David Lord, PhD dl@45dB.com
Sarah Taubitz, MSME st@45dB.com

California | Colorado
www.45dB.com

45dB Acoustics
CONSULTANTS IN SOUND AND VIBRATION

July 2, 2018
Project 18033

Acoustical Analysis of:	Requested by:	Client:
Santa Barbara Polo Villas **3250-3282 Via Real** **Carpinteria, CA 93013**	Suzanne Elledge Planning and Permitting Services 1625 State Street Santa Barbara, CA 93101 Laurel Fisher Perez, AICP	3250-3282 Via Real, LLC Attn.: Niel Botts 123 E. Carrillo St. Santa Barbara, CA 93101

1 Executive Summary

45dB Acoustics, LLC has conducted an acoustical analysis of the proposed 40-unit residential complex. The analysis predicts the potential impact of noise from nearby major transportation noise sources — Via Real, Highway 101 and the UPRR railroad. SoundPLAN® was used to model noise levels for the Project, using published traffic counts.

- Noise levels at the exterior of three southwestern-most Project dwellings reach CNEL = 76 dBA without any noise barriers. The twelve existing apartments in this location, which are currently subjected to these noise levels, are to be demolished and replaced with the proposed Project. The Project's proposed 8-to-10-foot high noise wall is anticipated to reduce exterior noise levels by 2-5 dB for residents of the southern buildings of the Project (C10-15, C9-5, and V12, V13 and V14) and brings all outdoor activity areas into compliance. The future potential 12-foot high Caltrans noise wall along Highway 101 provides a further benefit of approximately 5dB reduction in levels at the southern buildings of the Project.
- It is recommended, and assumed, that both these noise walls will be built. Additional noise mitigation measures in the buildings would be required in the event that the CalTrans wall is not constructed in a timely manner.
- With both noise walls in place, an STC of approximately 50 for the walls—and 33 for the windows—facing the noise source will ensure indoor spaces meet the indoor sound level criteria of 45dBA for all habitable spaces, with a 6-point margin for as-built conditions.

for 45dB Acoustics, LLC

Sarah Taubitz, Member INCE-USA
(805) 250-1566 ext. 2

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David Lord, PhD dl@45dB.com
Sarah Taubitz, MSME st@45dB.com

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2 Introduction

This sound level assessment determines potential noise impacts associated with the proposed building project. The following topics are presented in this report in response to County of Santa Barbara requirements for projects identified by the Noise Element of the County's General Plan.

- The topographical relationship of potential transportation sources and the nearby potential sensitive receptors
- Identification of noise sources and their characteristics, including predicted noise spectra and sound levels at the exterior of the proposed dwelling, considering present and future land usage and terrain
- Basis for the sound level prediction (i.e., acoustically modeled from published data), noise attenuation measures to be applied, and an analysis of the noise propagation considering the physical layout of built environment
- Analysis of the noise insulation effectiveness of the proposed construction showing that the prescribed interior noise level requirements are met.
- Information on fundamentals of noise and vibration to aid in interpreting the report

The location of the proposed Project is at 3250 – 3282 Via Real, in the Carpinteria area of Santa Barbara County, immediately west of the Santa Barbara Polo & Racquet Club (Figure 1). U.S. Highway 101 divided roadway lies immediately to the south of Via Real, and the Union Pacific Railroad (UPRR) tracks lie beyond the highway (Figure 2). Traffic noise from UPRR, Highway 101 and Via Real are all considered in this study. The terrain generally slopes to the south in this location.

Figure 1: Plan view of vicinity with future project overlaid

Figure 2: Proximity of Project boundary to noise sources

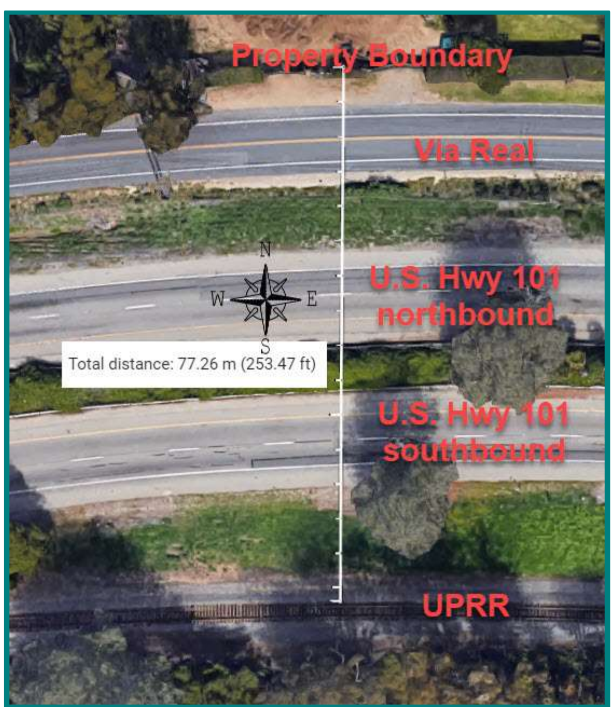
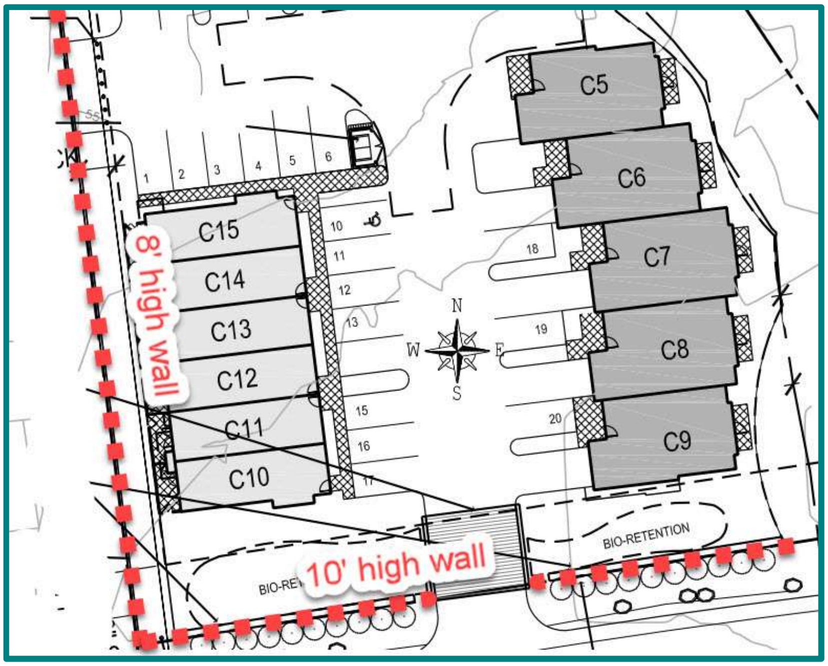


Figure 3 below identifies project noise walls, to be located at the western and southern sides of the site that may experience the worst-case noise impact. The wall is 8 feet high at the west side and 10 feet high facing the noise source (south).

Figure 3: Southwest corner of noise wall depicted with red dashed lines



3 Regulatory Setting

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

3.1 Federal Regulation

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

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

The Department of Transportation (DOT) assumed a significant role in noise control. The Federal Aviation Administration (FAA) regulates noise of aircraft and airports. Surface transportation system noise is regulated by the Federal Transit Administration (FTA). Freeways that are part of the interstate highway system are regulated by the Federal Highway Administration (FHWA).

The Santa Barbara Municipal Airport is approximately 15 miles to the west and outside the published ALUP noise contours. This is a less-than-significant noise factor.

3.2 State Regulation

California State Code Section 65302 mandates that the legislative body of each county and city in California adopt a noise element as part of its comprehensive general plan. The local noise element must recognize the land use compatibility guidelines published by the State Department of Health Services. The guidelines rank noise land use compatibility in terms of normally acceptable, conditionally acceptable, normally unacceptable, and clearly unacceptable.

