in the Protocol include the following:

- Avoiding the impact by using design alternatives, such as altering the horizontal and vertical alignments of the proposed project;
- Constructing noise barriers;
- Acquiring property to serve as buffer zones;
- Using traffic management measures to regulate types of vehicles and speeds; and
- Acoustically insulating public-use or nonprofit institutional structures.

All of these abatement options have been considered. However, because of the configuration and location of the five project sites, abatement in the form of a noise barrier is the only abatement that is considered feasible for the locations evaluated.

Table 7-1 show the number of barriers evaluated for each project site for feasibility based on achievable noise reduction. Project Site 3 did not have receptor locations that exceeded the NAC, therefore, noise barriers were not considered at this location. For each noise barrier found to be acoustically feasible, a reasonable cost allowance was calculated. Table B-1 in Appendix B shows the barrier modeling results. For any noise barrier to be considered reasonable from a cost perspective, the estimated cost of the noise barrier should be equal to or less than the total cost allowance calculated for the barrier. The cost calculations of the noise barrier should include all items appropriate and necessary for construction of the barrier, such as traffic control, drainage modification, and retaining walls.

Table 7-1. Noise Barrier Statistics

Project Site	Number of Noise Barriers
1	2
2	1
3	0
4	1
5	2

Source: LSA Associates, Inc. (August 2015).

The design of noise barriers presented in this report is preliminary and has been conducted at a level appropriate for environmental review and not for final design of the project. Preliminary information on the physical location, length, and height of the noise barriers is provided in this report. If pertinent parameters change substantially during the final project design, preliminary noise barrier designs may be modified or eliminated from the final project. A final decision on construction of the noise abatement will be made upon completion of the project design.

The following is a discussion of the noise abatement considered for each project site where traffic noise impacts are predicted.

7.2.2. NB No. 1-1

An 817 ft long barrier along the property line/State right-of-way on the west side of SR-41 south of Huntington Boulevard was analyzed to shield Receptors R-1.1 through R-1.3, R-1.7, R-1.8, R-1.12, R-1.22, R-1.23, and R-1.28 because traffic noise levels would exceed the 67 dBA L_{eq} NAC under Activity Categories B and C. Traffic modeling results in Table B-1 in Appendix B indicate that traffic noise levels would range between 68 and 76 dBA L_{eq}. NB No. 1-1 was evaluated from 6 to 16 ft at 2 ft increments. NB No. 1-1 is shown on Figure 7-1. Table 7-2 lists the barrier reductions, the number of benefited residences, the reasonable allowances per benefited residence, and the total reasonable allowance for each barrier height.

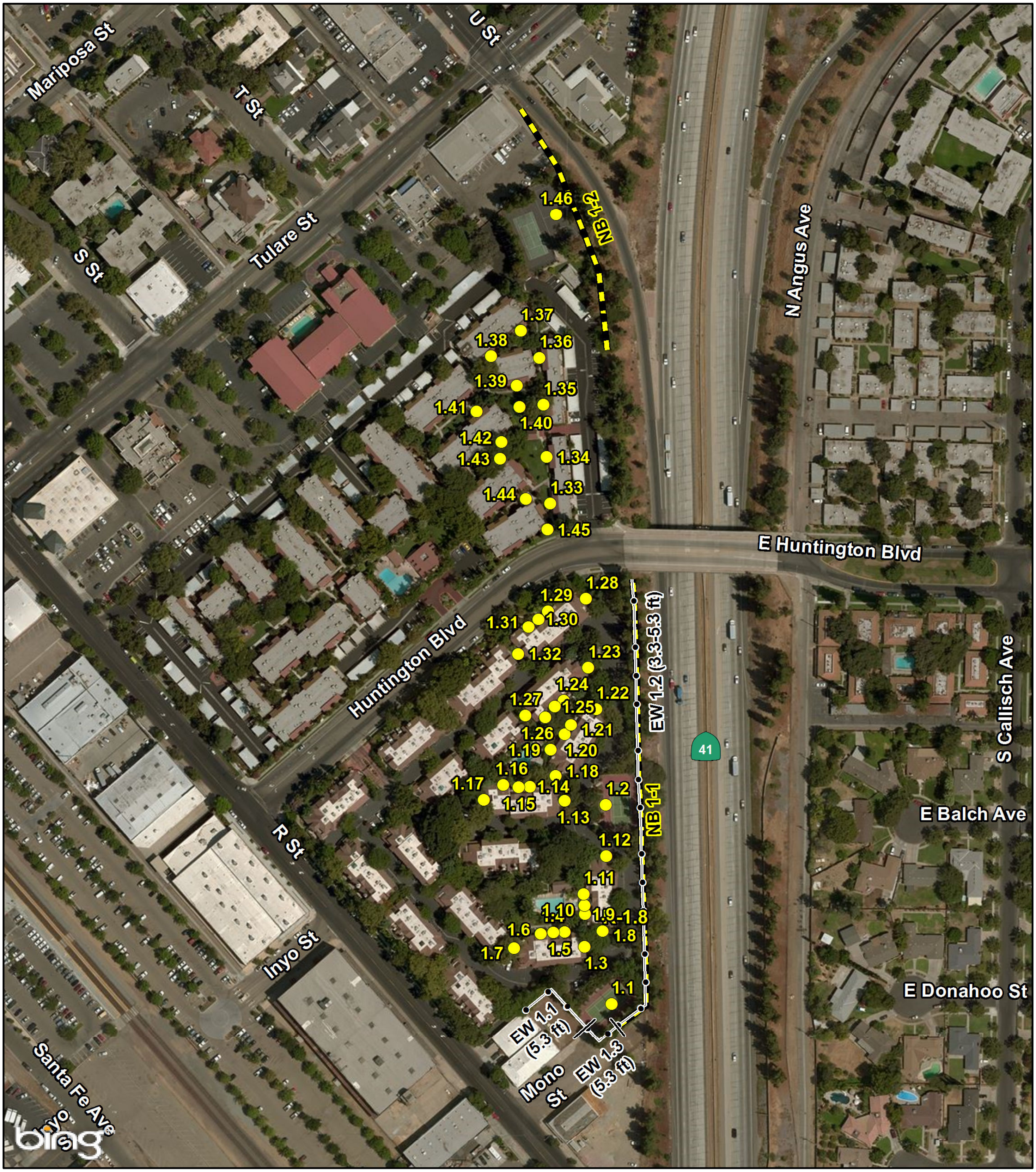
Table 7-2. Summary of Reasonableness for NB No. 1-1

