ITEM 9.C.

MOORPARK CITY COUNCIL
AGENDA REPORT

TO: **Honorable City Council**

FROM: **David A. Bobardt, Planning Director**
Prepared By: Joseph Fiss, Principal Planner

DATE: **May 2, 2008 (CC Meeting of 5/21/2008)**

SUBJECT: **Consider Noise Study for State Route 23 Freeway Soundwalls Adjacent to Tract 4975 (Toscana Neighborhood)**

BACKGROUND

On October 19, 2006, staff reported to the City Council on freeway noise in the residential areas of the Carlsberg Specific Plan (Serenata), and why soundwalls were not required to be constructed as part of the Carlsberg Specific Plan project or the SR-23 freeway widening project currently under construction. On February 7, 2007, the City Council authorized preparation of a noise study to identify the feasibility of the construction of freeway soundwalls adjacent to the homes on Crabapple Court at the eastern boundary of Tract 4975 (Toscana at Serenata neighborhood) within the Carlsberg Specific Plan Area, bordering the SR-23 freeway. The City contracted with Wieland Associates, Inc., a firm specializing in noise studies, to determine the potential effectiveness of a soundwall in this area.

DISCUSSION

Wieland recently completed their study regarding the effectiveness of a soundwall at the western edge of the freeway, within the Caltrans right-of-way. The purpose of the study was to evaluate the traffic noise levels at existing homes on Crabapple Court, in the City of Moorpark, for a retrofit sound wall on the west side of State Route 23. The noise-sensitive areas of concern at the residences are the exterior living spaces.

Wieland conducted noise measurements in this area, and with their computer noise model, assessed the need for a 14-foot high soundwall on the western edge of the freeway, within the Caltrans right-of-way as shown in Attachment 1. The top-of-slope adjacent to the freeway shoulder was determined to be the most efficient location for reducing freeway noise based on the surrounding topography. The edge of the right-of-way is not considered a good location for a soundwall because it is lower in elevation than both the freeway and the homes, and a soundwall works by interrupting the "line of sight" between the noise source and the receptor. A full analysis of a soundwall in this location is included in Attachment 2.

Although the City has no adopted standards for determining if a soundwall would be effectively reduce noise at a reasonable cost, Caltrans has standards for feasibility and reasonableness, used when State funding is considered for a soundwall project. The noise study evaluated the potential soundwall under the Caltrans criteria and determined that a soundwall as shown in Attachment 1 would effectively reduce freeway noise at a reasonable cost. It would reduce future peak hour noise by 5 to 8 dB at the impacted residences at a cost of about $299,000, according to Wieland's estimate. This estimate was confirmed by the Public Works Department to be close to actual bid prices for the soundwalls recently constructed on the SR-23. Although not determined necessary to meet City outdoor noise criteria, staff recommends that the soundwall be extended south of the Tierra Rejada off-ramp to provide additional noise buffering that would benefit all 18 homes on Crabapple Court in anticipation of future traffic increases on the SR-23 freeway, particularly by heavy trucks.

ENVIRONMENTAL DOCUMENTATION

Environmental documentation will be prepared once a soundwall is designed.

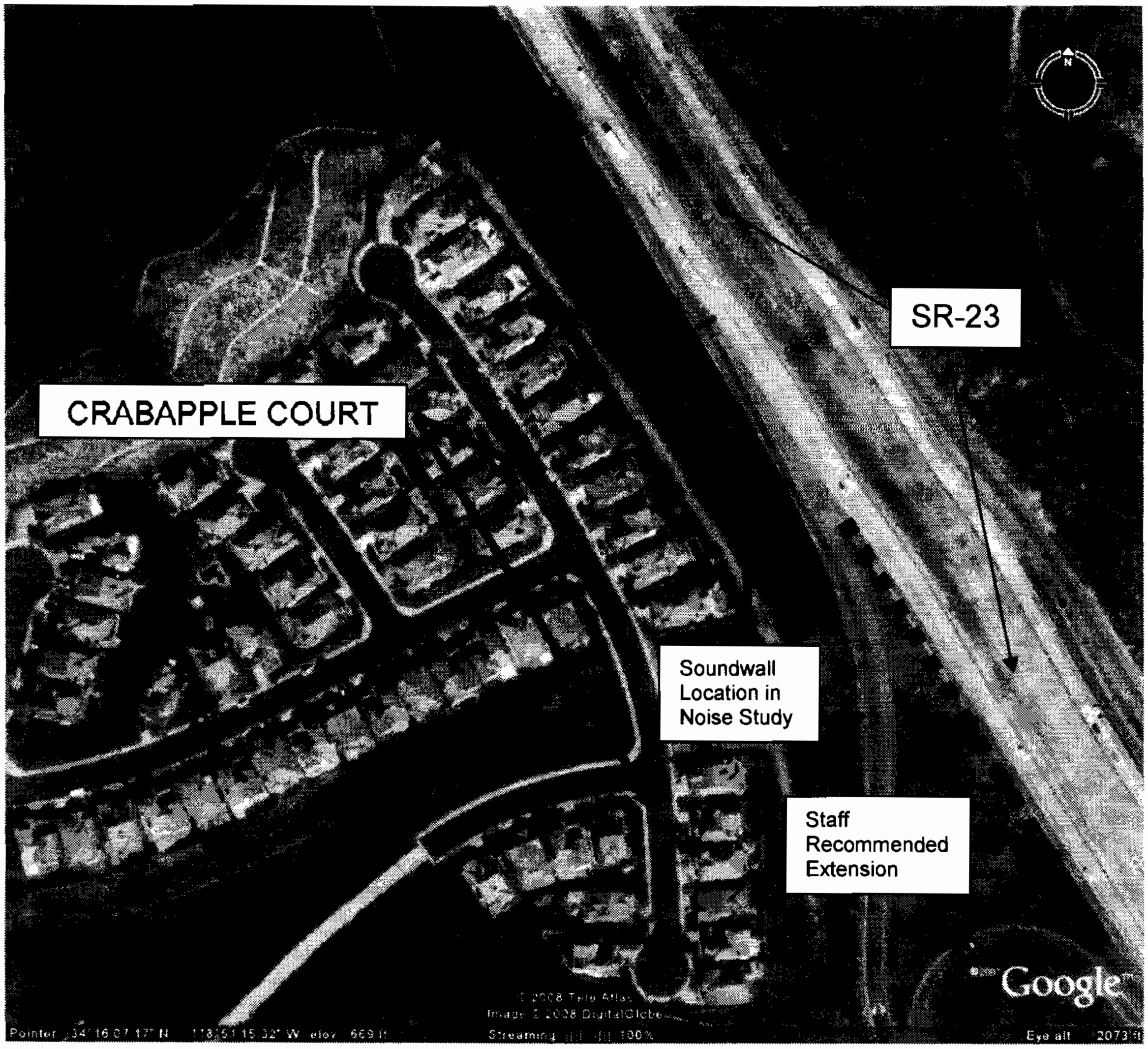
FISCAL IMPACT

Design, permitting, and construction costs are not known at this time. It is anticipated that these costs could be covered by existing money in the Carlsberg Mitigation Fund. Allocation of money to the soundwall project would return to the City Council for further consideration.

STAFF RECOMMENDATION

Direct staff to proceed with soundwall design and permitting.

Attachments:
1. Location of Potential Soundwall
2. Traffic Noise Impact Technical Report



Potential Soundwall Location "SW-1"
and
Staff-Recommended Extension

CC ATTACHMENT 1

STATE ROUTE 23 SOUTHBOUND,
NORTH OF TIERRA REJADA ROAD, MOORPARK

Caltrans Reference: N/A
Approximate Postmile Limits: 7-Ven-23 PM 10.0/10.4

TRAFFIC NOISE IMPACT TECHNICAL REPORT

Project File 07.030.00

March 26, 2008

Prepared for:

City of Moorpark
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Submitted to:

California Department of Transportation
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CC ATTACHMENT 2

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I. EXECUTIVE SUMMARY

The purpose of this study is to evaluate the traffic noise levels at existing residences (single family homes) on Crabapple Court, in the City of Moorpark, for a retrofit sound wall on the southbound side of State Route 23. It is noted that this study does not involve a Caltrans or Ventura County Transportation Commission (VCTC) project; rather the study was conducted for the City of Moorpark in response to residents' concerns about freeway traffic noise. The noise-sensitive areas of concern at the residences are the exterior living spaces. No sound walls currently exist at the site. However, the residences are buffered from the traffic noise by existing property line walls.