Title 24, Chapter 1, Article 4 of the California Administrative Code (California Noise Insulation Standards) requires noise insulation inside single-family detached housing to provide an annual average noise level of no more than 45 dBA Community Noise Equivalent Level (CNEL). When such structures are located within a 55 dBA CNEL (or greater) noise contour, an acoustical analysis is required to ensure that interior levels do not exceed the 45 dBA CNEL annual threshold. In addition, Title 21, Chapter 6, Article 1 of the California Administrative Code requires that all habitable rooms shall have an interior CNEL of 45 dBA or less. The 2013 California Green Building Standards Code (CGBSC), Division of the State Architect - Structural Safety (DSA-SS) (CCR, Title 24, Part 11) submittal guideline, chapter 5 contains mandatory requirements for acoustical control:

> *"5.507.4.1 Exterior noise transmission prescriptive method*
>
> *"Wall and roof-ceiling assemblies exposed to the noise source making up the building or addition envelope or altered envelope shall meet a composite STC rating of at least 50 or a composite OITC rating of no less than 40, with exterior windows of a minimum STC of 40 or OITC of 30 ... within the 65 CNEL or LDN noise contour of a freeway or expressway, railroad, industrial source or fixed-guideway source as determined by the Noise Element of the General Plan."*

Chapter 5.507.4.1.1 governs acoustical performance and noise exposure where noise contours are not readily available:

> *"Buildings exposed to a noise level of 65 dB Leq-1-hr during any hour of operation shall have building, addition or alteration exterior wall and roof-ceiling assemblies exposed to the noise source meeting a composite STC rating of at least 45 (or OITC 35), with exterior windows of a minimum STC of 40 (or OITC 30)."*

The performance method described above may be used to comply with CGBSC in the following way:

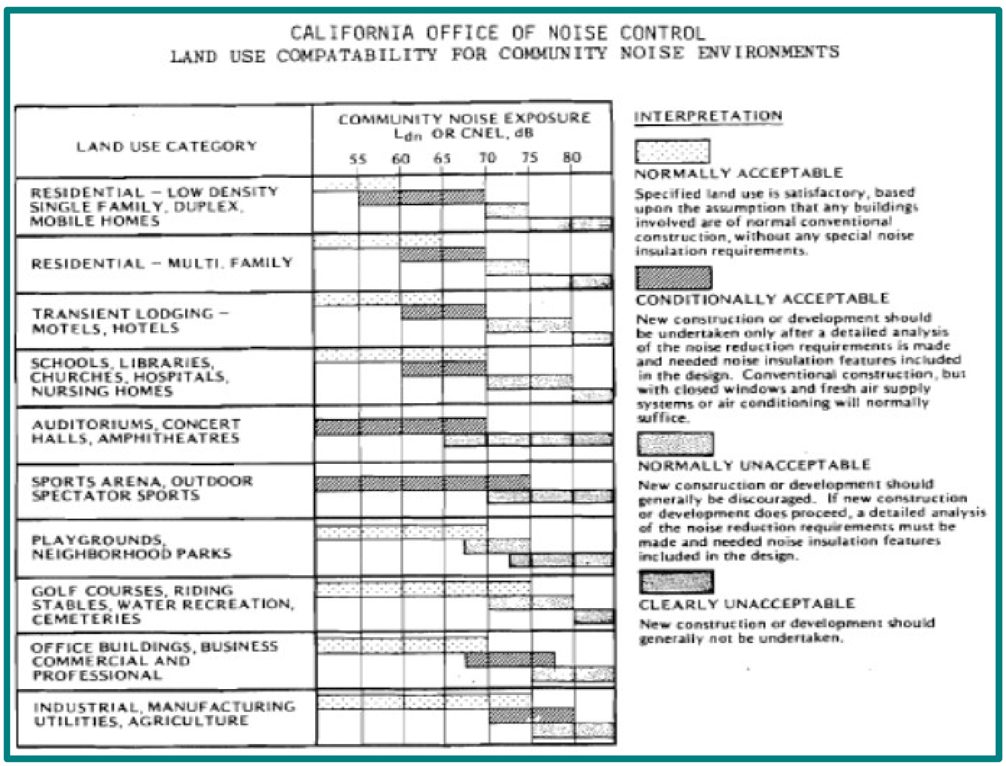
> *"...wall and roof-ceiling assemblies exposed to the noise source making up the building or addition envelope or altered envelope shall be constructed to provide an interior noise environment attributable to exterior sources that does not exceed an hourly equivalent noise level (Leq -1Hr) of 50 dBA in occupied areas during any hour of operation."*

3.3 Local Regulation

Although the *Toro Canyon Plan (2004)* is the applicable planning document for this Project, that document does not have noise-specific criteria. The Noise Element of Santa Barbara County's *General Plan: Noise Element* is consulted for noise regulations for residential development. The Noise Element Santa Barbara County General Plan provides standards and guidelines, and provides the conclusions, recommendations, and strategies necessary to ensure an appropriately quiet and pleasurable interior environment for the residents of the proposed project. Since the regulation of transportation noise sources such as roadway and aircraft primarily fall under either State or federal jurisdiction, the local jurisdiction generally uses land use and planning decisions to limit locations or volumes of such transportation noise sources, to avoid development within noise impact zones, or to shield impacted receivers or sensitive receptors.

An outdoor CNEL of 65 dBA, and an indoor CNEL of 45 dBA, is acceptable here for multi-family residential land use, shown in Table 1. The Santa Barbara County Planning and Development's *Guidelines for the Implementation of California Environmental Quality Act of 1970 as Amended* is consistent with the Noise Element and with Santa Barbara County *Environmental Thresholds and Guidelines Manual*.

Table 1: Santa Barbara County Land Use Compatibility



4 Modeled Exterior Noise Levels

All noise propagation model results show CNEL in units of dBA (see Glossary for definitions), to enable direct comparison with regulations. Resulting sound level contour plots depict sound level at a typical ground receiver height of 1.8m / 6 ft above grade.

The noise propagation software SoundPLAN utilizes traffic counts published by Caltrans (reprinted in Figure 4) to accurately model/predict Highway 101 traffic noise levels using Transportation Noise Model, published by the Federal Highway Administration. Via Real traffic counts were conservatively assumed to be 6,000 Average Annual Daily Traffic (AADT).

Figure 4: Applicable traffic counts for Highway 101 (Caltrans)

2016 Traffic Volumes (for ALL vehicles on CA State Highways) 2016 Volumes Home ▾ View

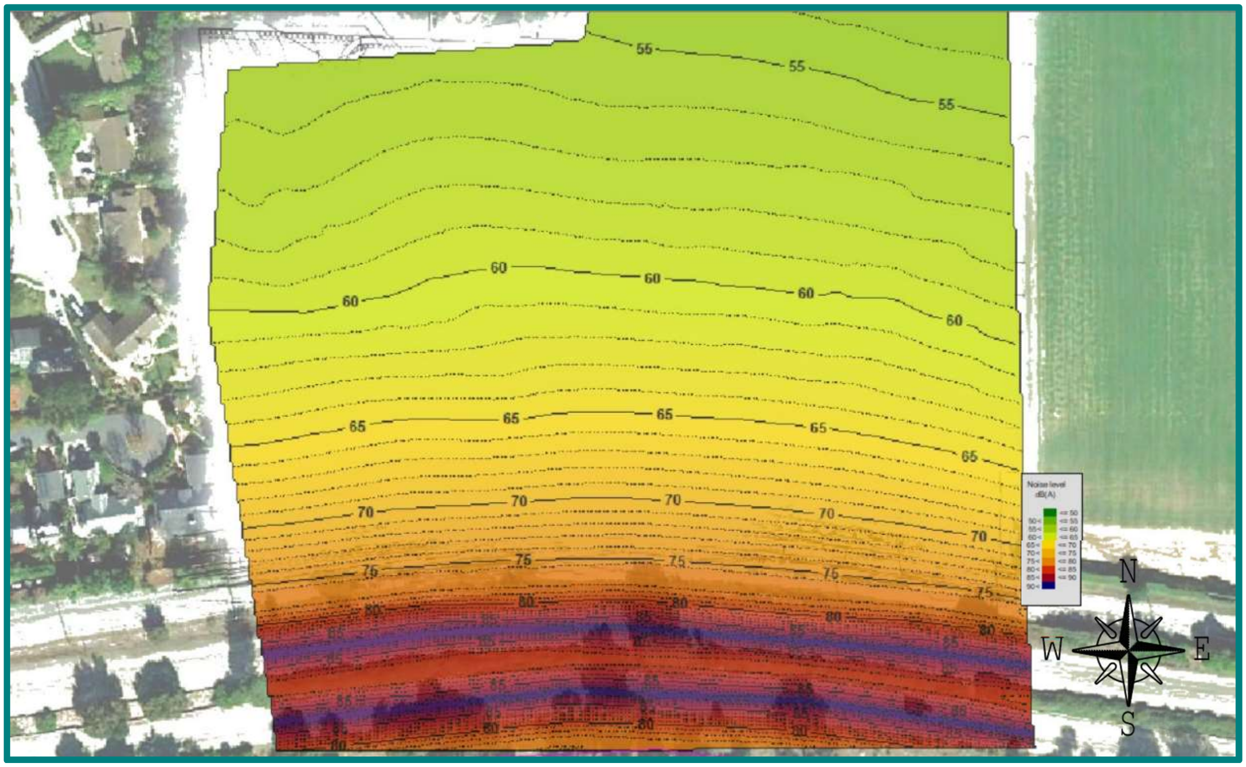
Dist	Rte	CO	Post Mile	Description	Back Peak Hour	Back Peak Month	Back AADT	Ahead Peak Hour	Ahead Peak Month	Ahead AADT
05	101	SB	2.64	CARPINTERIA, CASITAS PASS ROAD	6000	80000	75400	5500	73000	69300
05	101	SB	3.059	CARPINTERIA, LINDEN AVENUE	5500	73000	69300	5800	77000	73100
05	101	SB	3.773	CARPINTERIA, SANTA MONICA ROAD	5800	77000	73100	5400	72000	67600
05	101	SB	R 5.283	SOUTH PADARO LANE	5500	73000	69300	5400	72000	67800
05	101	SB	R 7.138	PADARO LANE	5400	72000	67800	5400	72000	68100

In comparison with traffic noise, the infrequent rail noise has been shown in previous studies to contribute minimally to the overall 24-hour CNEL level—i.e., the contribution of rail noise from Union Pacific Railroad has been shown to increase CNEL by less than 1 dB. Therefore, this source can be considered to be negligible for determination of compliance with CNEL regulations.