Barrier I.D.: NB No. 1-1						
Future with Barrier	**6 ft Barrier**	**8 ft Barrier**	**10 ft Barrier**	**12 ft Barrier**	**14 ft Barrier**	**16 ft Barrier**
Highest Noise Barrier Reduction (dB)	2	4	6	7	8	9
Number of Benefited Residences	0	0	1	4	5	7
Reasonable Allowance per Benefited Residence[1]	N/A	N/A	$71,000	$71,000	$71,000	$71,000
Total Reasonable Allowance	**N/A**	**N/A**	**$71,000**	**$284,000**	**$355,000**	**$497,000**

Source: LSA Associates, Inc. (August 2015).

[1] The cost consideration in the reasonableness determination of noise abatement is based on a 2015 allowance per benefited unit/receptor of $71,000.

dB = decibels
ft = foot/feet
N/A = Not Applicable
NB = Noise Barrier



LEGEND

Modeled Receptor Location

Existing Wall

Modeled Noise Barrier

FIGURE 7-1

N

0 120 240

FEET

SOURCE: Bing (2013)

Retrofit Sound Wall Study
Noise Study Report

Project Site 1

Modeled Noise Barriers and Receptor Locations

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7.2.3. NB No. 1-2

A 460 ft long barrier along the property line/State right-of-way on the west side of SR-41 north of Huntington Boulevard was analyzed to shield Receptor R-1.46 because traffic noise levels would exceed the 67 dBA L_{eq} NAC under Activity Category C. Traffic modeling results in Table B-1 in Appendix B indicate that traffic noise levels would be 70 dBA L_{eq}. NB No. 1-2 was evaluated from 6 to 16 ft at 2 ft increments. NB No. 1-2 is shown on Figure 7-1. Table 7-3 lists the barrier reductions, the number of benefited residences, the reasonable allowances per benefited residence, and the total reasonable allowance for each barrier height.

Table 7-3. Summary of Reasonableness for NB No. 1-2

Barrier I.D.: NB No. 1-2						
Future with Barrier	**6 ft Barrier**	**8 ft Barrier**	**10 ft Barrier**	**12 ft Barrier**	**14 ft Barrier**	**16 ft Barrier**
Highest Noise Barrier Reduction (dB)	6	7	8	9	9	9
Number of Benefited Residences	1	1	1	1	1	1
Reasonable Allowance per Benefited Residence[1]	$71,000	$71,000	$71,000	$71,000	$71,000	$71,000
Total Reasonable Allowance	**$71,000**	**$71,000**	**$71,000**	**$71,000**	**$71,000**	**$71,000**

Source: LSA Associates, Inc. (August 2015).

[1] The cost consideration in the reasonableness determination of noise abatement is based on a 2015 allowance per benefited unit/receptor of $71,000.

dB = decibels
ft = foot/feet
NB = Noise Barrier

7.2.4. NB No. 2-1

A 2,056 ft long barrier along the State right-of-way on the east side of SR-41 was analyzed to shield Receptors R-2.1 through R-2.7 and R-2.12 through R-2.14 because traffic noise levels would exceed the 67 dBA L_{eq} NAC under Activity Category B. Traffic modeling results in Table B-1 in Appendix B indicate that traffic noise levels would range between 68 and 70 dBA L_{eq}. NB No. 2-1 was evaluated from 6 ft to 16 ft at 2 ft increments. NB No. 2-1 is shown on Figure 7-2. Table 7-4 lists the barrier reductions, the number of benefited residences, the reasonable allowances per benefited residence, and the total reasonable allowance for each barrier height.

