Acoustical Assessment

St. Mary's Double Roundabouts Project
Town of Moraga

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LIST OF ABBREVIATED TERMS

APN	Assessor's Parcel Number
ADT	average daily traffic
ASTM	American Society for Testing and Materials
dBA	A-weighted sound level
CEQA	California Environmental Quality Act
MCM	Moraga Municipal Code
CSMA	California Subdivision Map Act
CNEL	community equivalent noise level
L_{dn}	day-night noise level
dB	decibel
du/ac	dwelling units per acre
L_{eq}	equivalent noise level
FHWA	Federal Highway Administration
FTA	Federal Transit Administration
HVAC	heating ventilation and air conditioning
Hz	hertz
in/sec	inches per second
LUD	Land Use Designation
L_{max}	maximum noise level
µPa	micropascals
L_{min}	minimum noise level
PPV	peak particle velocity
RMS	root mean square
STC	Sound Transmission Class
sf	square feet
TNM	Traffic Noise Model
VdB	vibration velocity level

1 INTRODUCTION

This report documents the results of an Acoustical Assessment completed for the St. Mary's Road Double Roundabouts Project. The purpose of this Assessment is to evaluate the Project's potential construction and operational noise and vibration impacts and determine the Project's level of impact on the environment.

1.1 PROJECT LOCATION

St. Mary's Road is a major north-south arterial that connects the Town of Moraga to the City of Lafayette in California. Figure 1: Regional Vicinity and Figure 2: Site Vicinity, depict the Project site in a regional and local context. St. Mary's Road is located just north of St. Mary's College campus and passes through grass-covered hills, intermixed with forested areas and riparian corridors. Trails and open space surround the project area, including the Lafayette/Moraga Regional Trail. The Lafayette/Moraga Regional Trail runs alongside St. Mary's Road, just to the north of it with riparian corridors between the trail and St. Mary's Road.