4.1 With No Project Built

Figure 5 shows resulting typical CNEL noise contours in plan view before the project, at 6 feet above grade.

Figure 5: Sound level contours, plan view, before project [CNEL = dBA]



4.2 Project Noise Contours without Walls

Results in this subsection do not include the future planned 12-foot high noise wall by Caltrans, close to Highway 101 (i.e., the "Caltrans wall"). This section does, however, show results both with and without the 8-foot- and 10-foot-high property perimeter wall that is planned to be constructed as part of the Project (i.e., the "Project wall").

Figure 6 shows resulting worst-case CNEL noise level contours with the built Project and with no noise walls in place. To help with visualization of the soundscape, Figure 7 shows a cross-section of the contours through units C9 – C5, and Figure 8 shows a 3D view of the contours of the entire site. Noise levels at the exterior of the two southwestern-most Project buildings reach CNEL = 73dBA at ground level without any noise barriers to mitigate traffic noise. The upper story of unit C9 facing the noise source will experience 3 dB higher sound levels, which is an audible difference. Outdoor patios of the single-story apartments are between 65-70dBA. These sound levels exceed the County's standard for exterior noise and would require significant mitigation.

Figure 6: Sound level contours of entire Project, without noise walls [CNEL = dBA]

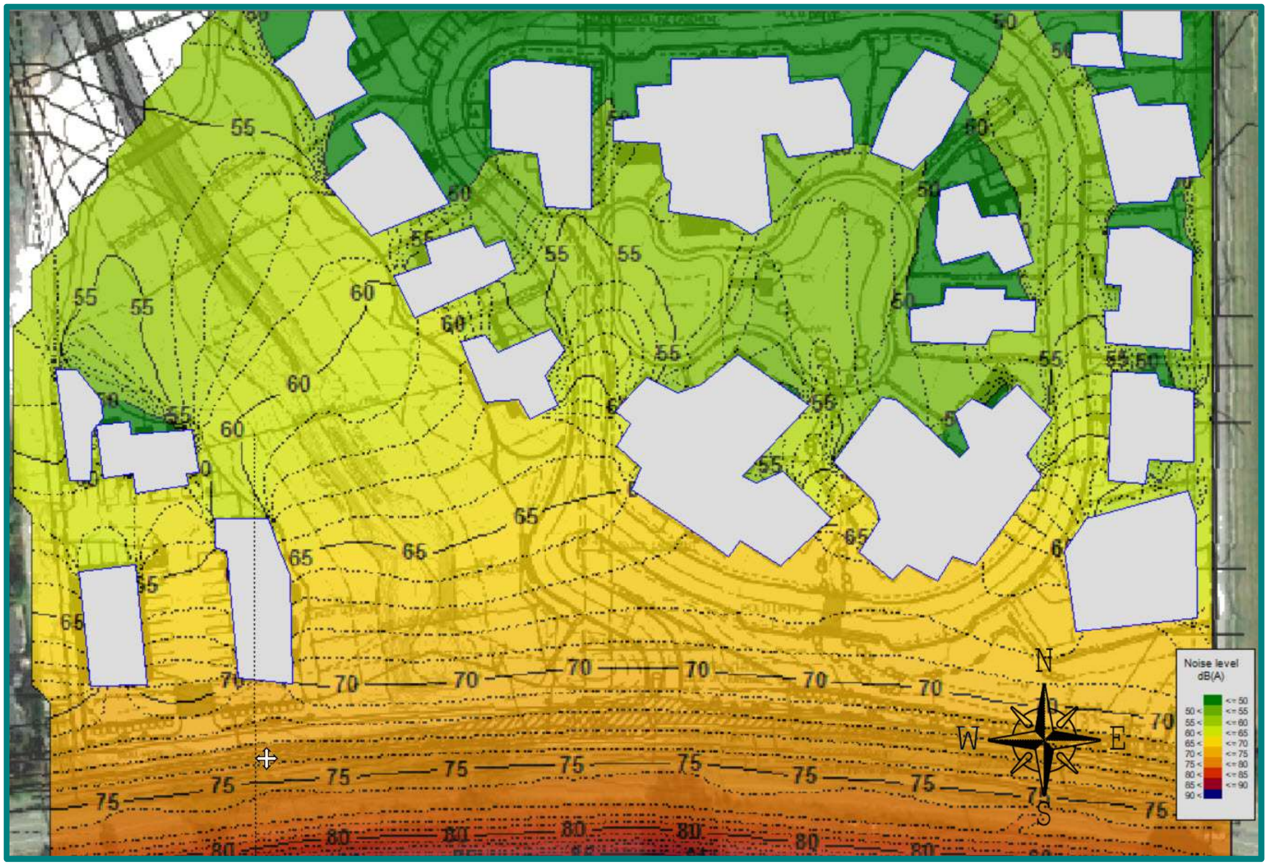


Figure 7: 3D view of cross-section noise contours for C9-C5 with no noise walls

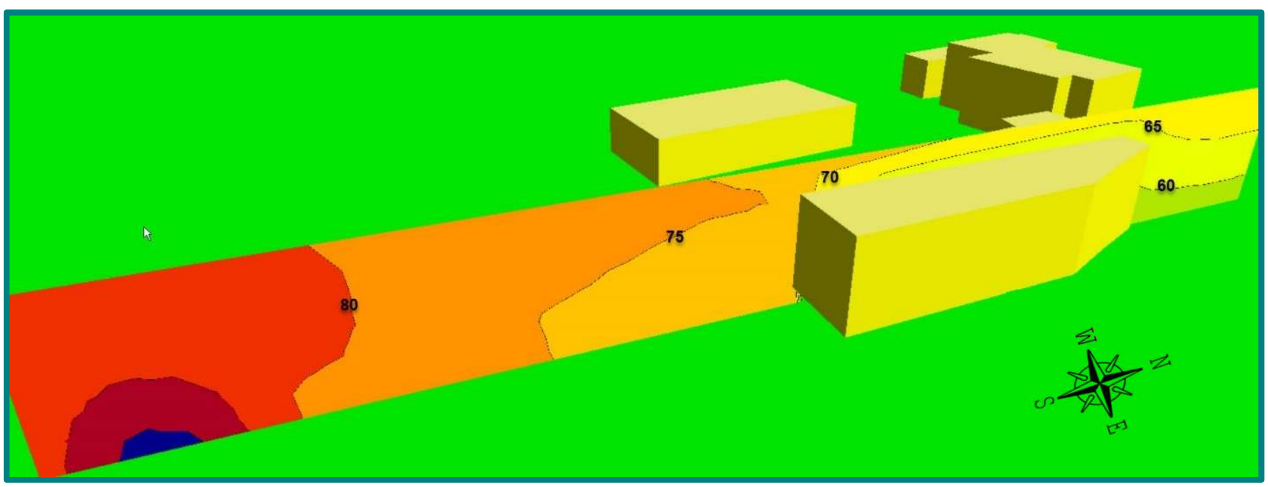
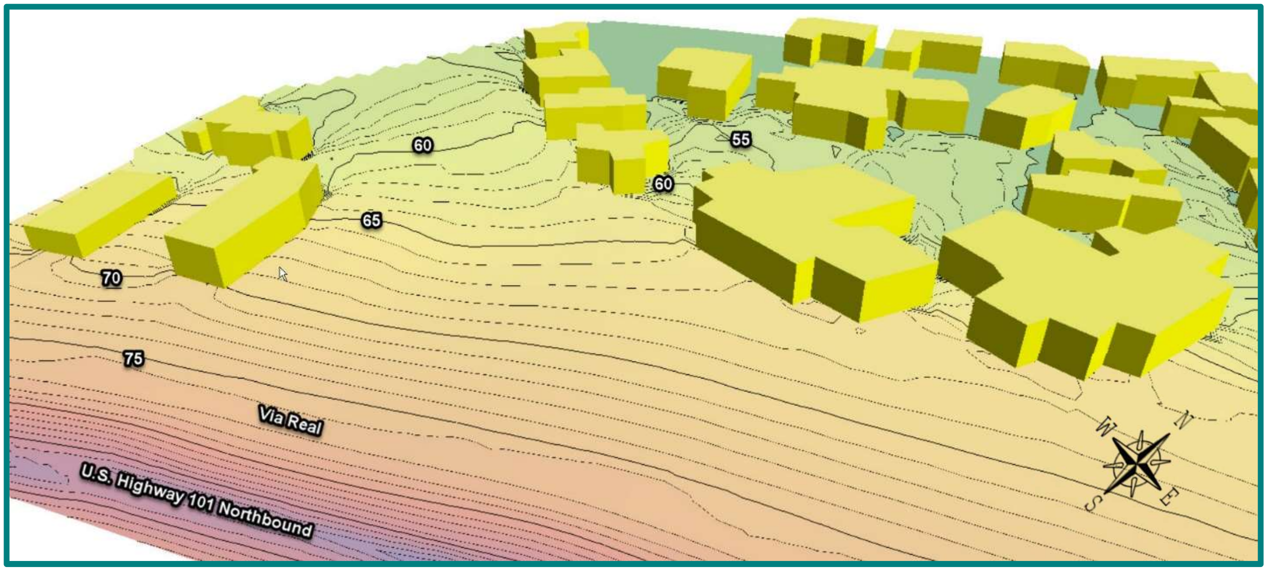


Figure 8: 3D view of sound level contours for entire Project, without Project noise wall



4.3 Noise Contours with Project Wall

In Figure 9, the Project's proposed 8- and 10-foot-high noise wall have been added to the south boundary and portions of the west boundary. Figure 10 is the same result in a 3D view, and Figure 11 shows a cross section of the noise contours for rowhomes C9 - C5.