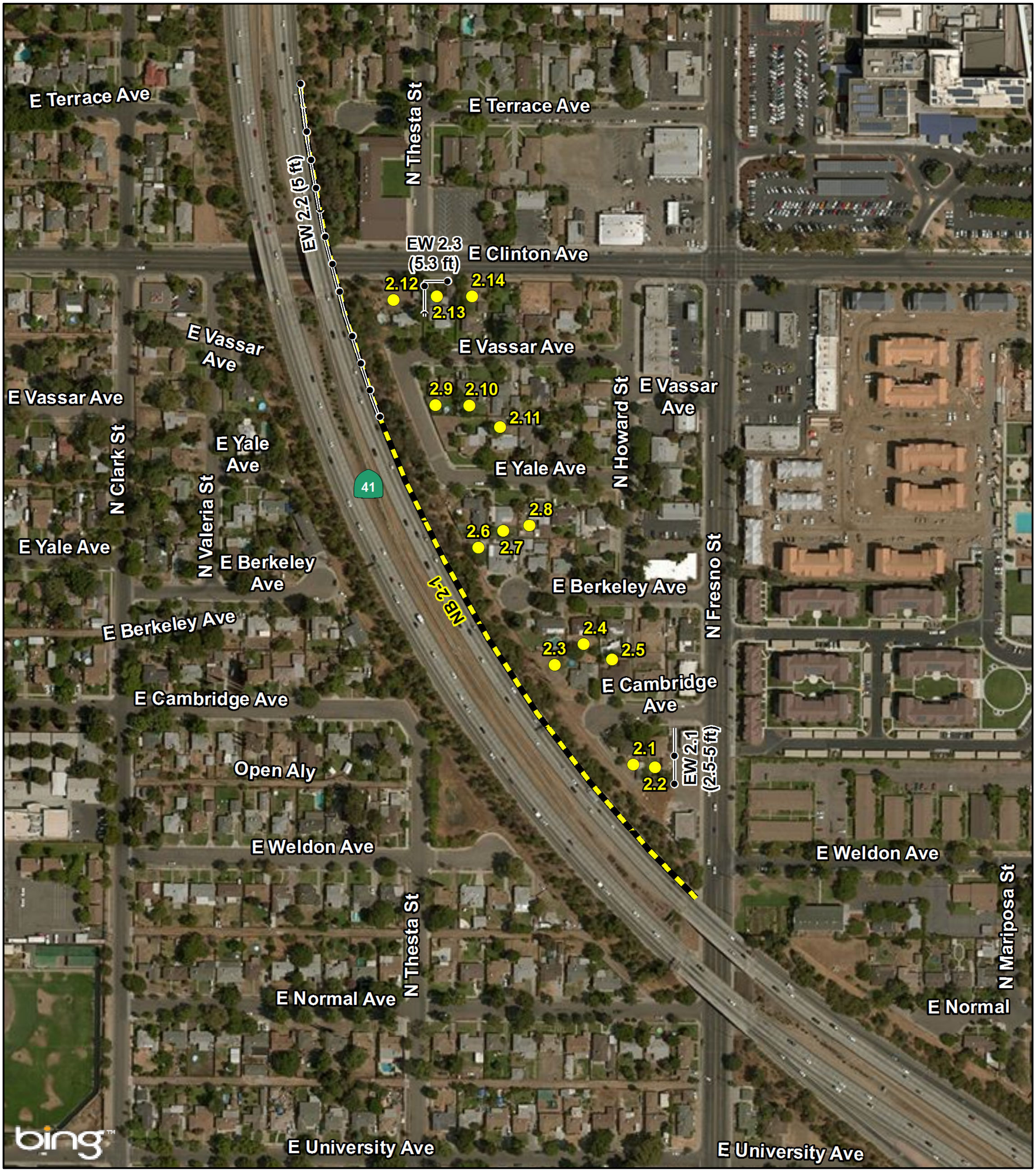
Table 7-4. Summary of Reasonableness for NB No. 2-1

Barrier I.D.: NB No. 2-1						
Future with Barrier	**6 ft Barrier**	**8 ft Barrier**	**10 ft Barrier**	**12 ft Barrier**	**14 ft Barrier**	**16 ft Barrier**
Highest Noise Barrier Reduction (dB)	4	4	6	7	8	9
Number of Benefited Residences	0	0	11	17	17	17
Reasonable Allowance per Benefited Residence[1]	N/A	N/A	$71,000	$71,000	$71,000	$71,000
Total Reasonable Allowance	**N/A**	**N/A**	**$781,000**	**$1,207,000**	**$1,207,000**	**$1,207,000**

Source: LSA Associates, Inc. (August 2015).