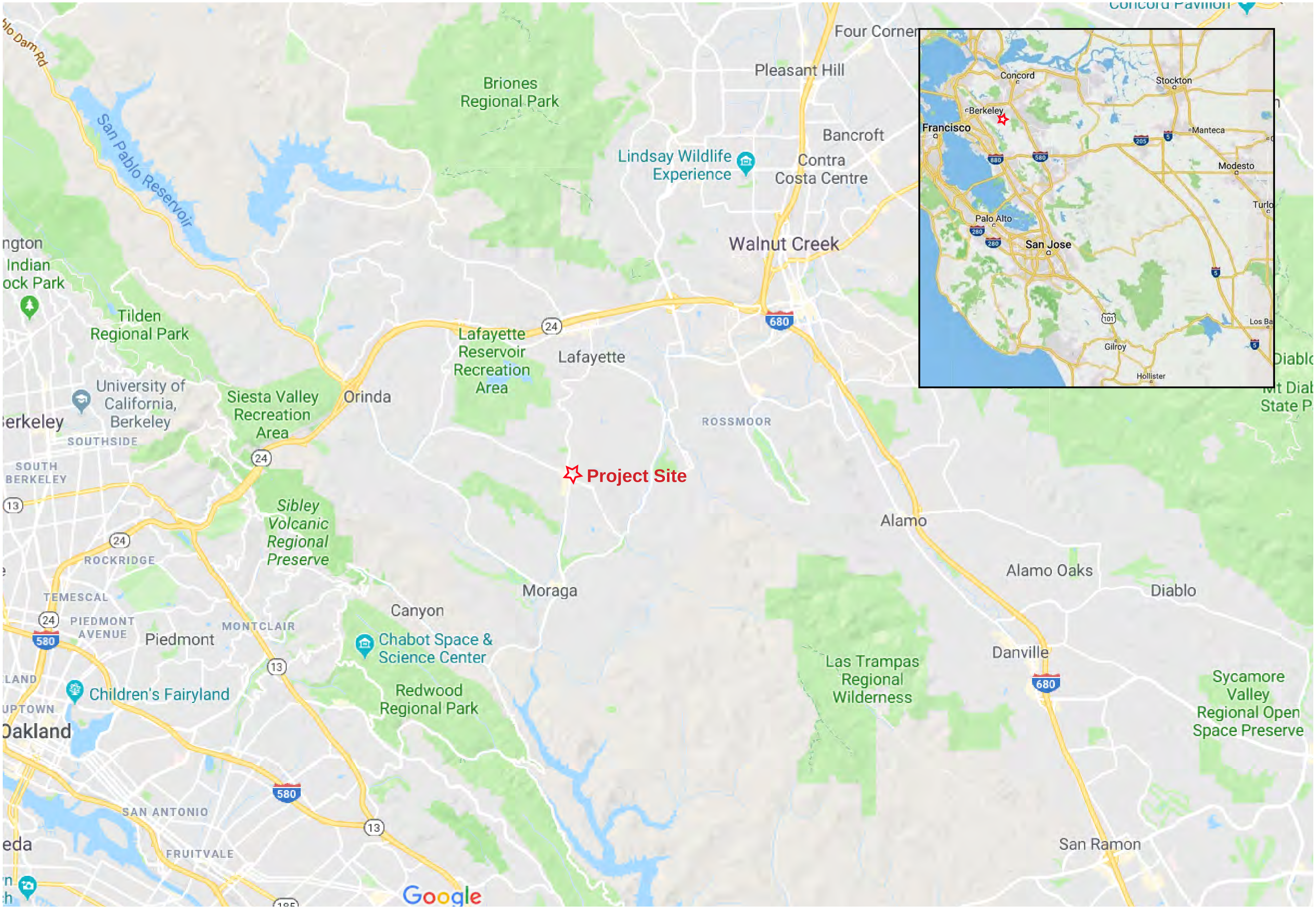
St. Mary's Road, through the project area, is currently a two-lane divided road with an unsignalized intersection at St. Mary's Road and Rheem Boulevard. St. Mary's Road, through the project area, splits off into Bollinger Canyon Road to the south, and continues onto St. Mary's Road to the north. Existing residential development is located to the east and west of the project area. North of St. Mary's Road is an open space area and south is a Pat Vincent Memorial Field and St. Mary's College.

1.2 PROJECT DESCRIPTION

The site plan for the Project is depicted on Figure 3: Site Plan. As proposed, the Project would provide improvements to the two intersections of St. Mary's Road / Rheem Boulevard and St. Mary's Road / Bollinger Canyon Road. The St. Mary's Double Roundabouts Project would improve traffic operations and pedestrian and bicycle access and safety. The Project would construct two roundabouts on St. Mary's Road at the Rheem Boulevard and Bollinger Canyon Road intersections, install green infrastructure, and create safer pedestrian and bicycle crossings. The purpose of the proposed Project is to provide congestion relief at the St. Mary's Road and Rheem Boulevard and to improve stopping sight distance and visibility at the Rheem Boulevard and Bollinger Canyon Road intersections. The Project is proposed to alleviate the current congestion, reduce intersection delays and queues, improve multimodal safety and to better accommodate pedestrian and bicycle traffic.

The travel lanes would be 12 feet wide. The proposed roundabout on St. Mary's Road/Rheem Boulevard would be 120 feet in diameter while the St. Mary's Road/Bollinger Canyon roundabout would be approximately 80 feet in diameter. Both roundabouts would have single-lane entries on all intersection approaches.

Construction is anticipated to begin in Summer 2021 and last approximately 12 months. St. Mary's Road would remain open during construction; however, there may be temporary lane closures on St. Mary's Road, Rheem Boulevard, and Bollinger Canyon Road during non-commute times, and there may be one-way traffic control at night during stage construction switchovers. Construction methods would include paving and grading.