These results show a reduction in sound levels for the worst-case residential units, i.e. those with the highest exterior noise level. With the Project wall built, C10 levels (at the 1st story) are reduced from 71 to 64 dBA, while C9 sound levels at the 2nd story will be reduced by approximately 2 dB, from 73 to 71 dBA. Outdoor activity spaces behind C10-C15 have been reduced by approximately 5 dB, and are now within the 65dBA regulation with the Project wall in place.

A reduction in sound levels of up to 5 dB is also evident at elevations of units V12, V13, and V15. Buildings further north and away from the noise barrier do not gain a substantial benefit from the noise wall. The effectiveness of noise barriers diminishes with distance away from a barrier. In other words, to be effective, barriers should be placed as close as possible to the noise source, or the receiver. The least effective position of a noise barrier is half-way between noise source and receiver.

The Project walls are anticipated to reduce exterior noise levels, and subsequently increase the quality of experience for residents of the southwestern buildings of the Project. Mitigation may be required if the Project walls are not built.

Figure 9: Sound level contours with Project noise wall

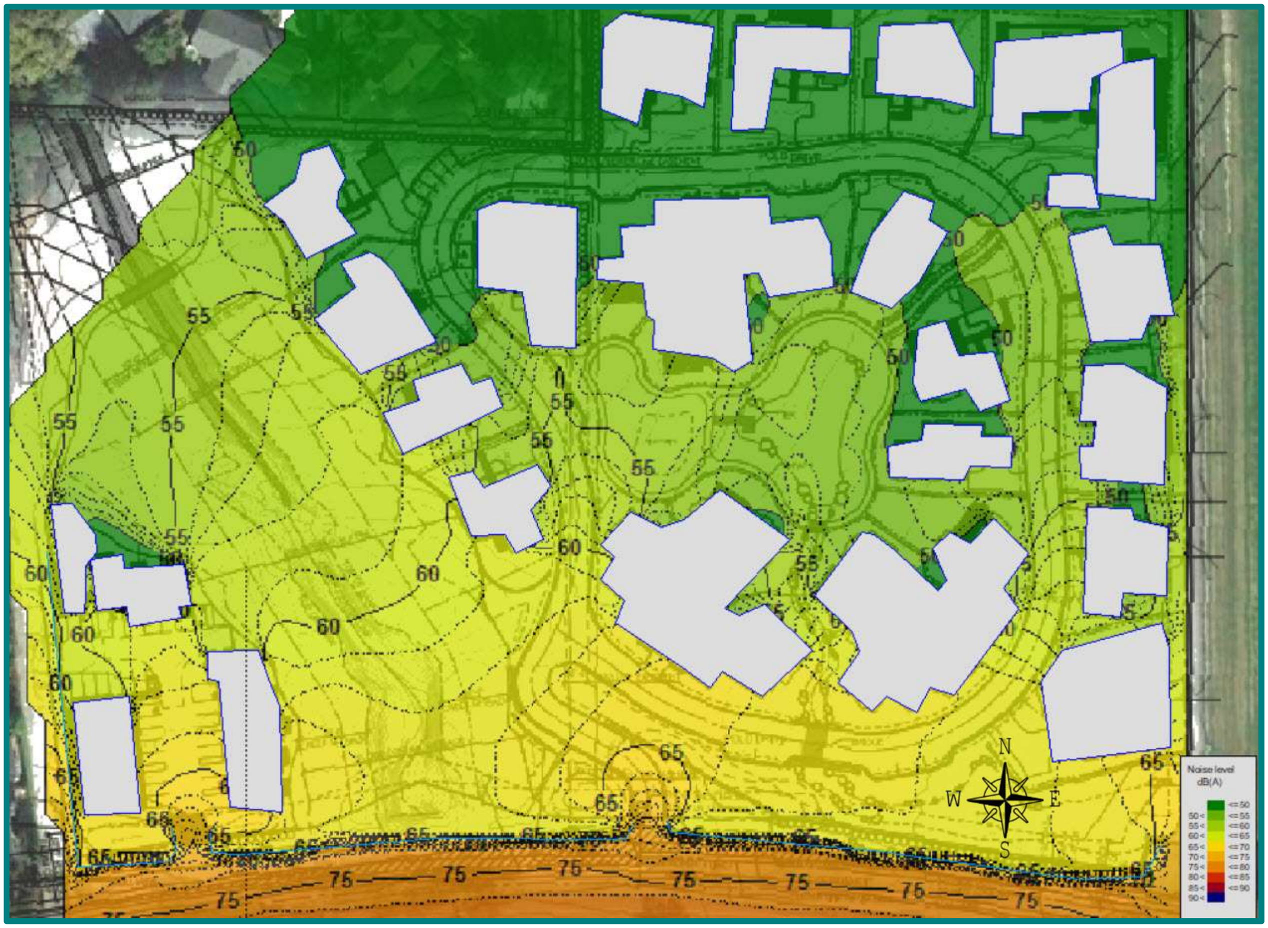


Figure 10: 3D view, sound level contours with Project noise wall

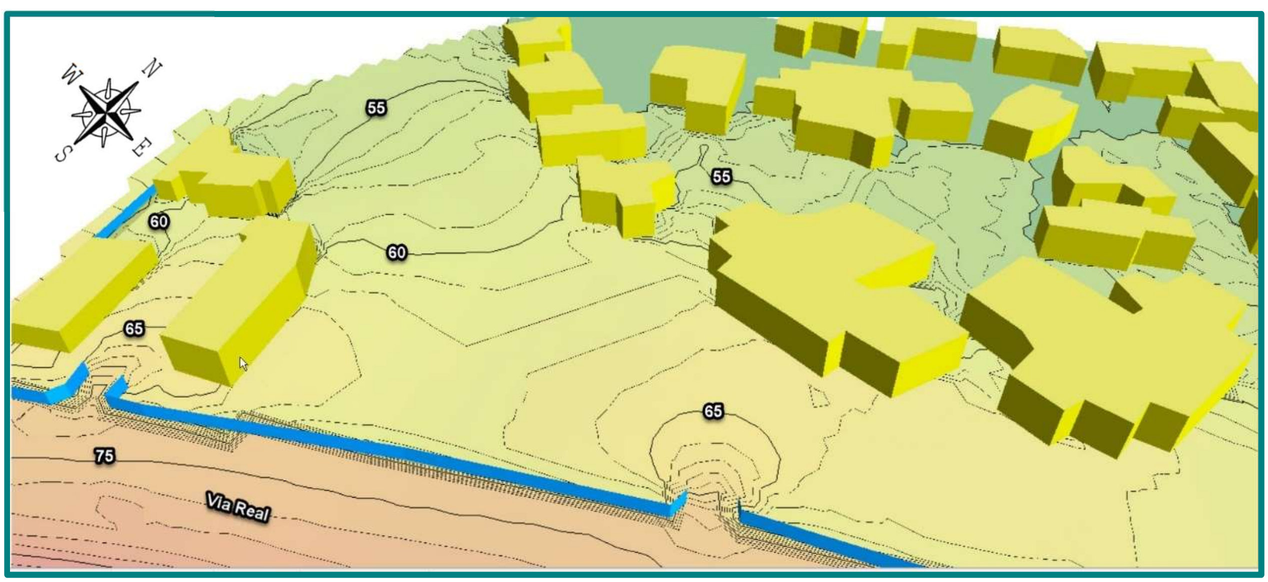
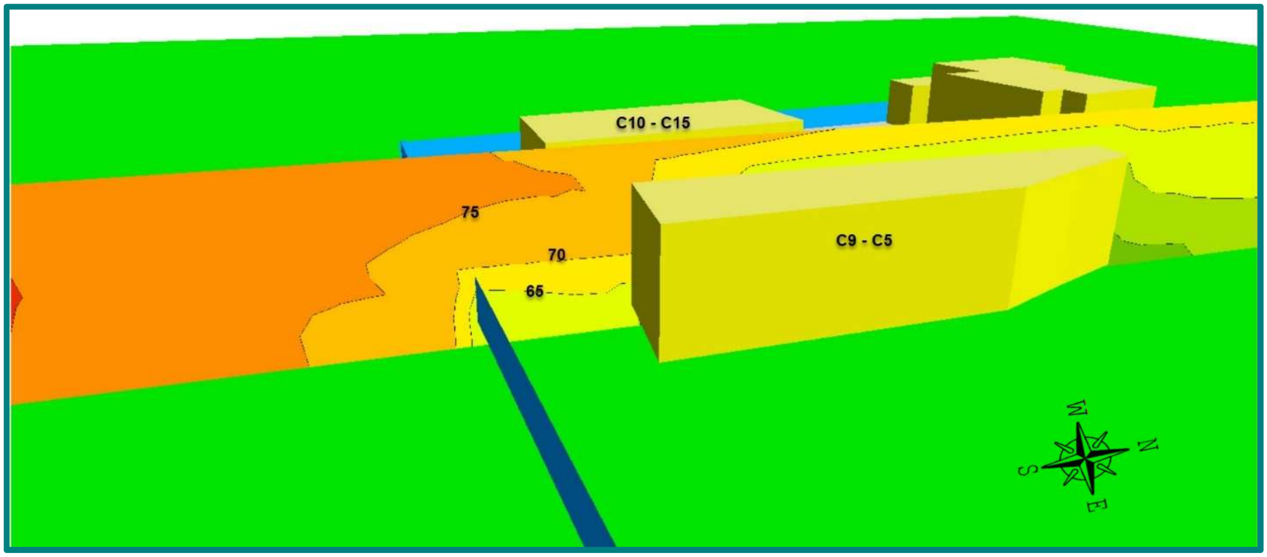