[1] The cost consideration in the reasonableness determination of noise abatement is based on a 2015 allowance per benefited unit/receptor of $71,000.

dB = decibels
ft = foot/feet
N/A = Not Applicable
NB = Noise Barrier



LEGEND

FIGURE 7-2

Modeled Receptor Location

Existing Wall

Modeled Noise Barrier

0 150 300
FEET

Retrofit Sound Wall Study
Noise Study Report

Project Site 2
Modeled Noise Barriers and Receptor Locations

SOURCE: Bing (2013)

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7.2.5. NB No. 4-1

A 1,412 ft long barrier along the State right-of-way on the east side of SR-168 was analyzed to shield Receptors R-4.8, 4.12, and 4.18 because traffic noise levels would exceed the 67 dBA L_{eq} NAC under Activity Category B. Traffic modeling results in Table B-1 in Appendix B indicate that traffic noise levels would range between 69 and 70 dBA L_{eq}. NB No. 4-1 was evaluated from 6 to 16 ft at 2 ft increments. NB No. 4-1 is shown on Figure 7-3. Table 7-5 lists the barrier reductions, the number of benefited residences, the reasonable allowances per benefited residence, and the total reasonable allowance for each barrier height.

Table 7-5. Summary of Reasonableness for NB No. 4-1

Barrier I.D.: NB No. 4-1						
Future with Barrier	**6 ft Barrier**	**8 ft Barrier**	**10 ft Barrier**	**12 ft Barrier**	**14 ft Barrier**	**16 ft Barrier**
Highest Noise Barrier Reduction (dB)	5	6	7	8	9	10
Number of Benefited Residences	1	2	3	4	10	11
Reasonable Allowance per Benefited Residence[1]	$71,000	$71,000	$71,000	$71,000	$71,000	$71,000
Total Reasonable Allowance	**$71,000**	**$142,000**	**$213,000**	**$284,000**	**$710,000**	**$781,000**

Source: LSA Associates, Inc. (August 2015).

[1] The cost consideration in the reasonableness determination of noise abatement is based on a 2015 allowance per benefited unit/receptor of $71,000.

dB = decibels

ft = foot/feet

NB = Noise Barrier

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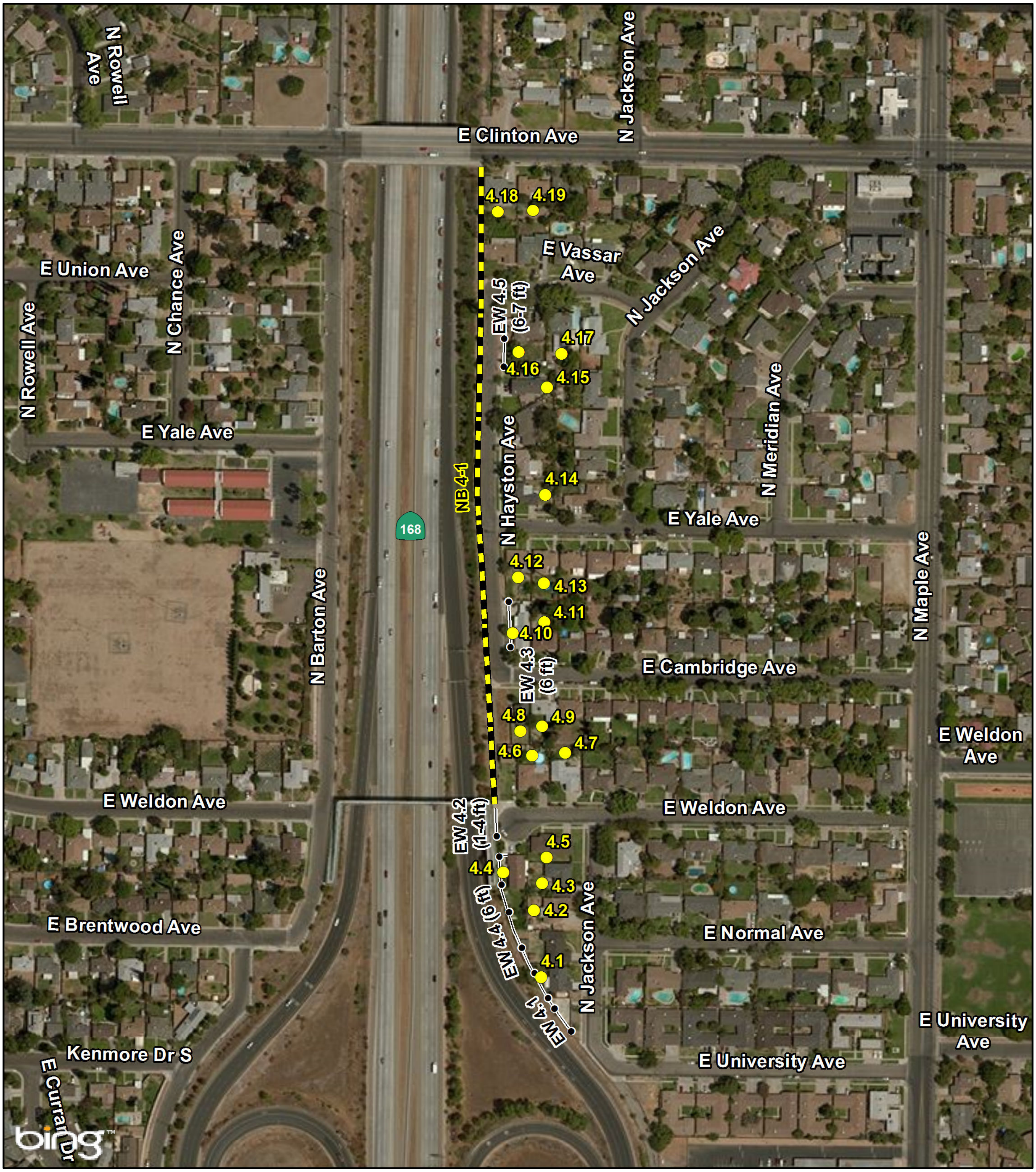