Source: Google Maps, 2019

Figure 1: Regional Vicinity

St Mary's Double Roundabouts Project

Not to scale

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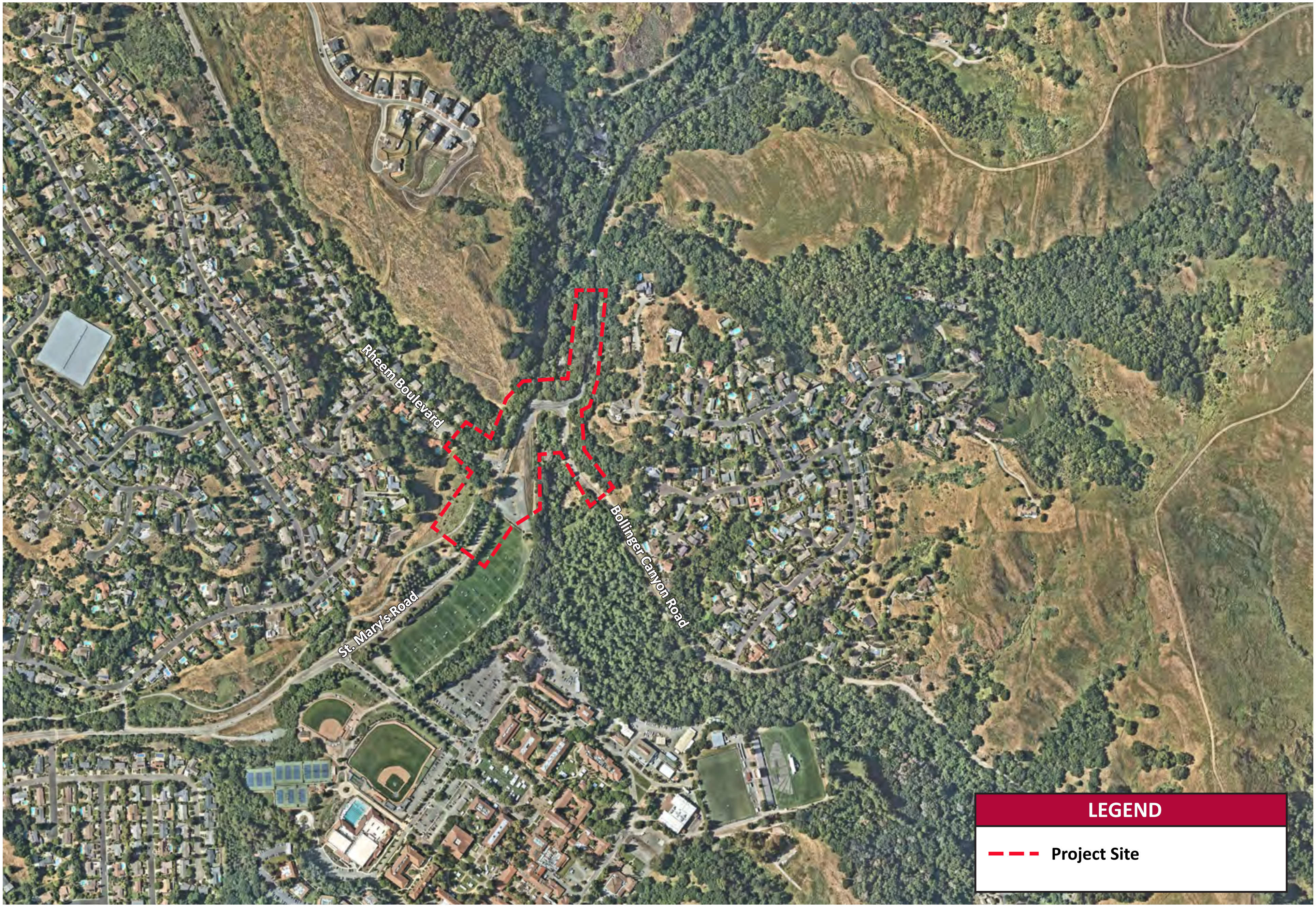