Figure 11: 3D view of cross-sectional noise contours for C9-C5, with Project noise wall



4.4 Noise Contours with Caltrans Wall

Results in this subsection include the noise wall planned by Caltrans in the future.

Figure 12 below shows a sketch, provided by Caltrans via the Client, of the approximate location and extent of the noise wall (in blue-dotted line between Highway 101 and the Project site) that may be built. This proposed 12-foot high wall was added into the previous analysis.

The cross-sectional view in Figure 16 shows that the higher Caltrans wall, built between Highway 101 and Via Real, results in a reduction of exterior noise levels for the Project of 2 dB at the southwestern-most buildings, lowering the sound levels of the elevation facing the highway to 62 dBA for the C10 façade, and 69 dBA at the 2^{nd} story of C9.

Figure 12: Sketched location of Caltrans noise wall (courtesy of Caltrans)

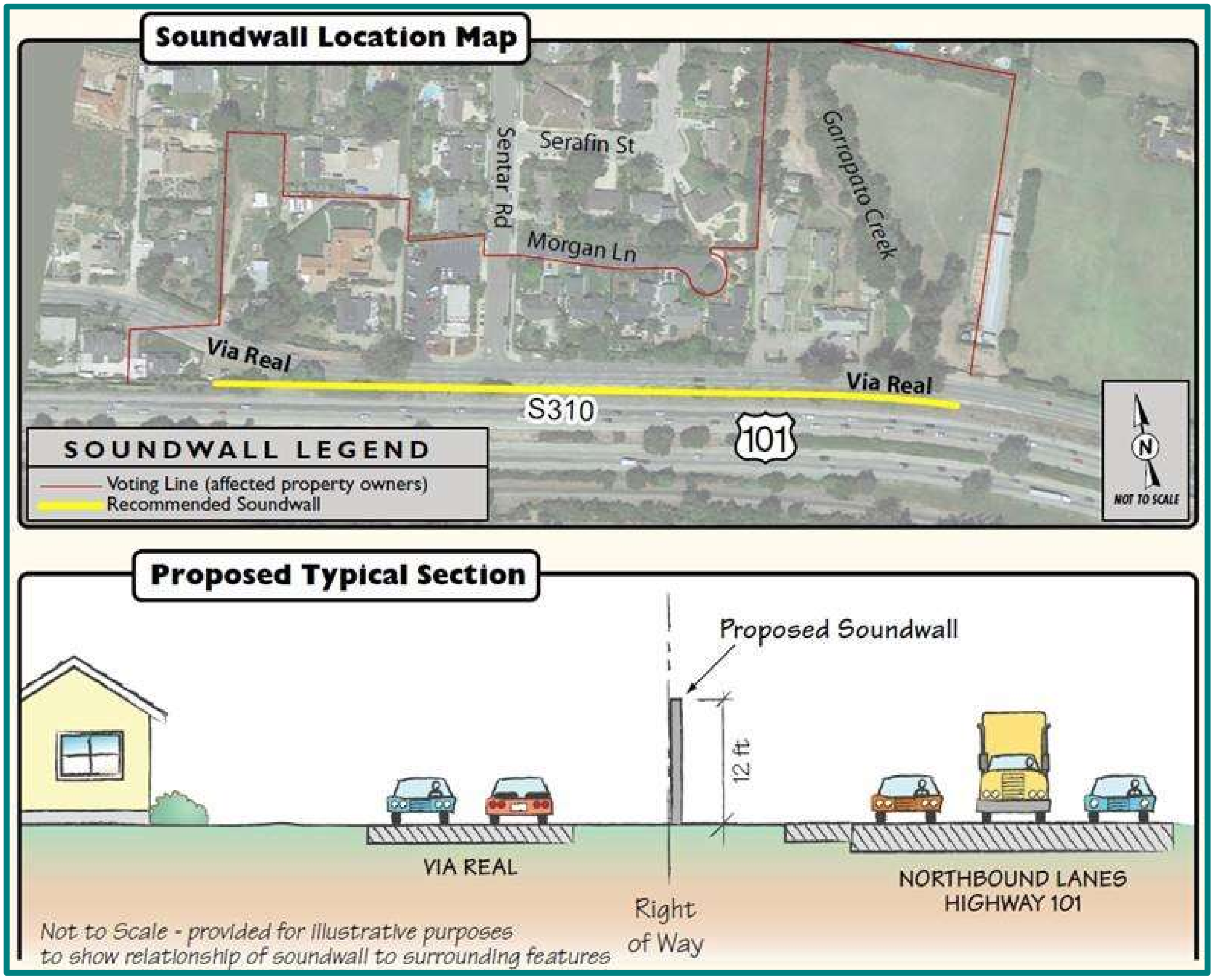


Figure 13: Sound level contours with both noise walls

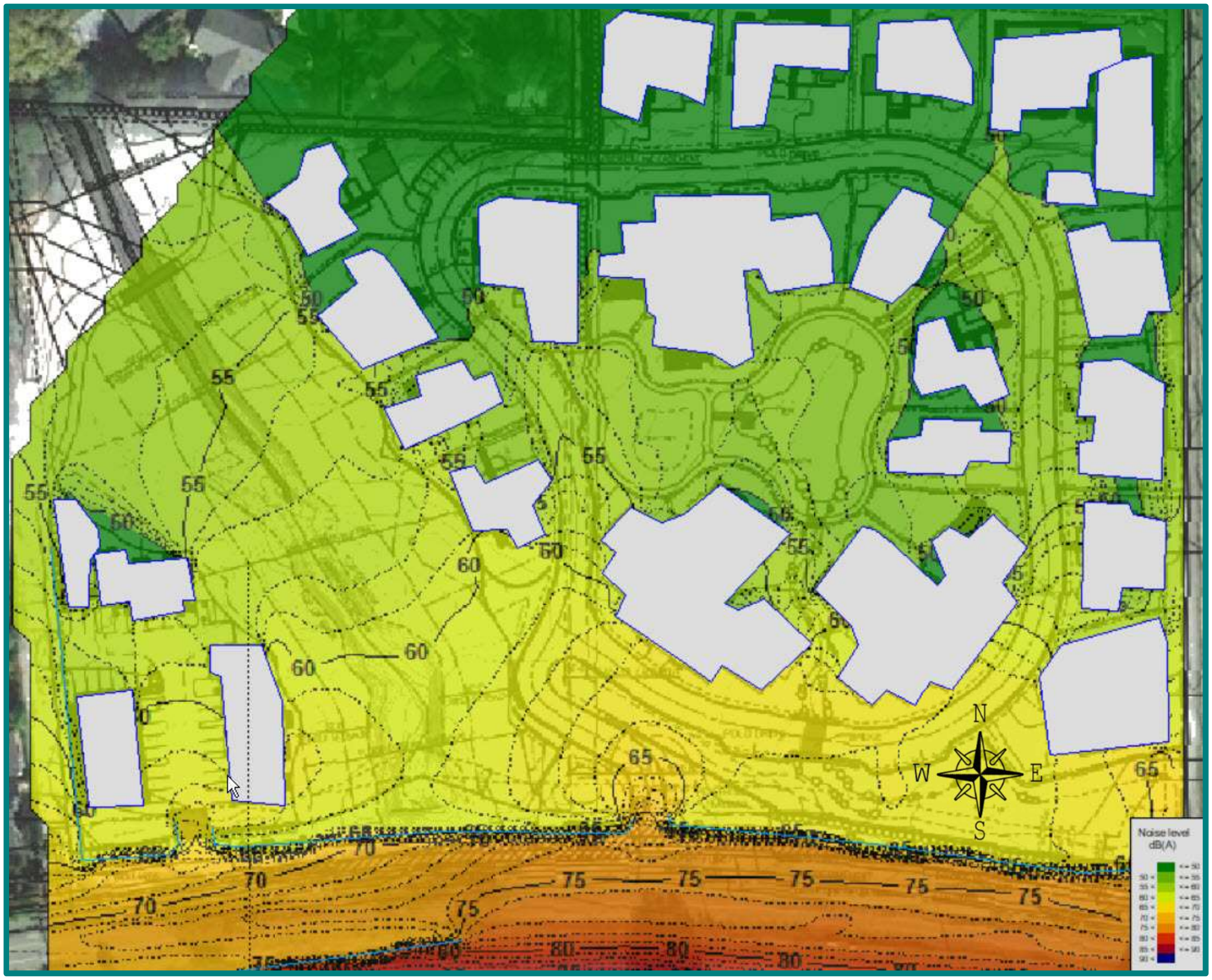


Figure 14: 3D view of noise contours with both walls

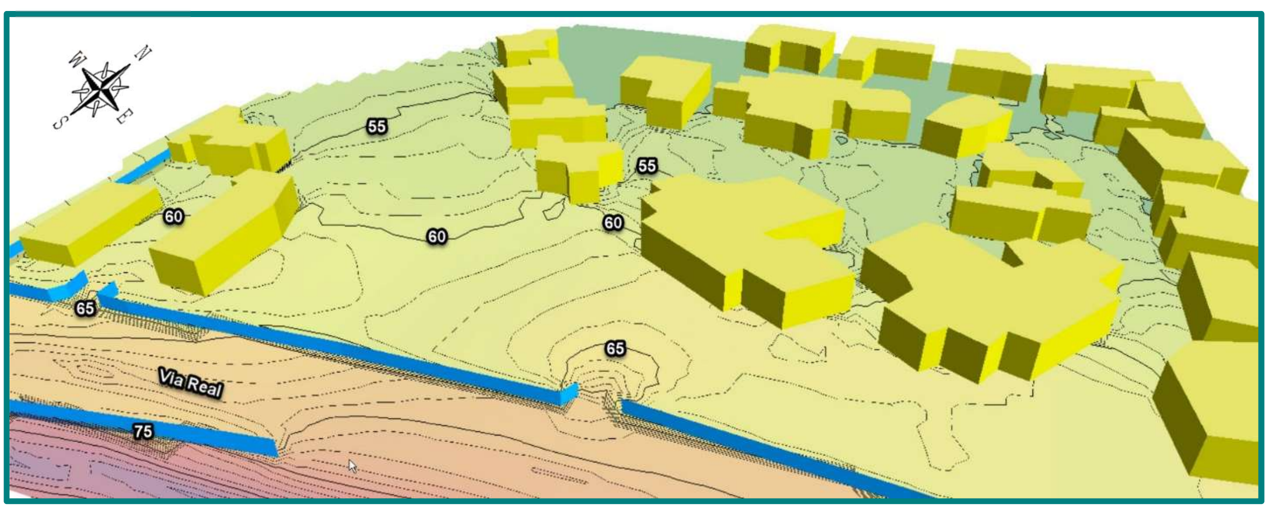


Figure 15: 3D noise contours with both walls (zoom-in of Figure 14)

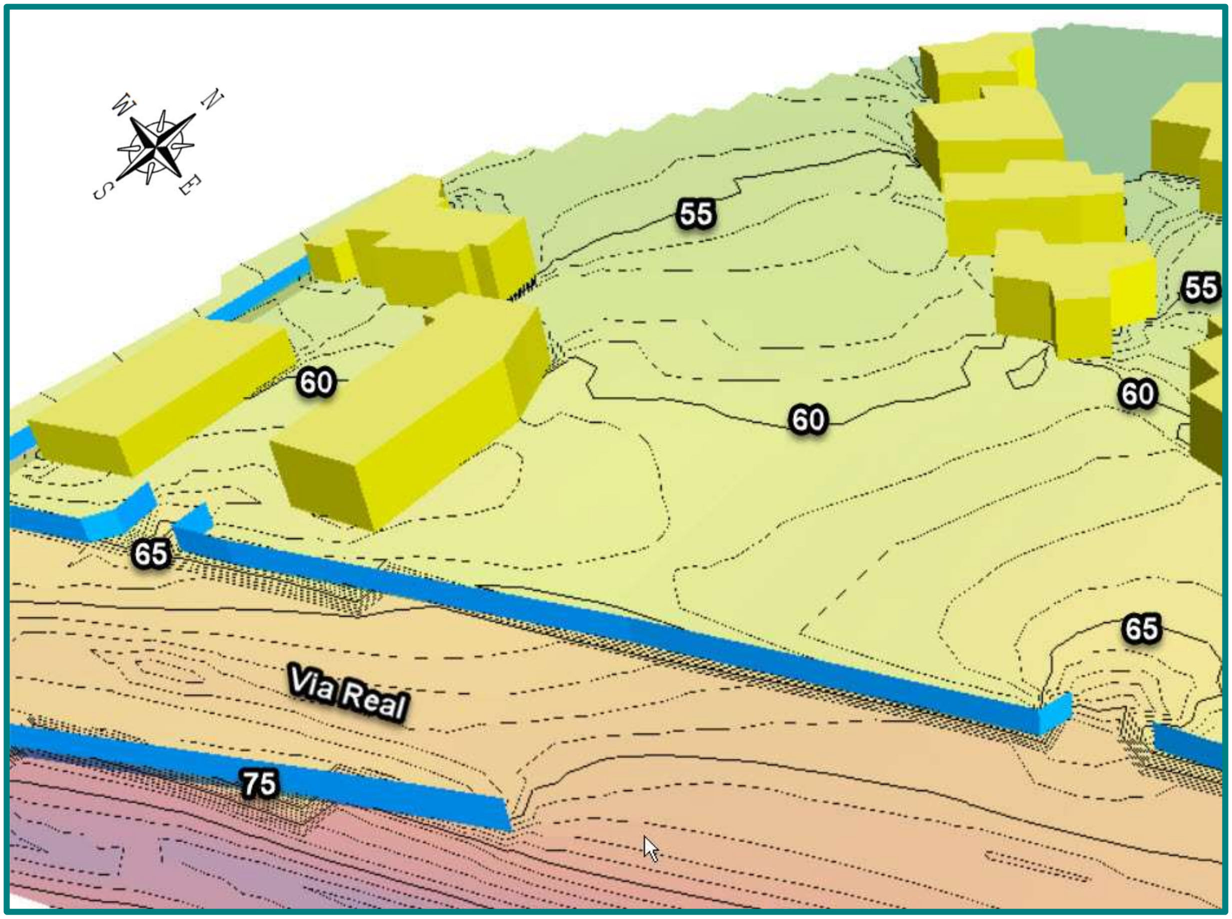


Figure 16: Vertical cross-section view of noise contours with both walls

5 Vibration