Two initial noise measurements were obtained within the study area in order to identify the peak noise hour. Subsequent noise measurements were obtained at four locations throughout the study area in order to document the existing noise environment; traffic data (traffic volumes, vehicle mix, and speeds) was gathered simultaneously with these measurements. Measured noise and traffic data was then used to calibrate a computer noise model of the study area. Eleven additional sites were selected for noise modeling. The results, summarized in Table I-1 on page 2, indicate that the peak noise hour level currently ranges from 57 to 66 dBA at the considered receivers.

Future traffic noise levels in the study area were predicted using the FHWA TNM model (version 2.5). Table I-1 on page 2 provides the results of our analysis at the fifteen receiver locations used in this study (four measured receivers plus eleven modeled receivers). Referring to the table, it is estimated that future peak noise hour levels in the study area will range from 59 to 68 dBA.

Based on the analysis, it is concluded that the FHWA and Caltrans noise abatement criteria will be approached or exceeded at six of the receivers considered in this study. Therefore, noise abatement has been considered at these locations.

An analysis was conducted to identify the necessary heights and locations of sound walls needed to comply with the FHWA criterion and the Caltrans noise barrier design guidelines. The results are summarized in Table I-2 on page 3. One sound wall, SW-1, was considered in the analysis. The calculations indicate that SW-1 is feasible. Table I-3 (page 4) identifies the height and length, the estimated cost, and the reasonable allowance for SW-1. Referring to the table, it is noted that SW-1 is considered both feasible and reasonable.

Table I-1. Estimated Future Peak Hour Traffic Noise Levels & Impacts

Receiver	Location or Address	Existing Worst Hour Noise Level	Future Worst-Case Noise Level	Noise Increase (+) or Decrease (-)	Noise Abatement Category and Criterion	Impact Type[1]
1	4348 Crabapple Court	65	67	+2	B (67)	A/E
2	3rd House from North End of Crabapple Court	65	67	+2	B (67)	A/E
3	5th House from North End of Crabapple Court	66	68	+2	B (67)	A/E
4	7th House from North End of Crabapple Court	65	67	+2	B (67)	A/E
5	4272 Crabapple Court	66	67	+1	B (67)	A/E
6	11th House from North End of Crabapple Court	64	66	+2	B (67)	A/E
7	12th House from North End of Crabapple Court	62	63	+1	B (67)	None
8	6th House from South End of Crabapple Court	63	65	+2	B (67)	None
9	5th House from South End of Crabapple Court	63	65	+2	B (67)	None
10	4th House from South End of Crabapple Court	62	64	+2	B (67)	None
11	3rd House from South End of Crabapple Court	62	64	+2	B (67)	None
12	4142 Crabapple Court	62	64	+2	B (67)	None
13	House at South End of Crabapple Court	61	63	+2	B (67)	None
14	4285 Crabapple Court (2nd Row)	57	59	+2	B (67)	None
15	4143 Crabapple Court (2nd Row)	60	62	+2	B (67)	None

Notes:

1. A/E = Approaches or Exceeds Noise Abatement Criteria

Table I-2. Predicted Noise Levels, Leq(h) and Insertion Loss (I.L., Noise Reduction), dBA for Sound Wall

Receiver	Without Wall	With Wall H = 1.8 m (6')		With Wall H = 2.4 m (8')		With Wall H = 3.0 m (10')		With Wall H = 3.7 m (12')		With Wall H = 4.3 m (14')	
		Leq(h)	I.L.	Leq(h)	I.L.	Leq(h)	I.L.	Leq(h)	I.L.	Leq(h)	I.L.
1	67	63	4	63	4	62	5	62*	5	61	6
2	67	64	3	63	4	63	4	62*	5	62	5
3	68	63	5	62	6	61	7	60*	8	59	9
4	67	64	3	63	4	62	5	61*	6	61	6
5	67	64	3	63	4	62	5	61*	6	61	6
6	66	63	3	62	4	61*	5	61	5	60	6
7	63	62	1	61	2	61*	2	60	3	60	3
8	65	64	1	64	1	64	1	64*	1	64	1
9	65	64	1	64	1	64	1	63*	2	63	2
10	64	63	1	63	1	63	1	63*	1	63	1
11[1]	64	63	1	63	1	63	1	63	1	63	1
12[1]	64	63	1	63	1	63	1	63	1	63	1
13[1]	63	63	0	63	0	63	0	63	0	63	0
14	59	57	2	57	2	56	3	56*	3	56	3
15[1]	62	60	2	60	2	59	3	59	3	59	3

Notes:

* Breaks line of sight between 3.5 m (11.5')-high exhaust stack and 1.5 m (5')-high receiver at impacted locations.

1. Receivers are further than 500 feet from the wall and are therefore not subject to the line of sight requirement.

Table I-3. Determination of Reasonableness of Recommended Sound Wall

Noise Barrier ID	Location	Recommended Wall Height	Approximate Linear Length of Recommended Sound Wall	Approximate Cost of Masonry Sound Wall at Recommended Height[1]	Approximate Cost of Recommended Sound Wall	Reasonable Allowance Per Noise Barrier	Recommended Sound Wall is Reasonable (Yes or No)
SW-1	See Figure II-3 (page 13)	4.3m (14')	259m (850')	$268.30 per sq. m. ($24.93 per sq. ft.)	$299,000	$418,000	YES

Notes:

1. Per Caltrans Traffic Noise Analysis Protocol [Reference 1] and the most recently published base allowance (2006) at: http://www.dot.ca.gov/hq/env/noise/index.htm

II. NOISE IMPACT TECHNICAL REPORT

The following sections will provide a description of the project, a brief description of traffic noise and its characteristics, a description of the applicable policies regarding traffic noise abatement, the methods and procedures used in this study, a description of the existing and future noise environment, impacts, and recommended abatement measures.

A. Introduction

The purpose of this study is to evaluate the traffic noise levels at existing residences (single family homes) on Crabapple Court, in the City of Moorpark, for a retrofit sound wall on the southbound side of State Route 23. Crabapple Court is located north of Tierra Rejada Road and to the west of the SR-23 freeway. (Refer to Figure II-1 on page 6 for the location of the study area.) It is noted that this study does not involve a Caltrans or Ventura County Transportation Commission (VCTC) project; rather the study was conducted for the City of Moorpark in response to residents' concerns about freeway traffic noise.

B. Project Description

The noise-sensitive areas of concern at the residences are the exterior living spaces. No sound walls currently exist at the site. However, the residences are buffered from the traffic noise by existing property line walls that range in height from approximately 5.5' to 9'. The study area includes 18 first row residences on the east side of Crabapple Court and 10 second row residences on the west side of Crabapple Court.

C. Fundamentals of Traffic Noise

The following sections briefly describe the fundamentals needed to understand traffic noise, its measurement, and the way it is perceived by the human ear.

Sound Characteristics

Sound may be thought of as mechanical energy of a vibrating object transmitted by pressure waves through a medium to the human ear. The medium of main concern is air. Noise, on the other hand, is defined as sound that is loud, unpleasant, unexpected or undesired.