Source: NearMap, 2019

Figure 2: Site Vicinity

St Mary's Double Roundabouts Project

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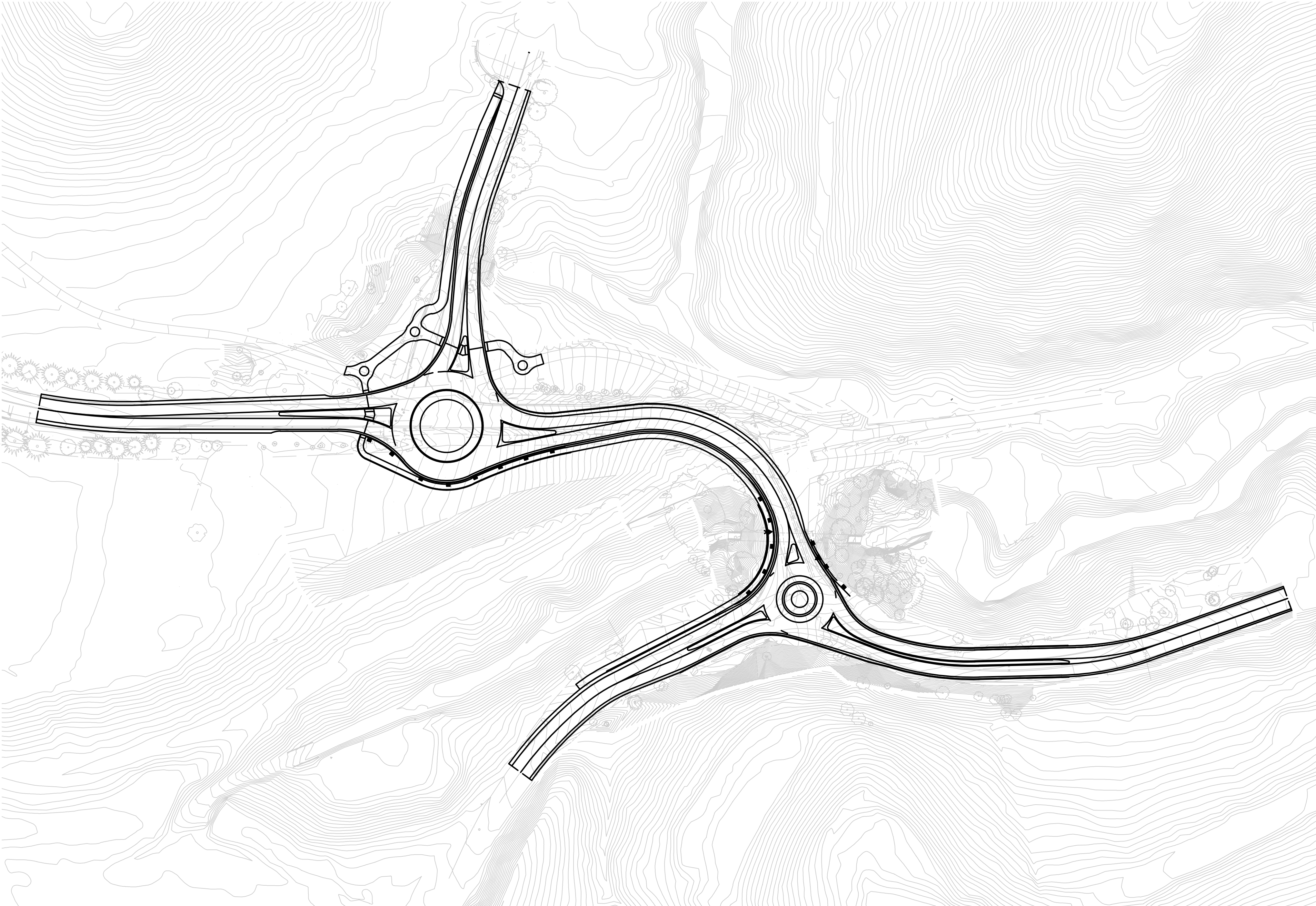

Source: Kimley-Horn, 2019

Figure 3: Site Plan

St Mary's Double Roundabouts Project

Not to scale

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2 ACOUSTIC FUNDAMENTALS

2.1 SOUND AND ENVIRONMENTAL NOISE

Acoustics is the science of sound. Sound can be described as the mechanical energy of a vibrating object transmitted by pressure waves through a medium (e.g., air) to human (or animal) ear. If the pressure variations occur frequently enough (at least 20 times per second), they can be heard and are called sound. The number of pressure variations per second is called the frequency of sound and is expressed as cycles per second, or hertz (Hz).