The potential for vibration near a highway is defined and described in the Federal Transit Administration *Transit Noise and Vibration Impact Assessment* document. The approximate human threshold of perception to vibration is 70 VdB (Vibration Velocity Level, dB). Buses, trucks and heavy street traffic at 50 feet distance from the highway is equal to 70 VdB or less. Vibration levels along transportation corridors are proportional to the speed and weight of the vehicles as well as the condition of the roadway and vehicle engines and tires. Typically, the setback to the 70 VdB contour along roadways is 100 feet or less from the centerline. Habitable spaces in the current project are located further than this distance. Therefore, vibration levels are anticipated to be less than the human threshold of perception, assuming roadways are properly maintained without large holes/irregularities.

6 Impact Assessment

With the Project and Caltrans noise walls, and recommended mitigation measures in place, the Project does not require other measures in order to meet planning standards. Therefore, outdoor and indoor living spaces are not significantly impacted by noise with mitigation in place.

The designated outdoor areas, including the club house, pool and spa, and central pond and retention area are below the 65dBA noise contour. Even if the Caltrans wall is not constructed, these designated outdoor areas meet County accepted noise levels for outdoor use.

7 Recommended Mitigation Measures

No vibration mitigation is required.

Both the Project wall and the Caltrans wall must be in place if the southwestern boundary areas are used as outdoor activity areas. These walls also provide significantly lower sound levels for the dwelling units, enabling more cost-efficient, mid-grade design.