In its most basic form, a continuous sound can be described by its frequency (pitch) and its amplitude (loudness). For a given single pitch of sound, the sound pressure waves are characterized by a sinusoidal periodic (recurring with regular intervals) wave. The number of times per second that the wave passes from a period of compression through a period of rarefaction and starts another period of compression is referred to as the frequency of the wave. Frequency is expressed in cycles per second, or Hertz (Hz). One Hertz equals one cycle per second. High frequencies are sometimes more conveniently expressed in units of kilohertz (kHz) or thousands of Hertz. The extreme range of

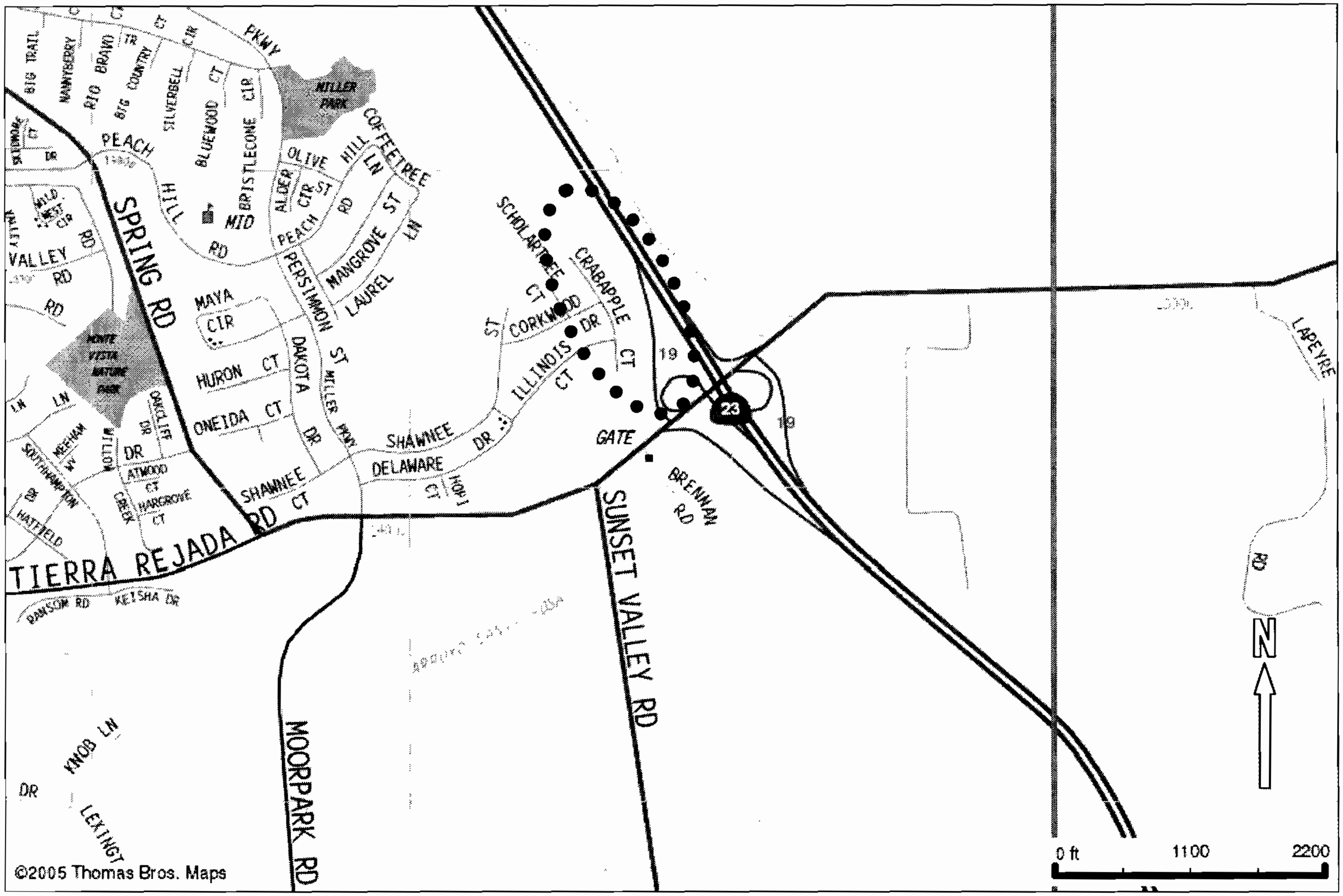

Figure II-1. Location of the Study Area

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frequencies that can be heard by the healthiest human ear spans from 16 to 20 Hz on the low end to about 20,000 Hz on the high end. Frequencies are heard as the pitch or tone of sound. High frequencies produce high-pitched sounds; low frequencies produce low-pitched sounds. Very-low-frequency airborne sound of sufficient amplitude may be felt before it can be heard, and is often confused with earthborne vibrations.

The pressures of sound waves continuously change with time or distance, and within certain ranges. The ranges of these pressure fluctuations are called the amplitude of the pressure waves. Whereas the frequency of the sound waves is responsible for the pitch or tone of a sound, the amplitude determines the loudness of the sound. Loudness of sound increases and decreases with the amplitude.

Decibels

Sound pressures can be measured in units called microPascals (μPa). However, expressing sound levels in terms of μPa would be very cumbersome since it would require a wide range of very large numbers. For this reason, sound pressure levels are described in logarithmic units of ratios of actual sound pressures to a reference pressure squared. These units are called bels. In order to provide a finer resolution, a bel is subdivided into 10 decibels, abbreviated dB.

Since decibels are logarithmic units, sound pressure levels cannot be added or subtracted by ordinary arithmetic means. For example, if one automobile produces a sound pressure level of 70 dB when it passes an observer, two cars passing simultaneously would not produce 140 dB. In fact, they would combine to produce 73 dB. This same principle can be applied to other traffic quantities as well. In other words, doubling the traffic volume on a street or the speed of the traffic will increase the traffic noise level by 3 dB. Conversely, halving the traffic volume or speed will reduce the traffic noise level by 3 dB.

A-Weighting

Sound pressure level alone is not a reliable indicator of loudness. The frequency or pitch of a sound also has a substantial effect on how humans will respond. While the intensity of the sound is a purely physical quantity, the loudness or human response depends on the characteristics of the human ear.

Human hearing is limited not only to the range of audible frequencies, but also in the way it perceives the sound pressure level in that range. In general, the healthy human ear is most sensitive to sounds between 1,000 Hz and 5,000 Hz, and perceives both higher and lower frequency sounds of the same magnitude with less intensity. In order to approximate the frequency response of the human ear, a series of sound pressure level adjustments is usually applied to the sound measured by a sound level meter. The adjustments, or weighting network, are frequency dependent.

The A-scale approximates the frequency response of the average young ear when listening to most ordinary everyday sounds. When people make relative judgments of the loudness or annoyance of a sound, their judgments correlate well with the A-scale sound levels of those sounds. A-weighted sound levels are abbreviated as dBA. A range of noise levels associated with common in- and outdoor activities are shown in Figure II-2.