LEGEND

Modeled Receptor Location

Existing Wall

Modeled Noise Barrier

N

0 150 300
FEET

FIGURE 7-3

Retrofit Sound Wall Study
Noise Study Report
Project Site 4
Modeled Noise Barriers and Receptor Locations

SOURCE: Bing (2013)

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7.2.6. NB No. 5-1

A 686 ft long barrier along the State right-of-way on the east side of SR-168 was analyzed to shield Receptor R-5.7 because traffic noise levels would exceed the 67 dBA L_{eq} NAC under Activity Category B. Traffic modeling results in Table B-1 in Appendix B indicate that traffic noise levels would be 70 dBA L_{eq}. NB No. 5-1 was evaluated from 6 to 16 ft at 2 ft increments. NB No. 5-1 is shown on Figure 7-4. Table 7-6 lists the barrier reductions, the number of benefited residences, the reasonable allowances per benefited residence, and the total reasonable allowance for each barrier height.

Table 7-6. Summary of Reasonableness for NB No. 5-1

Barrier I.D.: NB No. 5-1						
Future with Barrier	**6 ft Barrier**	**8 ft Barrier**	**10 ft Barrier**	**12 ft Barrier**	**14 ft Barrier**	**16 ft Barrier**
Highest Noise Barrier Reduction (dB)	5	6	7	8	9	10
Number of Benefited Residences	2	2	2	2	2	2
Reasonable Allowance per Benefited Residence[1]	$71,000	$71,000	$71,000	$71,000	$71,000	$71,000
Total Reasonable Allowance	**$142,000**	**$142,000**	**$142,000**	**$142,000**	**$142,000**	**$142,000**

Source: LSA Associates, Inc. (August 2015).

[1] The cost consideration in the reasonableness determination of noise abatement is based on a 2015 allowance per benefited unit/receptor of $71,000.

dB = decibels

ft = foot/feet

NB = Noise Barrier

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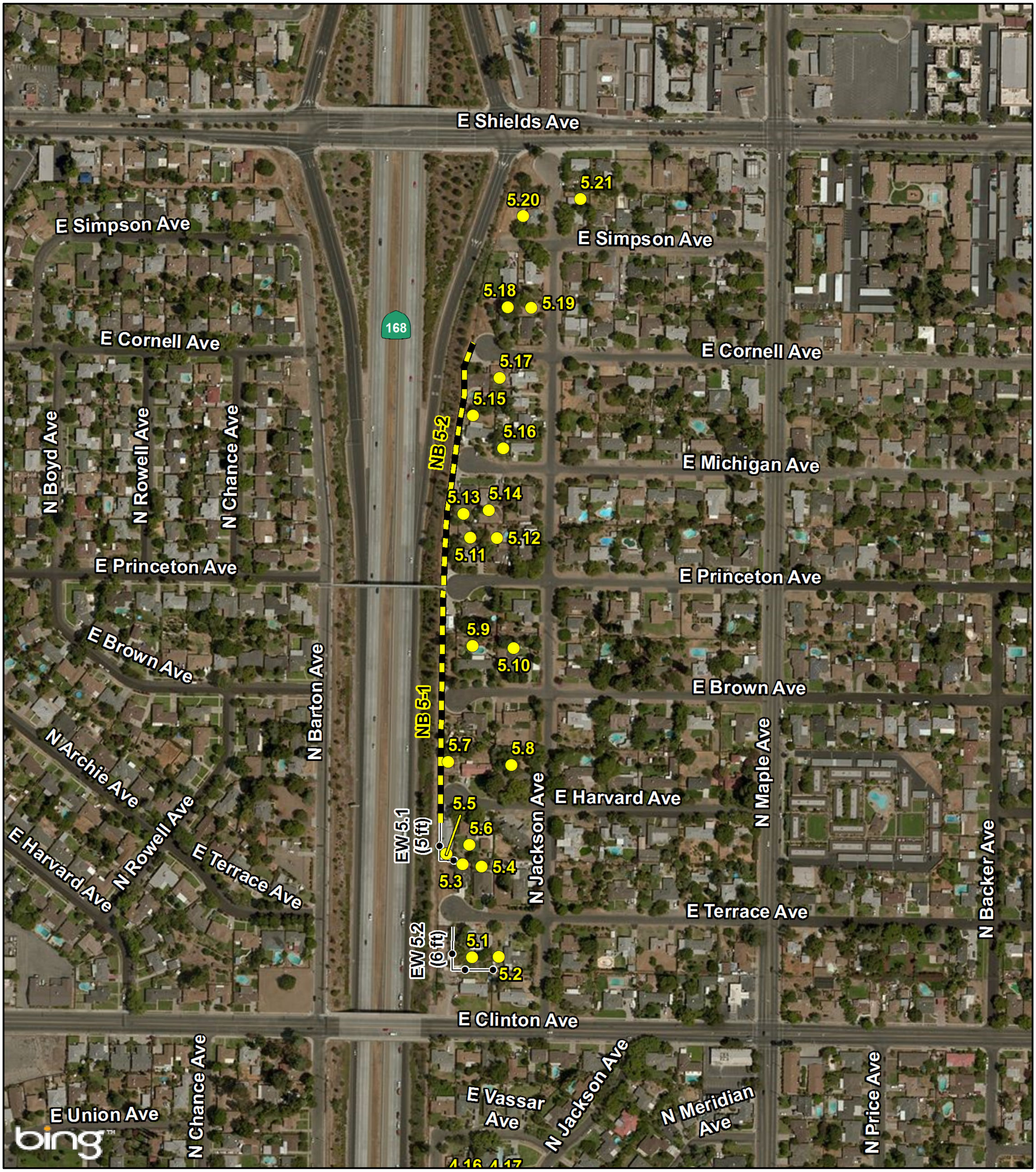