Recommendations for building walls and windows are contained in the subsection below.

7.1 Interior Noise Analysis (STC/OITC)

Sound Transmission Class (STC) and Outdoor-to-Indoor Transmission Class (OITC) calculations are frequency band-based, so they require defined wall and window designs—materials, thicknesses, and room dimensions to confirm interior levels will not exceed the 45-dBA standard. Without these designs, one can only make design assumptions of typical wall and window assemblies. Specific wall designs, if different from the below, should be re-analyzed to verify if the interior noise level will still meet the requirement.

The floor plan for unit C10 was provided by the Client. The worst-case habitable space here will be the living room, since windows transmit more noise than walls, and the bedroom has no windows facing the noise source. From this, approximate wall and window dimensions, window and wall square-footages are estimated from the floor plan provided.

Figure 17 shows the STC result of 33 of a typical dual-glazed window (at the center of the glass, and assuming no leakage of noise around its frame). Figure 18 shows the STC result of 50 of a common wall assembly of 7/8” exterior stucco, 2” x 4” wood studs at 24” on-center spacing, with 3” of fiberglass insulation, and 5/8” gypsum wall board. Figure 19 shows the resulting OITC calculation for the living room with a 20-foot wide wall of 8 feet high, with a 5’-by-5’ window. With outdoor noise at 69 dBA, the interior will not exceed 40 dBA. It is a best practice to allow for a 5-point difference between this theoretical calculated STC and as-built Field STC values, so this window-wall assembly does meet the standards for the worst-case Project units.

Figure 17: Window STC calculation with theoretical window

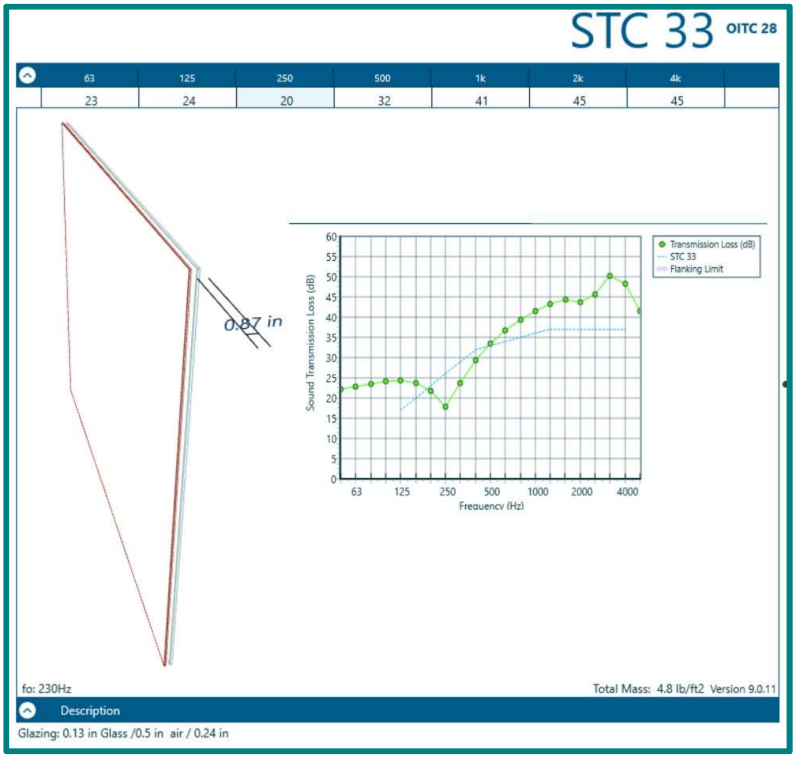


Figure 18: Wall STC calculation with theoretical wall

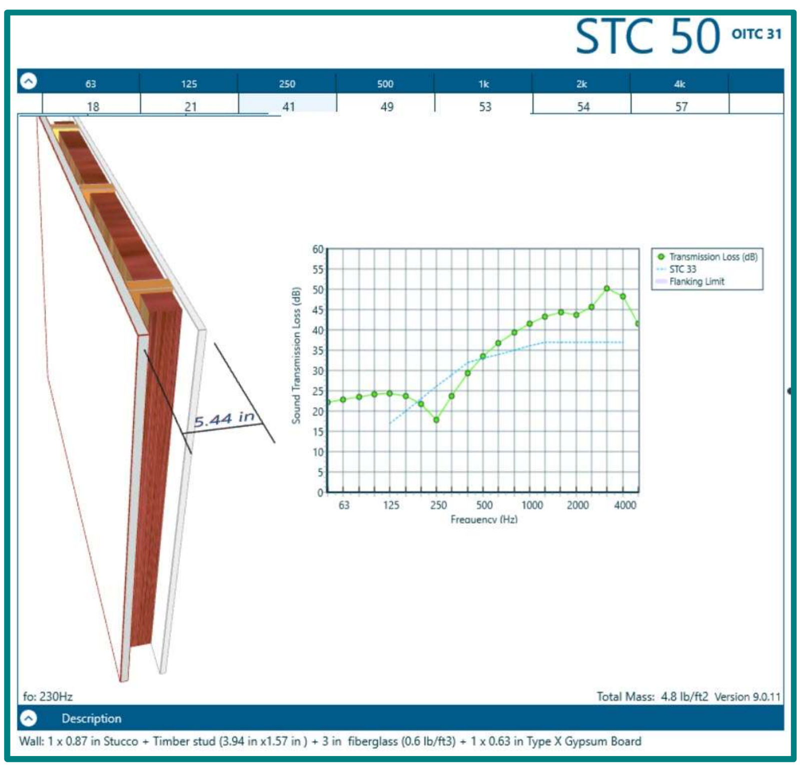


Figure 19: Outdoor-to-Indoor calculation with theoretical wall

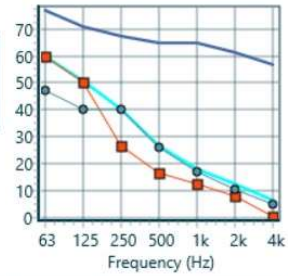
Title

C10

Comment

Dining Room 15'x20'
One window 5'x5'
Wall 20'l x 8'h

Standard Sources



Exterior Sound Pressure Level	63	125	250	500	1k	2k	4k	Overall dBA
Traffic (ISO 717)	76.9	70.8	67.3	64.9	64.7	61.5	56.7	69.0

Path

Element 1 | Element 2 | Element 3 | Element 4 | Element 5 | Element 6 | Element 7 | Element 8

Description: window Area: 25 ft2

	63	125	250	500	1k	2k	4k	Overall dBA
-Sound Transmission Loss (Get R)	-23	-24	-20	-32	-41	-45	-45	
-Facade Shape Level diff. (Facade)	0	0	0	0	0	0	0	
Insertion Loss	0	0	0	0	0	0	0	
+10 Log(A)	14.0	14.0	14.0	14.0	14.0	14.0	14.0	

Receiving Room Volume: 2400 ft3

Notes	63	125	250	500	1k	2k	4k	Overall dBA
-10 Log(V)+16	-18	-18	-18	-18	-18	-18	-18	
Reverberation Time (secs) (RT)	0.5	0.5	0.5	0.5	0.5	0.5	0.5	
+10 Log(T)	-3.0	-3.0	-3.0	-3.0	-3.0	-3.0	-3.0	-
Element Sound Level Contribution	47	40	40	26	17	10	5	33.2
Room Sound Level	60	51	40	26	18	12	6	38.4
D2m,nT	20.3	23.2	30.1	41.6	49.7	52.4	53.7	30.6

8 Conclusion

With no noise walls on site, levels reach CNEL = 76 dBA. With the Project noise wall at the southern project boundaries, but without the Caltrans wall, exterior noise levels at the southwestern buildings facing the roadways reach CNEL = 71 dBA. With the Caltrans noise wall also in place, the outdoor activity spaces do not exceed 65dBA.

Assuming both walls are in place, an STC of approximately 50 for the walls—and 33 for the windows—facing the noise source will ensure indoor spaces meet the indoor sound level criteria, with a 6-point margin for as-built conditions.

9 Appendix

9.1 Characteristics of Sound

When an object vibrates, it radiates part of its energy as acoustical pressure in the form of a sound wave. Sound can be described in terms of amplitude (loudness), frequency (pitch), or duration (time). The human hearing system is not equally sensitive to sound at all frequencies. Therefore, to approximate this human, frequency-dependent response, the A-weighted filter system is used to adjust measured sound levels. The normal range of human hearing extends from approximately 0 to 140 dBA. Unlike linear units such as inches or pounds, decibels are measured on a logarithmic scale, representing points on a sharply rising curve. Because of the physical characteristics of noise transmission and of noise perception, the relative loudness of sound does not closely match the actual amounts of sound energy. Table 2 below presents the subjective effect of changes in sound pressure levels.