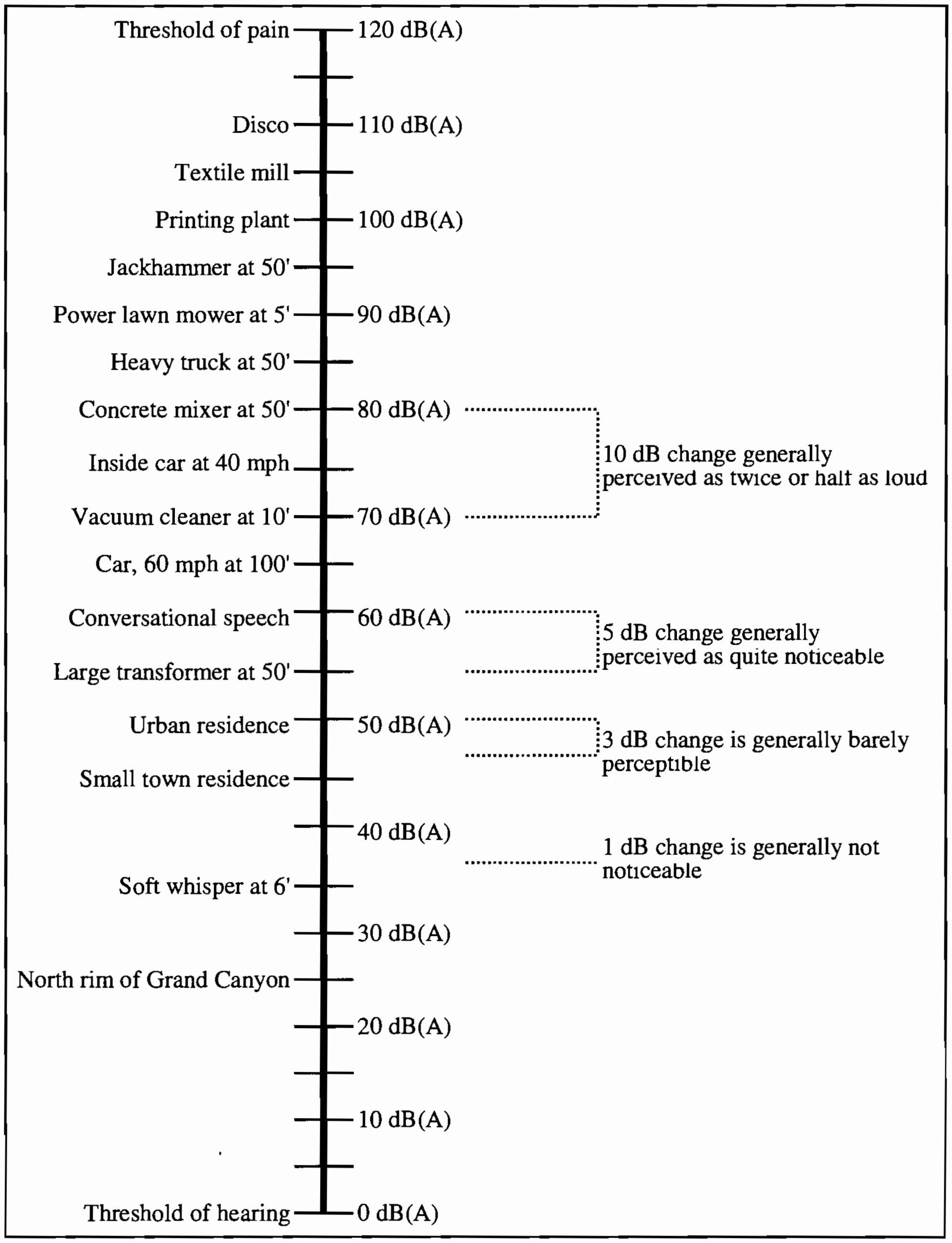

Figure II-2. Common Noise Sources and A-Weighted Noise Levels

Sound Propagation

From the source to the receiver, noise changes both in level and frequency spectrum. The most obvious is the decrease in noise as the distance from the source increases. The manner in which noise reduces with distance depends on the following important factors:

- Geometric spreading from point and line sources
- Ground absorption
- Atmospheric effects and refraction
- Shielding by natural and manmade features, noise barriers, diffraction, and reflection

Geometric Spreading. Sound from a small localized source (approximating a "point" source) radiates uniformly outward as it travels away from the source in a spherical pattern. The sound level attenuates or drops-off at a rate of 6 dBA for each doubling of the distance. This decrease is referred to as the inverse square law. However, highway traffic noise is not a single, stationary point source of sound. The movement of the vehicle makes the source of the sound appear to emanate from a line (line source) rather than a point when viewed over some time interval. This results in cylindrical spreading rather than the spherical spreading of a point source, and a drop-off rate of 3 dBA for each doubling of distance.

Ground Absorption. Most often, the noise path between the highway and the observer is very close to the ground. Noise attenuation from ground absorption and reflective wave canceling adds to the attenuation due to geometric spreading. Traditionally, the excess attenuation has also been expressed in terms of attenuation per doubling of distance. TNM allows for the input of various different ground types including pavement, water, hard soil, loose soil, lawn, field grass, granular snow and powder snow.

Atmospheric Effects. Research has shown that atmospheric conditions can have a profound effect on noise levels within 60m (200') from a highway. Wind has been shown to be the single most important meteorological factor within approximately 150m (500'), while vertical air temperature gradients are more important over longer distances. Other factors such as air temperature and humidity, and turbulence, also have significant effects. As discussed in Section E, below, the effect of atmospheric conditions on the modeling/analysis process is minimized by taking noise measurements during appropriate atmospheric conditions.

Shielding. A large object in the path between a noise source and a receiver can significantly attenuate noise levels at that receiver. The amount of attenuation provided by this "shielding" depends on the size of the object, and frequencies of the noise levels. Natural terrain features, such as hills and dense woods, as well as manmade features, such as buildings and walls can significantly alter noise levels. Walls are often specifically used to reduce noise.

Effects of Noise

People react to sound in a variety of ways. Human tolerance to noise depends on a variety of acoustical characteristics of the source, as well as environmental characteristics. These factors are briefly discussed below:

1. The level, variability in level (dynamic range), frequency spectrums and time patterns of noise. Exposures to very high noise levels can damage hearing. A high level is more objectionable than a low-level noise, and intermittent truck peak noise levels are more objectionable than the continuous level of fan noise. Humans have better hearing sensitivities in the high frequency region than in the low. This is reflected in the A-scale, which de-emphasizes the low frequency sounds. Studies indicate that the annoyance or disturbance correlates with the A-scale.
2. The amount of background noise present before the intruding noise. People tend to compare an intruding noise with the existing background noise. If the new noise is readily identifiable or considerably louder than the background or ambient, it usually becomes objectionable.
3. The nature of the work or living activity that is exposed to the noise source. Highway traffic noise might not be disturbing to workers in a factory or office, but the same noise might be annoying or objectionable to people sleeping at home or studying in a library. An automobile horn at 2:00 a.m. is more disturbing than the same noise in traffic at 5:00 p.m.

Under controlled conditions in an acoustics laboratory, the trained healthy human ear is able to discern changes in sound levels of 1 dBA when exposed to steady, single frequency ("pure tone") signals in the mid-frequency range. Outside of such controlled conditions, the trained ear can detect changes of 2 dBA in normal environmental noise. It is widely accepted that the average healthy ear, however, can barely perceive noise level changes of 3 dBA. A change of 5 dBA is readily perceptible.

As discussed earlier with regard to A-weighting, the human response curve of frequencies in the audible range is not linear, i.e., humans do not hear all frequencies equally well. The human perception of loudness is also not linear. Two noise sources do not sound twice as loud as one noise source. However, based on numerous studies, it is generally accepted that a change of 10 dBA in noise level is perceived as being twice or half as loud.

Noise Descriptors

Traffic noise can vary significantly over time. To describe the fluctuating noise both Caltrans and FHWA use the energy equivalent sound level, abbreviated Leq. This is a single number representation of the fluctuating sound level in dBA over a specified time period. For Caltrans noise studies, this time period is the single noisiest hour of the day.

D. *Federal & State Policies and Procedures*

FHWA Noise Abatement Criteria

The Federal-Aid Highway Program Manual, Volume 7, Chapter 7, Section 3 (FHPM 7.7.3) establishes the following noise abatement criteria (NAC) for different activity categories:

Activity Category	NAC, 1-Hour Leq	Description of Activities
A	57 dBA	Exterior of lands on which serenity and quiet are of extraordinary significance and serve an important public need.
B	67 dBA	Exterior of picnic areas, recreation areas, playgrounds, active sports areas, parks, residences, motels, hotels, schools, churches, libraries and hospitals.
C	72 dBA	Exterior of developed lands, properties, or activities not included in Categories A or B above.
D	N/A	Undeveloped lands.
E	52 dBA	Interior of residences, motels, hotels, public meeting rooms, schools, churches, libraries, hospitals and auditoriums

Leq is the equivalent, or average, sound level during the noisiest 1-hour period of the day.

A significant traffic noise impact is assessed when the predicted noise levels approach or exceed the NAC identified in the above table. As defined in Caltrans' *Traffic Noise Analysis Protocol* [Reference 1], a noise level approaches the NAC if it is within 1 dBA of the NAC. The interior NAC of Category E applies where no exterior activity area is identified; or where the interior, but not the exterior, activities would be affected by the traffic noise.

Caltrans Noise Barrier Guidelines

Caltrans' noise barrier design policy includes the following guidelines:

- Noise barriers should provide at least 5 dB of noise reduction at an impacted receiver.
- Noise barriers may not exceed 4.9m (14') in height when located 15' or less from the edge of the traveled way, and should not exceed 16' in height when located more than 15' from the traveled way.
- Noise barriers should block the line-of-sight from a 1.5m (5') -high receiver to a 3.5m (11½') -high truck exhaust stack in the nearest travel lane.
- Mitigation must be considered when traffic noise impacts for the design year approach or exceed the noise abatement criteria for the existing land use ("approach" is defined as within 1 dBA of the noise abatement criteria).
- Mitigation must be considered when the traffic noise impacts for the design year represent a substantial increase over the existing noise levels. A "substantial increase" is defined as 12 dBA or more.