Noise is defined as loud, unexpected, or annoying sound. The fundamental acoustics model consists of a noise source, receptor, and the propagation path between the two. The loudness of the noise source, obstructions, or atmospheric factors affecting the propagation path, determine the perceived sound level and noise characteristics at the receptor. Acoustics deal primarily with the propagation and control of sound. A typical noise environment consists of ambient noise that is the sum of many distant and indistinguishable noise sources. Superimposed on this ambient noise is the sound from individual local sources. These sources can vary from an occasional aircraft or train passing by to continuous noise from traffic on a major highway. Perceptions of sound and noise are highly subjective from person to person.

Measuring sound directly in terms of pressure would require a large range of numbers. To avoid this, the decibel (dB) scale was devised. The dB scale uses the hearing threshold of 20 micropascals (μPa) as a point of reference, defined as 0 dB. Other sound pressures are then compared to this reference pressure, and the logarithm is taken to keep the numbers in a practical range. The dB scale allows a million-fold increase in pressure to be expressed as 120 dB, and changes in levels correspond closely to human perception of relative loudness. Table 1: Typical Noise Levels provides typical noise levels.

Table 1: Typical Noise Levels

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

Source: California Department of Transportation, *Technical Noise Supplement to the Traffic Noise Analysis Protocol*, September 2013.

Noise Descriptors

The dB 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. Several rating scales have been developed to analyze the adverse effect of community noise on people. Because environmental noise fluctuates over time, these scales consider that the effect of noise on people is largely dependent on the total acoustical energy content of the noise, as well as the time of day when the noise occurs. The equivalent noise level (L_{eq}) is the average noise level averaged over the measurement period, while the day-night noise level (L_{dn}) and Community Equivalent Noise Level (CNEL) are measures of energy average during a 24-hour period, with dB weighted sound levels from 7:00 p.m. to 7:00 a.m. Most commonly, environmental sounds are described in terms of L_{eq} that has the same acoustical energy as the summation of all the time-varying events. Each is applicable to this analysis and defined in Table 2: Definitions of Acoustical Terms.