Table 2: Sound Level Change Relative Loudness/Acoustic Energy Loss

0 dBA	Reference 0%
-3 dBA	Barely Perceptible Change 50%
-5 dBA	Readily Perceptible Change 67%
-10 dBA	Half as Loud 90%
-20 dBA	1/4 as Loud 99%
-30 dBA	1/8 as Loud 99.9%

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

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

When sound is measured for distinct time intervals, the statistical distribution of the overall sound level during that period can be obtained. The Leq is the most common parameter associated with such measurements. The Leq metric is a single-number noise descriptor that represents the average sound level over a given period of time. For example, the L50 noise level is the level that is exceeded 50 percent of the time. This level is also the level that is exceeded 30 minutes in an hour. Similarly, the L02, L08 and L25 values are the noise levels that are exceeded 2, 8, and 25 percent of the time or 1, 5, and 15 minutes per hour. Other values typically noted during a noise survey are the Lmin and Lmax. These values represent the minimum and maximum root-mean-square noise levels obtained over the measurement period.

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

9.2 Terminology/Glossary

Annual Average Daily Traffic (AADT)
The total volume of vehicle traffic of a highway or road for a year divided by 365 days.

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

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

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

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

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

Day-Night Sound Level (Ldn)
The Leq of the A-weighted noise level over a 24-hour period with a 10-dB penalty applied to noise levels between 10 p.m. and 7 a.m. Ldn is similar to CNEL.

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

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

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

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

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

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

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

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

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

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

- A change in sound level of 3 dBA is *barely perceptible* by most listeners.

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

9.3 Traffic Noise Model

The Federal Highway Administration Traffic Noise Model (TNM) used for the sound level analysis in this study, contains the following components:

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

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

9.4 SoundPLAN Acoustics Software

SoundPLAN, the software used for this acoustic analysis, is an acoustic ray-tracing program dedicated to the prediction of noise in the environment. Noise emitted by various sources propagates and disperses over a given terrain in accordance with the laws of physics. Worldwide, governments and engineering associations have created algorithms to calculate acoustical phenomena to standardize the assessment of physical scenarios. Accuracy has been validated in published studies to be + / - 2.7 dBA with an 85% confidence level.

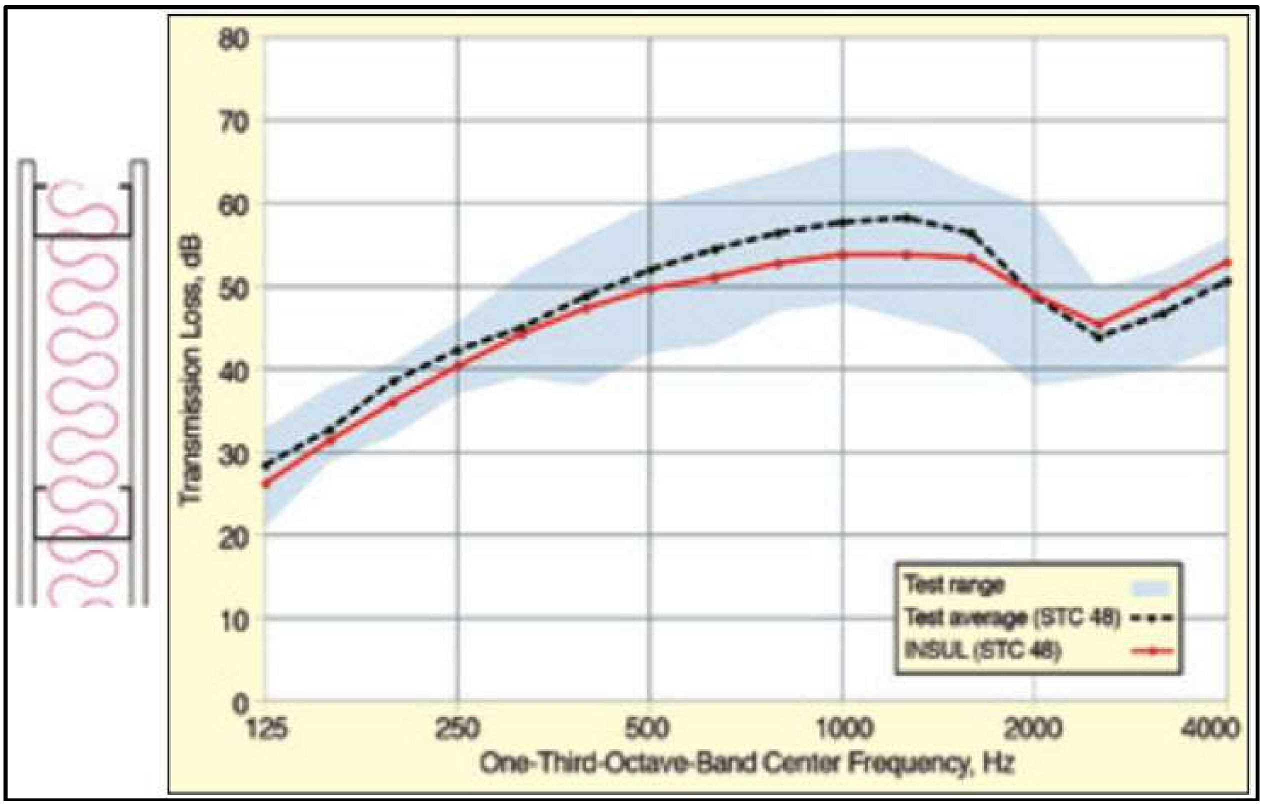
The software calculates sound attenuation of environmental noise, even over complex terrain, uneven ground conditions, and with complex obstacles. The modeling software calculates the sound field in accordance with ISO 9613-2 “Acoustics - Attenuation of sound during propagation outdoors, Part 2: General Method of Calculation.” This standard states that “this part of ISO 9613 specifies an engineering method for calculating the attenuation of sound during propagation outdoors, in order to predict the levels of environmental noise at a distance from a variety of sources. The method predicts the equivalent continuous A-weighted sound pressure level under meteorological conditions favorable to propagation from sources of known sound emissions. These conditions are for downwind propagation under a well-developed moderate ground-based temperature inversion, such as commonly occurs at night.”

9.5 Computer Modeling of Sound Transmission Class

The use of computer modeling to estimate sound transmission class (STC) ratings has become increasingly common. There are several factors to consider when using software to estimate the sound insulation of architectural elements and assemblies. One of the most important factors is the question of real-world accuracy. Others include the use of analytical vs. empirical models, the complexity of assemblies that can be modeled and the level of user experience and knowledge necessary to yield valid or useful results.

Computational results using INSUL software yield octave or third-octave-band transmission loss values as well as providing an estimated single-number STC rating. Modeled results are compared to published laboratory test data for several representative assemblies in the figure below.

Comparison of INSUL and Laboratory Testing:



9.6 Evidence of Compliance

Evidence of compliance shall consist of submittal of an acoustical analysis report, prepared under the supervision of a person experienced in the field of acoustical engineering, with the application for building permit or use permit. The report shall show topographical relationship of noise sources and dwelling site, identification of noise sources and their characteristics, predicted noise spectra at the exterior of the proposed dwelling structure considering present and future land usage, basis for the prediction (measured or obtained from published data), noise attenuation measures to be applied, and an analysis of the noise insulation effectiveness of the proposed construction showing that the prescribed interior noise level requirements are met. If interior allowable noise levels are met by requiring that windows be unopenable or closed, the design for the structure must also specify the means that will be employed to provide ventilation and cooling, if necessary, to provide a habitable interior environment.

10 References

1. County of Santa Barbara Planning and Development. Republished 2009. *General Plan.* County of Santa Barbara Planning and Development. Revised 2010. *Environmental Thresholds and Guidelines Manual.*
2. American National Standards Institute, Inc. 2004. *ANSI 1994 American National Standard Acoustical Terminology*. ANSI S.1.-1994, (R2004), New York, NY.
3. American Society for Testing and Materials. 2012. ASTM E1014 - 12 *Standard Guide for Measurement of Outdoor A-Weighted Sound Levels*.
4. American Society for Testing and Materials. 2014. ASTM E1503 - 14 *Standard Test Method for Conducting Outdoor Sound Measurements Using a Digital Statistical Sound Analysis System*.
5. American Society for Testing and Materials. 2010. ASTM E966 – 10. *Standard Guide for Field Measurements of Airborne Sound Attenuation of Building Facades and Façade Elements.*
6. Bolt, Beranek and Newman. 1973. *Fundamentals and Abatement of Highway Traffic Noise*, Report No. PB-222-703. Prepared for Federal Highway Administration.
7. California Department of Transportation (Caltrans). 1982. *Caltrans Transportation Laboratory Manual.*
8. ______. 1998. Caltrans Traffic Noise Analysis Protocol for New Highway Construction and Highway Reconstruction Projects
9. Federal Highway Administration. 2006. *FHWA Roadway Construction Noise Model User's Guide Final Report.* FHWA-HEP-05-054 DOT-VNTSC-FHWA-05-01
10. Harris, Cyril M., editor. 1979 *Handbook of Noise Control*.