E. *Study Methods and Procedures*

In order to determine the existing peak noise hour and to document the existing noise environment, measurements were obtained in August 2007 and February 2008 at a total of six locations throughout the study area. Refer to Figure II-3 on page 13 for these locations. The noise measurements were also used to calibrate a 3-dimensional computer noise model for the SR-23 freeway utilizing the FHWA TNM (Version 2.5) software.

The ambient noise level measurements were obtained by positioning the sound level meter on the property at a height of 5' above the ground. The instrument was calibrated prior to obtaining the measurement. Noise measurements were not taken when:

- The pavement in the area was not generally dry;
- Winds were greater than 12 miles per hour;
- Non-typical noise such as from aircraft flyovers, construction, sirens, unusual pedestrian activity, and parked idling vehicles occurred; and
- Relative humidity exceeded 90 percent.

The instrumentation used to obtain the noise measurements consisted of integrating sound level meters (Models 712, 820, 824 and 870), and acoustic calibrators (Models CAL200 and CAL250) manufactured by Larson Davis Laboratories. The sound level meters were calibrated before each measurement. The accuracy of the calibrators is maintained through a program established by the manufacturer, and is traceable to the National Bureau of Standards. All instrumentation meets the requirements of the American National Standards Institute (ANSI) S1.4-1971.

The highway traffic noise prediction model used to model noise levels was FHWA TNM (Version 2.5). TNM predicts noise levels based on traffic volumes, speeds, traffic mix, site conditions, and distance from the roadway to the receiver. TNM relies on 3-dimensional input data to model the study area. The northing, easting, and elevation of the data points used to describe the layout and profile of the freeway, ramps, existing barriers, topography and the noise-sensitive receivers in the traffic noise model were obtained from the referenced freeway CAD (.dxf) files, provided by Caltrans, and residential site and grading plans provided by the City of Moorpark. Additional wall and building height data was obtained with field measurements.

Two long-term ambient noise measurements were initially obtained at locations LT1 and LT2 in August 2007 for a continuous 24-hour period to determine the peak noise hour. The peak noise hour was determined to occur between 6 a.m. and 7 a.m. In February 2008, two noise measurements were obtained during the entire 7 a.m. to 8 a.m. hour at Receivers 1 and 5, and two were obtained for twenty minutes within that hour at Receivers 14 and 15. Traffic counts and speed measurements were conducted simultaneously with the noise measurements. (The measurements and traffic data were not obtained during the peak hour since sunrise was after 6 a.m. on the day of the measurements. The 7 a.m. to 8 a.m. hour was the closest hour to the peak noise hour during which light conditions were favorable.) The traffic counts were obtained by videotaping traffic on the freeway and southbound

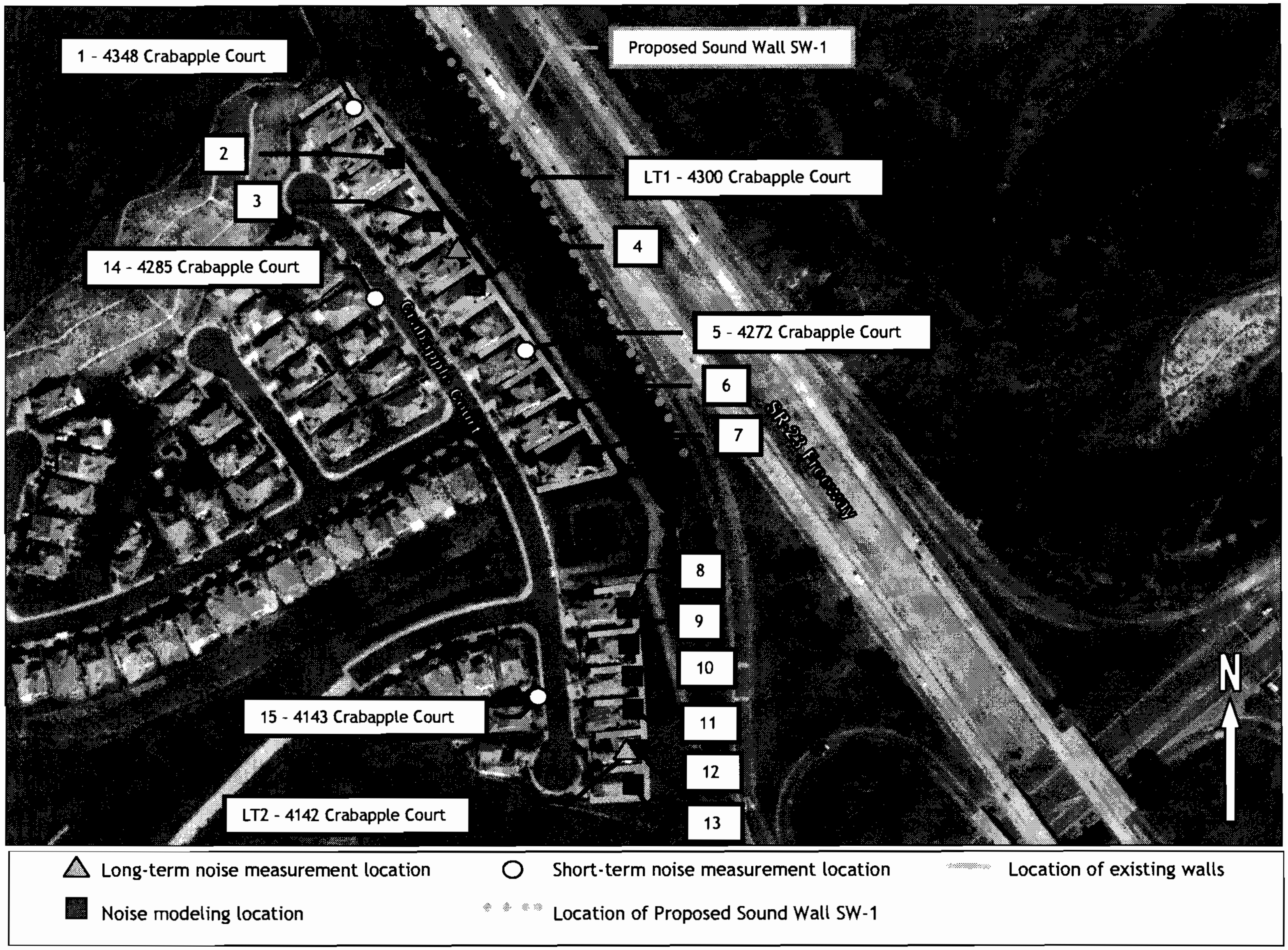

Figure II-3. Noise Measurement & Modeling Locations, Existing Walls & Proposed Sound Wall off-ramp at Tierra Rejada Road, and then reviewing the tape to identify the number and type of vehicles in each lane. Vehicles were classified as autos, medium trucks and heavy trucks. Traffic speed data was gathered by measuring the time taken for vehicles to pass between two points a known distance apart. The noise measurements were then used, along with the traffic data, to calibrate the TNM model. Refer to Appendix A for a complete listing of the measurement data and the equipment used in the study. The traffic count and speed data is provided in Appendix B. The results of the calibration analysis are provided in Appendix C.

Eleven additional locations were selected for modeling in order to adequately cover the study area.

F. *Existing Noise Environment*

The primary noise source affecting the homes within the study area is traffic on SR-23 and the southbound off-ramp at Tierra Rejada Road. Existing block walls at the rear of the properties on the east side of Crabapple Court, which range in height from approximately 5.5' to 9', provide some noise reduction at the homes under consideration in this study.

The homes in the study area are located below the freeway elevation. The ground slopes down from the west edge of the freeway before rising again to the elevation of the property-line walls at the homes such that a slight gully is formed between the homes and the freeway. It is noted that the right-of-way line is generally located within this gully and, therefore, is generally lower than both the freeway and the homes on Crabapple Court.