LEGEND

FIGURE 7-4

Modeled Receptor Location

Existing Wall

Modeled Noise Barrier

N

0 200 400

FEET

SOURCE: Bing (2013)

Retrofit Sound Wall Study
Noise Study Report

Project Site 5

Modeled Noise Barriers and Receptor Locations

I:\FCG1401\GIS\Fig7_5_ModNoiseBarriers_RecLoc.mxd (6/29/2015)

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7.2.7. NB No. 5-2

A 726 ft long barrier along the State right-of-way on the east side of SR-168 was analyzed to shield Receptor R-5.15 because traffic noise levels would exceed the 67 dBA L_{eq} NAC under Activity Category B. Traffic modeling results in Table B-1 in Appendix B indicate that traffic noise levels would be 68 dBA L_{eq}. NB No. 5-2 was evaluated from 6 to 16 ft at 2 ft increments. NB No. 5-2 is shown on Figure 7-4. Table 7-7 lists the barrier reductions, the number of benefited residences, the reasonable allowances per benefited residence, and the total reasonable allowance for each barrier height.

Table 7-7. Summary of Reasonableness for NB No. 5-2

Barrier I.D.: NB No. 5-2						
Future with Barrier	**6 ft Barrier**	**8 ft Barrier**	**10 ft Barrier**	**12 ft Barrier**	**14 ft Barrier**	**16 ft Barrier**
Highest Noise Barrier Reduction (dB)	6	7	8	9	10	11
Number of Benefited Residences	2	2	2	3	3	4
Reasonable Allowance per Benefited Residence[1]	$71,000	$71,000	$71,000	$71,000	$71,000	$71,000
Total Reasonable Allowance	**$142,000**	**$142,000**	**$142,000**	**$213,000**	**$213,000**	**$284,000**

Source: LSA Associates, Inc. (August 2015).
[1] The cost consideration in the reasonableness determination of noise abatement is based on a 2015 allowance per benefited unit/receptor of $71,000.
dB = decibels
ft = foot/feet
NB = Noise Barrier

7.2.8. Reasonableness

For any noise barrier to be considered reasonable from a cost perspective, the estimated construction cost of the noise barrier should be equal to or less than the total cost allowance calculated for the barrier. In addition, the barrier must achieve at least a noise level reduction of 7 dBA at one or more benefited receptors in order to be considered reasonable.

The total reasonable allowance was determined based on the number of benefited residences multiplied by the reasonable allowance per residence. The estimated noise barrier construction cost was calculated by the engineering firm Mark Thomas and Company. The preliminary construction costs were determined by reviewing similar recent project bid summaries, data from the latest Caltrans Contract Cost Data book, data from the California Highway Construction Cost Index, and the Caltrans Engineering Service Center site. The preliminary construction cost estimates were developed using the Caltrans standard 6-page cost estimate form and are included in Appendix D. If the estimated noise barrier construction cost exceeds the total reasonable allowance, the noise barrier is determined to be not reasonable. However, if the estimated noise barrier construction cost is within the total reasonable allowance, the noise barrier is determined to be reasonable.

Table 7-8 provides the reasonableness determination of the feasible noise barriers, as well as the preliminary cost estimates. The height, approximate length, noise attenuation range, number of benefited residences, reasonable allowance per residence, total reasonable allowance, and estimated construction cost for each feasible noise barrier are also shown. As shown in Table 7-8, at Site 1 the 16 foot high barrier NB No. 1-1, at Site 2 the 12 to 16 foot high barriers at NB No.2-1, and at Site 4 the 14 and 16 foot high barriers at NB No. 4-1are considered reasonable. All other feasible noise barriers were determined to be not reasonable because either the estimated construction cost exceeded the total reasonable allowance or the barrier would not achieve a noise level reduction of 7 dBA at one or more benefited receptors.