As indicated in the previous section, calibration measurements were obtained between 7 a.m. and 8 a.m., while the peak noise hour occurred between 6 a.m. and 7 a.m. Using long-term noise measurements obtained during the study, it was possible to determine the difference in average noise levels between the peak noise hour and the 7 a.m. to 8 a.m. hour. The peak noise hour levels were estimated by applying this difference to the measured and modeled receivers in the calibration analysis. Refer to Appendix C for the estimated peak noise hour calculations. The measurement and modeling positions are presented graphically in Figure II-3 (page 13), and are described in further detail in Table II-1 (page 15). The table also identifies the estimated existing peak noise hour Leq at each location.

Table II-1. Existing Peak Hour Traffic Noise Levels & Impacts

Receiver	Location or Address	Type of Development	Number of Units Represented	Noise Abatement Category and Criterion	Existing Peak Noise Hour Level	Noise Level Measured or Modeled?	Impact Type
1	4348 Crabapple Court	Single Family Home	1	B (67)	65	Measured	None
2	3rd House from North End of Crabapple Court	Single Family Home	2	B (67)	65	Modeled	None
3	5th House from North End of Crabapple Court	Single Family Home	2	B (67)	66	Modeled	A/E
4	7th House from North End of Crabapple Court	Single Family Home	2	B (67)	65	Modeled	None
5	4272 Crabapple Court	Single Family Home	2	B (67)	66	Measured	A/E
6	11th House from North End of Crabapple Court	Single Family Home	2	B (67)	64	Modeled	None
7	12th House from North End of Crabapple Court	Single Family Home	1	B (67)	62	Modeled	None
8	6th House from South End of Crabapple Court	Single Family Home	1	B (67)	63	Modeled	None
9	5th House from South End of Crabapple Court	Single Family Home	1	B (67)	63	Modeled	None
10	4th House from South End of Crabapple Court	Single Family Home	1	B (67)	62	Modeled	None
11	3rd House from South End of Crabapple Court	Single Family Home	1	B (67)	62	Modeled	None
12	4142 Crabapple Court	Single Family Home	1	B (67)	62	Modeled	None
13	House at South End of Crabapple Court	Single Family Home	1	B (67)	61	Modeled	None
14	4285 Crabapple Court (2nd Row)	Single Family Home	7	B (67)	57	Measured	None
15	4143 Crabapple Court (2nd Row)	Single Family Home	3	B (67)	60	Measured	None

Notes:

1. A/E = Approaches or Exceeds Noise Abatement Criteria

G. *Future Noise Environment, Impacts, and Considered Mitigation*

The calibrated TNM model was used, along with the future traffic parameters identified in Table II-2, to identify the future worst-case noise levels in the study area. Table II-3 (page 17) provides the future traffic noise levels at each of the receiver locations. (Refer to Appendix D for the calculations.)

Table II-2. Future Traffic Parameters for TNM Model

Parameter	SR-23	
	Travel Lanes	Off-Ramp
Vehicles per hour per lane (vphpl)[1]	1,950	1,200
Truck mix[2] North of Tierra Rejada Rd. South of Tierra Rejada Rd.	 94.75%, 3.90%, 1.35% 94.34%, 4.55%, 1.11%	 94.75%, 3.90%, 1.35%
Traffic Speed[1]	65 mph	Varies - 35 mph to 65 mph

Notes:

1. Provided by staff at Caltrans District 7.
2. Based on most recent published truck mix (2006) obtained from Caltrans' website at: http://www.dot.ca.gov/hq/traffops/saferesr/trafdata/

As indicated in Table II-3 (page 17), it is estimated that the future noise level will be 59 to 68 dBA at the noise-sensitive locations within the study area. At six receiver positions, (1 through 6), the worst case noise level approaches or exceeds the FHWA criterion of 67 dBA for Category B land uses. At the remaining receiver positions the noise levels are below the FHWA criterion.

Table II-3. Estimated Future Peak Hour Traffic Noise Levels & Impacts

Receiver	Location or Address	Existing Worst Hour Noise Level	Future Worst-Case Noise Level	Noise Increase (+) or Decrease (-)	Noise Abatement Category and Criterion	Impact Type[1]
1	4348 Crabapple Court	65	67	+2	B (67)	A/E
2	3rd House from North End of Crabapple Court	65	67	+2	B (67)	A/E
3	5th House from North End of Crabapple Court	66	68	+2	B (67)	A/E
4	7th House from North End of Crabapple Court	65	67	+2	B (67)	A/E
5	4272 Crabapple Court	66	67	+1	B (67)	A/E
6	11th House from North End of Crabapple Court	64	66	+2	B (67)	A/E
7	12th House from North End of Crabapple Court	62	63	+1	B (67)	None
8	6th House from South End of Crabapple Court	63	65	+2	B (67)	None
9	5th House from South End of Crabapple Court	63	65	+2	B (67)	None
10	4th House from South End of Crabapple Court	62	64	+2	B (67)	None
11	3rd House from South End of Crabapple Court	62	64	+2	B (67)	None
12	4142 Crabapple Court	62	64	+2	B (67)	None
13	House at South End of Crabapple Court	61	63	+2	B (67)	None
14	4285 Crabapple Court (2nd Row)	57	59	+2	B (67)	None
15	4143 Crabapple Court (2nd Row)	60	62	+2	B (67)	None

Notes:

1. A/E = Approaches or Exceeds Noise Abatement Criteria

H. Impacts and Considered Abatement

Assessment of Impact

Referring to Table II-3 on page 17, it may be concluded that the future noise levels in the study area approach or exceed the FHWA noise abatement criterion of 67 dBA for Category B land uses at Receivers 1 through 6.

Abatement Measures

As discussed in Section F, the impacted receivers are below the elevation of the freeway. Therefore, the most acoustically efficient location for a sound wall is at the top-of-slope adjacent to the freeway shoulder. The right-of-way line is not considered a good location for a sound wall because, as mentioned in Section F, this line is typically below the elevations of both the freeway and the homes. For these reasons only the edge-of-shoulder location has been considered for a possible sound wall.

Proposed sound wall heights, locations and anticipated noise reduction at each receiver location are shown in Table II-4 (page 19), and in Figure II-3 (page 13). Refer to Appendix E for the sound wall analysis. The proposed barrier represents the height required to provide: a) a minimum attenuation of 5 dBA at the impacted receivers; and, b) the maximum noise reduction achievable (within the *reasonableness* guidelines, see below).

All sound walls recommended in this study must be *feasible* and *reasonable*. *Feasibility* is an engineering consideration, which states that the recommended sound walls must achieve a minimum noise reduction of 5 dBA at the impacted receivers. *Reasonableness*, on the other hand, is a more subjective consideration. Using procedures developed by Caltrans [Reference 1], a sound wall will be considered reasonable in this study if it costs less than the reasonable allowance per *benefited residence* identified in Table II-5 (page 19). (A *benefited residence* is defined as a dwelling unit that is expected to receive a noise reduction of at least 5 dBA from the sound wall.)

One new sound wall, SW-1, has been considered in this study. This sound wall is located close to the top of the slope at the edge of shoulder of the southbound lanes and runs from adjacent to the northernmost house on Crabapple Court to the twelfth house from the north end. If constructed at the maximum permitted height of 4.3m (14') at the edge of shoulder, the sound wall will reduce the future peak noise hour level by 5 to 8 dB at impacted Receivers 1 through 6. Therefore, the wall is considered to be a feasible abatement measure at these locations. Referring to Table II-5 on page 19, and Tables II-6 and II-7 on page 20, this wall will benefit 11 homes at a cost of about $299,000. Since this is less than the reasonable allowance of $418,000, the sound wall is also considered reasonable.