7.2.9. Conclusion

Based on the results of the preliminary noise barrier analysis, the barriers at Project Sites 1, 2, 4 and 5 would provide a noise reduction benefit. However, under Type 2 project standards, NB No. 1-1 with a height of 16 ft, NB No. 2-1 with heights of 12 ft, 14 ft, and 16 ft, and NB No. 4-1 with heights of 14 ft and 16 ft were determined to be reasonable because the estimated noise barrier construction cost is within the total reasonable allowance and the barrier would achieve a noise level reduction of 7 dBA at one or more benefited receptors. However, the remaining noise barriers were determined to be not reasonable because either the estimated noise barrier construction cost would exceed the total reasonable allowance or the barrier would not achieve a noise level reduction of 7 dBA at one or more benefited receptors.

For the reasonable noise barriers, a priority index was calculated based on the guidelines in Chapter 30 of the Caltrans Project Development Procedures Manual (PDPM). The formula to calculate the priority index is shown below, which considers the achievable reduction, measured noise levels above 67 dBA, number of living units, and the cost of the proposed noise barriers in thousands of dollars.

Priority Index (PI) = $(NL-67)^2$ x AR x LU / Cost

The following data are the variables necessary for calculating Priority Index:

Table 7-8: Noise Barrier Reasonableness

Site	NB No.	Height (feet)	Approximate Length (feet)	Noise Attenuation Range (dBA)	Number of Benefited Residences[1]	Reasonable Allowance per Residence	Total Reasonable Allowance	Estimated Noise Barrier Construction Cost[2]	Reasonable?
1	1-1	10	817	6	1	$71,000	$71,000	--[3]	No
		12	817	5-7	4	$71,000	$284,000	$370,000	No
		14	817	5-8	5	$71,000	$355,000	$405,000	No
		16	817	5-9	7	$71,000	$497,000	$445,000	Yes
	1-2	6	460	6	1	$71,000	$71,000	--[3]	No
		8	460	7	1	$71,000	$71,000	$130,000	No
		10	460	8	1	$71,000	$71,000	$150,000	No
		12	460	9	1	$71,000	$71,000	$175,000	No
		14	460	9	1	$71,000	$71,000	$195,000	No
		16	460	9	1	$71,000	$71,000	$215,000	No
2	2-1	10	2,056	5-6	11	$71,000	$781,000	--[3]	No
		12	2,056	5-7	17	$71,000	$1,207,000	$900,000	Yes
		14	2,056	5-8	17	$71,000	$1,207,000	$995,000	Yes
		16	2,056	6-9	17	$71,000	$1,207,000	$1,100,000	Yes
4	4-1	6	1,412	5	1	$71,000	$71,000	--[3]	No
		8	1,412	5-6	2	$71,000	$142,000	--[3]	No
		10	1,412	5-7	3	$71,000	$213,000	$445,000	No
		12	1,412	5-8	4	$71,000	$284,000	$510,000	No
		14	1,412	5-9	10	$71,000	$710,000	$575,000	Yes
		16	1,412	5-10	11	$71,000	$781,000	$640,000	Yes
5	5-1	6	686	5	2	$71,000	$142,000	--[3]	No
		8	686	6	2	$71,000	$142,000	--[3]	No
		10	686	7	2	$71,000	$142,000	$220,000	No
		12	686	8	2	$71,000	$142,000	$250,000	No
		14	686	9	2	$71,000	$142,000	$280,000	No
		16	686	5-10	2	$71,000	$142,000	$315,000	No
	5-2	6	726	6	2	$71,000	$142,000	--[3]	No
		8	726	7	2	$71,000	$142,000	$195,000	No
		10	726	8	2	$71,000	$142,000	$230,000	No
		12	726	5-9	3	$71,000	$213,000	$265,000	No
		14	726	6-10	3	$71,000	$213,000	$300,000	No
		16	726	5-11	4	$71,000	$284,000	$330,000	No

Source: LSA Associates, Inc. (August 2015).

1 Number of residences that are attenuated by 5 dBA or more by the modeled barrier.

2 Based on estimates provided by Mark Thomas and Compaany (See Appendix D)

3 Noise barrier height was determined to be not reasonable because the barrier would not achieve at least a noise level reduction of 7 dBA at one or more benefited receptors.

Caltrans = California Department of Transportation
dBA = A-weighted decibels
COG = Council of Governments
NB = Noise Barrier

- **Measured Noise Levels Above 67 dBA (NL)—**The average of the field-measured noise levels, dBA, L_{eq}(h) adjusted to future design hour noise level using computerized using computerized versions of the FHWA Highway Traffic Noise Prediction Model with California Vehicle Noise (CALVENO) reference energy mean emission levels.
- **Achievable Reduction (AR) —**The average reduction in noise levels that the proposed noise barrier will achieve. The 67 dBA, L_{eq}(h), is a goal for achievement, but is not mandatory. However, any noise barrier considered under this program must provide a minimum 5 dBA noise reduction.
- **Living Units (LU) —**The number of residential units immediately adjacent to the freeway (i.e., first line receivers) that will receive a minimum 5 dBA noise reduction with the proposed barrier.
- **Cost—**The noise barrier cost in $1,000s includes all items necessary for construction according to the Caltrans Traffic Noise Analysis Protocol and Chapter 30 of the Caltrans Project Development Procedures Manual.

Table 7-9 shows the values used for calculating the Priority Index and the Preliminary Priority Index value.