Table II-4. Predicted Noise Levels, Leq(h) and Insertion Loss (I.L., Noise Reduction), dBA for Sound Wall

Receiver	Without Wall	With Wall H = 1.8 m (6')		With Wall H = 2.4 m (8')		With Wall H = 3.0 m (10')		With Wall H = 3.7 m (12')		With Wall H = 4.3 m (14')	
		Leq(h)	I.L.	Leq(h)	I.L.	Leq(h)	I.L.	Leq(h)	I.L.	Leq(h)	I.L.
1	67	63	4	63	4	62	5	62*	5	61	6
2	67	64	3	63	4	63	4	62*	5	62	5
3	68	63	5	62	6	61	7	60*	8	59	9
4	67	64	3	63	4	62	5	61*	6	61	6
5	67	64	3	63	4	62	5	61*	6	61	6
6	66	63	3	62	4	61*	5	61	5	60	6
7	63	62	1	61	2	61*	2	60	3	60	3
8	65	64	1	64	1	64	1	64*	1	64	1
9	65	64	1	64	1	64	1	63*	2	63	2
10	64	63	1	63	1	63	1	63*	1	63	1
11[1]	64	63	1	63	1	63	1	63	1	63	1
12[1]	64	63	1	63	1	63	1	63	1	63	1
13[1]	63	63	0	63	0	63	0	63	0	63	0
14	59	57	2	57	2	56	3	56*	3	56	3
15[1]	62	60	2	60	2	59	3	59	3	59	3

Notes:

* Breaks line of sight between 3.5 m (11.5')-high exhaust stack and 1.5 m (5')-high receiver at impacted locations.

1. Receivers are further than 500 feet from the wall and are therefore not subject to the line-of-sight requirement.

Table II-5. Data for Reasonableness Determination, SW-1

SOUND WALL ID: SW-1					
PREDICTED, W/O SOUND WALL					
Predicted Noise Level, Leq(h), dBA[1]	68				
Change re. No-build, dBA[1]	0				
PREDICTED, WITH SOUND WALL	H=1.8 m (6')	H=2.4 m (8')	H=3.0 m (10')	H=3.7 m (12')	H=4.3m (14')
Insertion Loss (Noise Reduction), dBA[1]	5	6	7	8	9
Benefited Receptors	2	2	9	11	11
New Highway, or More Than 50% of Receptors Predate 1978? (Yes or No)	NO	NO	NO	NO	NO
Reasonable Allowance Per Benefited Receptor[2]	$34,000	$36,000	$36,000	$36,000	$38,000

Notes:

1. At critical receiver (#3).
2. Reasonable allowance obtained from Caltrans Traffic Noise Analysis Protocol [Reference 1].

Table II-6. Calculation of Reasonable Allowance Per Receptor

Noise Barrier ID	*Reasonable Allowance Per Benefited Receptor*	*No. of Benefited Receptors*	*Reasonable Allowance Per Noise Barrier*	*Fraction of Total Reasonable Allowance*	*Reduction of Reasonable Allowance Per Noise Barrier*	*Reduction of Reasonable Allowance Per Benefited Receptor*	*Modified Reasonable Allowance Per Benefited Receptor*
SW-1	$38,000	11	$418,000	N/A	N/A	N/A	N/A
Total Reasonable Allowance for Abatement			$418,000				
Estimated Project Cost x 0.5			N/A				
Result			N/A				

Table II-7. Determination of Reasonableness of Recommended Sound Wall

Noise Barrier ID	Location	Recommended Wall Height	Approximate Linear Length of Recommended Sound Wall	Approximate Cost of Masonry Sound Wall at Recommended Height[1]	Approximate Cost of Recommended Sound Wall	Reasonable Allowance Per Noise Barrier	Recommended Sound Wall is Reasonable (Yes or No)
SW-1	See Figure II-3 (page 13)	4.3m (14')	259m (850')	$268.30 per sq. m. ($24.93 per sq. ft.)	$299,000	$418,000	YES

Notes:

1. Per Caltrans Traffic Noise Analysis Protocol [Reference 1] and the most recently published base allowance (2006) at: http://www.dot.ca.gov/hq/env/noise/index.htm

I. Construction Noise

Construction noise represents a short-term impact to ambient noise levels. Receivers that would be affected by traffic noise would be adversely affected by construction noise as well. Typical construction equipment and the related noise levels are shown in Table II-8 (page 22). It is noted that construction activities would be limited to the construction of the recommended sound wall.

The following mitigation measure should be used to minimize adverse construction noise:

The control of noise from construction activities shall conform to Section 5-1, "Sound Control Requirements", in the Standard Special Provisions. Sound control shall conform to the provisions in Section 7-1.011, "Sound Control Requirement", of the Standard Specifications and these special provisions:

"The noise level from the Contractor's operations, between the hours of 9:00 pm and 6:00 am shall not exceed 86 dBA at a distance of 15 meters (50 feet). This requirement in no way relieves the Contractor from responsibility for complying with local ordinances regulating noise level.

"Said noise level requirement shall apply to all equipment on the job or related to the job, including but not limited to trucks, transit mixers or transient equipment that may or may not be owned by the Contractor. The use of loud sound signals shall be avoided in favor of light warnings except those required by safety laws for the protection of personnel.

Full compensation for conforming to the requirements of this Section shall be considered as included in the prices paid for the various contract items of work involved and no additional compensation will be allowed therefor."

Table II-8. Typical Construction Equipment Noise With and Without Mitigation

Equipment	Mitigation	Unmitigated Noise Level, dBA	Mitigated Noise Level, dBA	Distance (ft.)
Pile Driver	Sound barrier and muffler on exhaust	103	95	25
Pavement Breaker	Muffler	105	100	3
Diesel Driven Electric Welder	Mufflers and enclosure	93	76	23
Diesel Driven Air Compressor	Muffler	105	85	3
Air Tracked Drill	Acoustical enclosure	104	83	23
Chain Saw				
Gasoline	None	113	113	3
Electric	None	86	86	3
Sinker Drill	Acoustical enclosure	95	78	3
Earth Movers				
Front Loader	Muffler	79	75	50
Backhoe	Muffler	85	57	50
Dozer	Muffler	80	57	50
Grader	Muffler	91	57	50
Truck	Muffler	91	57	50
Paver	Muffler	89	80	50
Material Handlers				
Concrete Mixer	Muffler	85	75	50
Crane	Muffler	83	75	50
Jack Hammer	Muffler or acoustical enclosure	88	75	50

Source: Urban Mass Transportation Administration, 1974; U.S. EPA, 1971.

J. References

1. *Traffic Noise Analysis Protocol for New Highway Construction, Reconstruction, and Retrofit Barrier Projects.* California Department of Transportation (Caltrans), Division of Environmental Analysis. August 14, 2006.
2. *Technical Noise Supplement.* Caltrans. October 1998.
3. *Highway Design Manual* – Chapter 1100 Highway Traffic Noise Abatement. Caltrans. September 1, 2006.
4. *Grading and Site Plans for Crabapple Court. Drawing No. 00-ML-10616.* Ramseyer and Associates. July 1998. Supplied by the City of Moorpark.
5. *Grading and Site Plans for Crabapple Court. Drawing No. 02-ML-10684.* VTN West, Inc. July 2002. Supplied by the City of Moorpark.
6. *Grading and Site Plans for Crabapple Court. Drawing No. 02-ML-10665.* VTN West, Inc. April 2002. Supplied by the City of Moorpark.

7. "711545ea031.dxf", "711545ea032.dxf", "711545ea033.dxf", "711545ea034.dxf", "711545ea035.dxf", "711545ea036.dxf", "711545ea037.dxf". 3-D CAD files of existing freeway layout and topography. Provided by Caltrans. July 5 and July 10, 2007.

APPENDIX A

Noise Measurements

Notes:

The data provided in this Appendix was used in the calibration/existing peak noise hour analysis of Appendix C.

Instrumentation

The following instrumentation was used to obtain the noise measurements:

- Larson Davis Model 820 Sound Level Meter, S/N 1632
- Larson Davis Model 870 Sound Level Meter, S/N 0157
- Larson Davis Model 712 Sound Level Meter, S/N 0555
- Larson Davis Model 712 Sound Level Meter, S/N 0556
- Larson Davis Model 824 Sound Level Meter, S/N 3536
- Larson Davis Model CAL200 Acoustical Calibrator, S/N 2916
- Larson Davis Model CAL250 Acoustical Calibrator, S/N 2966
- Sony CCD-TRV58 Hi8 camcorder

APPENDIX B

Traffic Data

Note:

The data provided in this Appendix was used in the calibration/existing peak noise hour analysis of Appendix C.

Table B-1. Traffic Counts for Receivers 1, 5, and 12.

Date: 7 February 2008

Time: 7:00 a.m. - 8:00 a.m.

Duration: 1 Hour

Lane(s)	Vehicle Type	Number of Vehicles	
		Counted During 1 Hour	**Estimated in 1 Hour**
Northbound Outside Lane	Auto	543	543
	Medium Truck	32	32
	Heavy Truck	57	57
Northbound Middle Lane	Auto	1005	1005
	Medium Truck	20	20
	Heavy Truck	6	6
Northbound Inside Lane	Auto	1014	1014
	Medium Truck	0	0
	Heavy Truck	0	0
Southbound Inside Lane	Auto	1480	1480
	Medium Truck	14	14
	Heavy Truck	2	2
Southbound Middle Lane	Auto	599	599
	Medium Truck	34	34
	Heavy Truck	65	65
Southbound Outside Lane / Southbound Off-Ramp	Auto	701	701
	Medium Truck	17	17
	Heavy Truck	8	8

Table B-2. Traffic Counts for Receiver 14

Date: 7 February 2008
Time: 7:30 a.m. - 7:55 a.m.
Duration: 25 Minutes

Lane(s)	Vehicle Type	Number of Vehicles	
		Counted During 25 Minutes	Estimated in 1 Hour
Northbound Outside Lane	Auto	231	554
	Medium Truck	13	31
	Heavy Truck	35	84
Northbound Middle Lane	Auto	424	1016
	Medium Truck	9	22
	Heavy Truck	3	7
Northbound Inside Lane	Auto	434	1040
	Medium Truck	0	0
	Heavy Truck	0	0
Southbound Inside Lane	Auto	529	1268
	Medium Truck	5	12
	Heavy Truck	1	2
Southbound Middle Lane	Auto	246	590
	Medium Truck	16	38
	Heavy Truck	22	53
Southbound Outside Lane / Southbound Off-Ramp	Auto	284	681
	Medium Truck	8	19
	Heavy Truck	4	10

Table B-3. Traffic Counts for Receiver 15

Date: 7 February 2008
Time: 7:01 a.m. - 7:22 a.m.
Duration: 21 Minutes

Lane(s)	Vehicle Type	Number of Vehicles	
		Counted During 21 Minutes	Estimated in 1 Hour
Northbound Outside Lane	Auto	209	603
	Medium Truck	9	26
	Heavy Truck	10	239
Northbound Middle Lane	Auto	370	1067
	Medium Truck	3	9
	Heavy Truck	2	6
Northbound Inside Lane	Auto	345	995
	Medium Truck	0	0
	Heavy Truck	0	0
Southbound Inside Lane	Auto	625	1803
	Medium Truck	5	14
	Heavy Truck	1	3
Southbound Middle Lane	Auto	230	663
	Medium Truck	8	23
	Heavy Truck	31	89
Southbound Outside Lane / Southbound Off-Ramp	Auto	268	773
	Medium Truck	6	17
	Heavy Truck	2	6

Table B-4. Traffic Speeds for Calibration of TNM Model

Date: 7 February 2008
Time: 7:00 a.m. - 8:00 a.m.

Lane (from W to E)	Southbound				Northbound		
	1 (Off-Ramp)	1 (Before Off-Ramp)	2	3	4	5	6
Speed (mph)	42.6	61.8	72.8	67.4	81.2	69.1	68.4
	66.1	58.5	61.8	73.6	71.1	66.6	57.0
	60.7	62.2	74.0	57.5	73.2	62.9	63.9
	56.1	67.5	59.3	60.2	69.8	73.7	67.1
	64.6	73.8	60.4	57.0	74.2	67.0	68.9
	55.7	66.7	66.7	55.6	74.6	71.3	61.3
	57.3	57.9	56.6	71.5	75.6	65.5	58.2
	61.6	67.5	65.8	62.5	75.1	63.9	67.6
	53.5		70.7	57.1	70.6	51.0	52.2
	62.5		52.9	45.7	72.4	67.0	62.7
	62.1		61.9	67.9	76.5	71.8	51.4
	46.2			57.8	71.1	70.9	66.7
	62.5						
Average Speed (mph)	**57.8**	**64.5**	**63.9**	**61.2**	**73.8**	**66.7**	**62.1**

APPENDIX C

Calibration of TNM to Existing Conditions & Calculation of Existing Peak Noise Hour Levels

Notes:

The calibration results and K-factors for all measurement locations are summarized as follows:

Receiver	Measured Noise Level, dBA	Predicted Noise Level from Uncalibrated TNM, dBA	Delta Between Values, dBA	K-Factor[1]
1	63.2	63.9	-0.7	0
2	Modeling location. K-factor assumed to be the same as for Receiver 1			0
3	Modeling location. K-factor assumed to be the same as for Receiver 1			0
4	Modeling location. K-factor assumed to be the same as for Receiver 5			1.7
5	64.9	63.2	1.7	1.7
6	Modeling location. K-factor assumed to be the same as for Receiver 5			1.7
7	Modeling location. K-factor assumed to be the same as for Receiver 5			1.7
8	Modeling location. K-factor assumed to be the same as for Receiver 12			0
9	Modeling location. K-factor assumed to be the same as for Receiver 12			0
10	Modeling location. K-factor assumed to be the same as for Receiver 12			0
11	Modeling location. K-factor assumed to be the same as for Receiver 12			0
12[2]	*61.1*	*60.8*	*0.3*	*0*
13	Modeling location. K-factor assumed to be the same as for Receiver 12			0
14	56.6	57.7	-1.1	-1.1
15	59.1	58.1	1.0	1.0

Notes:

1. Per Caltrans Technical Noise Supplement [Reference 3], Section N-5460, no calibration has been used when calculated and measured noise levels agree within 1 dBA.
2. A noise measurement was attempted at Receiver 12 (4142 Crabapple Court) on February 7, 2008. However, reliable data was not obtained due to extraneous noise from a nearby fountain. Therefore, this measurement was excluded from the study and could not be used to calibrate the TNM model. Instead, the data gathered during the corresponding hour of the day (7 a.m. to 8 a.m.) from the August 2007 measurements was used to verify the accuracy of the model at the south end of the study area.

It is noted that that the K-factors in the above table are for the calibration hour (7 a.m. to 8 a.m.). In order to estimate the peak noise hour levels (6 a.m. to 7 a.m.) an additional 0.7 dB has been added at each receiver to account for the difference in levels between the two hours. This additional adjustment represents the average difference in noise levels between the 6 a.m. to 7 a.m. and 7 a.m. to 8 a.m. periods at Receivers 1 and 5.

APPENDIX D

Calculation of Future Peak Noise Hour Levels

Notes:

The geometric data and calibration factors (K-factors) used in the future peak noise model are the same as those used the calibration model. As this data is provided in full in Appendix C, it is not repeated here. However, the TNM traffic data was changed for the future peak noise hour case and has, therefore, been included in this appendix.

APPENDIX E

Sound Wall Analysis

Notes:

The following geometric data used in the sound wall analysis is the same as that used the calibration model: roadways, receivers, terrain lines and ground zones. As this geometric data is provided in full in Appendix C, it is not repeated here. However, the addition of the sound wall to the model altered the barrier geometry data; therefore, the updated barrier geometry data has been included in this appendix.

The TNM traffic data used in the sound wall analysis is the same as for the future peak noise hour case. As this traffic data is provided in full in Appendix C, it is not repeated here.

APPENDIX F

Geometric Data for Sound Wall SW-1

Coordinates			
X (Easting) m	*Y (Northing)* m	*Z_0 (Base of Wall Elevation)* m	*Z_1 (Top of Wall Elevation)* m
1,921,310.0	585,789.6	219.5	223.8
1,921,343.8	585,735.7	218.1	222.3
1,921,356.3	585,715.0	217.2	221.5
1,921,382.4	585,666.6	215.7	220.0
1,921,403.7	585,626.9	214.2	218.5
1,921,424.1	585,589.0	212.1	216.4
Data is provided in metric units to correspond with the metric coordinate system used in the referenced DXF plans.			