Table 7-9: Preliminary Priority Index

NB No.	Height (feet)	Noise Level (NL)	Achievable Reduction (AR) dBA	Living Units (LU)	Cost[1]	Priority Index (PI)
1-1	16	72	3	7	445	1.18
2-1	12	71	5	17	900	1.51
2-1	14	71	6	17	995	1.64
2-1	16	71	6	17	1,100	1.48
4-1	14	70	4	10	575	0.63
4-1	16	70	5	11	640	0.77

Source: LSA Associates, Inc. (November 2015).
[1] Noise barrier cost in $1,000s.

Chapter 8. Construction Noise

Two types of short-term noise impacts would occur during the construction of noise barriers. The first type would be from construction crew commutes and the transport of construction equipment and materials to the project site and would incrementally raise noise levels on access roads leading to the site. The pieces of heavy equipment for grading and construction activities will be moved on site, will remain for the duration of each construction phase, and will not add to the daily traffic volumes in the project vicinity. A high single-event noise exposure potential at a maximum level of 75 dBA L_{max} from trucks passing at 50 ft will exist. However, the projected construction traffic volume will be minimal when compared to existing traffic volumes on SR-41, SR-168, and other affected streets, and the associated long-term noise level change will not be perceptible. Therefore, short-term construction-related worker commutes and equipment transport noise impacts would be less than substantial.

The second type of short-term noise impact is related to noise generated during roadway construction. Construction is performed in discrete steps, each of which has its own mix of equipment and consequently its own noise characteristics. These various sequential phases would change the character of the noise generated and the noise levels within the project area 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 8-1 lists typical construction equipment noise levels (L_{max}) recommended for noise impact assessments, based on a distance of 50 ft between the equipment and a noise receptor.

Typical noise levels at 50 ft from an active construction area range up to 87 dBA L_{max} during the noisiest construction phases. The site preparation phase, which includes grading and paving, tends to generate the highest noise levels because the noisiest construction equipment is earthmoving equipment. Earthmoving equipment includes excavating machinery such as backfillers, bulldozers, 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.

Table 8-1. Typical Construction Equipment Noise Levels

Equipment Description	Spec 721.560[1] L_{max} at 50 ft	Actual Measured[2] L_{max} at 50 ft
Backhoes	80	78
Compactor (ground)	80	83
Cranes	85	81
Dozers	85	82
Dump Truck	84	76
Excavators	85	81
Flatbed Trucks	84	74
Front-End Loaders	80	79
Graders	85	N/A[3]
Jackhammer	85	89
Pickup Truck	55	75
Pneumatic Tools	85	85
Pumps	77	81
Rock Drill	85	81
Roller	85	80
Scrapers	85	84
Tractors	84	N/A
Vibratory Pile Driver	95	101

Source: FHWA Roadway Construction Noise Model (January 2006).
Note: Noise levels reported in this table are rounded to the nearest whole number.
1 Maximum noise levels were developed based on Spec 721.560 from the CA/T program to be consistent with the City of Boston's Noise Code for the "Big Dig" project.
2 The maximum noise level was developed based on the average noise level measured for each piece of equipment during the CA/T program in Boston, Massachusetts.
3 Since the maximum noise level based on the average noise level measured for this piece of equipment was not available, the maximum noise level developed based on Spec 721.560 was used.
CA/T = Central Artery/Tunnel
FHWA = Federal Highway Administration
ft = foot/feet
L_{max} = maximum instantaneous sound level
N/A = Not Applicable

Construction of the proposed project is expected to require the use of front-end loaders, bulldozers, and water trucks/pickup trucks. Noise associated with the use of construction equipment is estimated between 75 and 85 dBA L_{max} at a distance of 50 ft from the active construction area for the site preparation phase. As seen in Table 8-1, the maximum noise level generated by each front-end loader is assumed to be approximately 80 dBA L_{max} at 50 ft from the front-end loader in operation. Each bulldozer would generate approximately 85 dBA L_{max} at 50 ft. The maximum noise level generated by water trucks/pickup trucks is approximately 75 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. Each piece of construction equipment operates as an individual point source. The worst-case composite noise level at the nearest residence during this phase of construction would be 87 dBA L_{max} (at a distance of 50 ft from an active construction area).

The closest residences are located within 50 ft of noise barrier construction areas. Therefore, these closest residences may be subject to short-term noise reaching 87 dBA L_{max} or higher generated by construction activities within the project area. Compliance with the construction hours specified in the County of Fresno Ordinance, the City of Fresno Municipal Code, and Caltrans Standard Specifications in Section 14-8.02 will be required to minimize construction noise impacts on sensitive land uses adjacent to the project site. Construction noise is regulated by Caltrans Standard Specifications in Section 14-8.02. Noise control shall conform to the provisions in Section 14-8.02. The noise level from the Contractor's operations, between the hours of 9:00 p.m. and 6:00 a.m., shall not exceed 86 dBA at a distance of 50 ft. In addition, the Contractor shall equip all internal combustion engines with the manufacturer-recommended muffler and shall not operate any internal combustion engine on the job site without the appropriate muffler.

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Chapter 9. References

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