Table 2: Definitions of Acoustical Terms

Term	Definitions
Decibel (dB)	A unit describing the amplitude of sound, equal to 20 times the logarithm to the base 10 of the ratio of the pressure of the sound measured to the reference pressure. The reference pressure for air is 20.
Sound Pressure Level	Sound pressure is the sound force per unit area, usually expressed in μPa (or 20 micronewtons per square meter), where 1 pascals is the pressure resulting from a force of 1 newton exerted over an area of 1 square meter. The sound pressure level is expressed in dB as 20 times the logarithm to the base 10 of the ratio between the pressures exerted by the sound to a reference sound pressure (e.g. 20 μPa). Sound pressure level is the quantity that is directly measured by a sound level meter.
Frequency (Hz)	The number of complete pressure fluctuations per second above and below atmospheric pressure. Normal human hearing is between 20 Hz and 20,000 Hz. Infrasonic sound are below 20 Hz and ultrasonic sounds are above 20,000 Hz.
A-Weighted Sound Level (dBA)	The sound pressure level in dB as measured on a sound level meter using the A-weighting filter network. The A-weighting filter de-emphasizes the very low and very high frequency components of the sound in a manner similar to the frequency response of the human ear and correlates well with subjective reactions to noise.
Equivalent Noise Level (L_{eq})	The average acoustic energy content of noise for a stated period of time. Thus, the L_{eq} of a time-varying noise and that of a steady noise are the same if they deliver the same acoustic energy to the ear during exposure. For evaluating community impacts, this rating scale does not vary, regardless of whether the noise occurs during the day or the night.
Maximum Noise Level (L_{max}) Minimum Noise Level (L_{min})	The maximum and minimum dBA during the measurement period.
Exceeded Noise Levels (L_{01}, L_{10}, L_{50}, L_{90})	The dBA values that are exceeded 1%, 10%, 50%, and 90% of the time during the measurement period.
Day-Night Noise Level (L_{dn})	A 24-hour average L_{eq} with a 10 dBA weighting added to noise during the hours of 10:00 p.m. to 7:00 a.m. to account for noise sensitivity at nighttime. The logarithmic effect of these additions is that a 60 dBA 24-hour L_{eq} would result in a measurement of 66.4 dBA L_{dn}.
Community Noise Equivalent Level (CNEL)	A 24-hour average L_{eq} with a 5 dBA weighting during the hours of 7:00 a.m. to 10:00 a.m. and a 10 dBA weighting added to noise during the hours of 10:00 p.m. to 7:00 a.m. to account for noise sensitivity in the evening and nighttime, respectively. The logarithmic effect of these additions is that a 60 dBA 24-hour L_{eq} would result in a measurement of 66.7 dBA CNEL.
Ambient Noise Level	The composite of noise from all sources near and far. The normal or existing level of environmental noise at a given location.
Intrusive	That noise which intrudes over and above the existing ambient noise at a given location. The relative intrusiveness of a sound depends on its amplitude, duration, frequency, and time of occurrence and tonal or informational content as well as the prevailing ambient noise level.

The A-weighted decibel (dBA) sound level scale gives greater weight to the frequencies of sound to which the human ear is most sensitive. Because sound levels can vary markedly over a short period of time, a method for describing either the average character of the sound or the statistical behavior of the variations must be utilized. Most commonly, environmental sounds are described in terms of an average level that has the same acoustical energy as the summation of all the time-varying events.

The scientific instrument used to measure noise is the sound level meter. Sound level meters can accurately measure environmental noise levels to within about plus or minus 1 dBA. Various computer models are used to predict environmental noise levels from sources, such as roadways and airports. The accuracy of the predicted models depends on the distance between the receptor and the noise source.

A-Weighted Decibels

The perceived loudness of sounds is dependent on many factors, including sound pressure level and frequency content. However, within the usual range of environmental noise levels, perception of loudness is relatively predictable and can be approximated by dBA values. There is a strong correlation between dBA and the way the human ear perceives sound. For this reason, the dBA has become the standard tool of environmental noise assessment. All noise levels reported in this document are in terms of dBA, but are expressed as dB, unless otherwise noted.

Addition of Decibels

The dB scale is logarithmic, not linear, and therefore sound levels cannot be added or subtracted through ordinary arithmetic. Two sound levels 10 dB apart differ in acoustic energy by a factor of 10. When the standard logarithmic dB is A-weighted, an increase of 10 dBA is generally perceived as a doubling in loudness. For example, a 70-dBA sound is half as loud as an 80-dBA sound and twice as loud as a 60-dBA sound. When two identical sources are each producing sound of the same loudness, the resulting sound level at a given distance would be 3 dBA higher than one source under the same conditions. Under the dB scale, three sources of equal loudness together would produce an increase of 5 dBA.

Sound Propagation and Attenuation

Sound spreads (propagates uniformly outward in a spherical pattern, and the sound level decreases (attenuates) at a rate of approximately 6 dB for each doubling of distance from a stationary or point source. Sound from a line source, such as a highway, propagates outward in a cylindrical pattern. Sound levels attenuate at a rate of approximately 3 dB for each doubling of distance from a line source, such as a roadway, depending on ground surface characteristics. No excess attenuation is assumed for hard surfaces like a parking lot or a body of water. Soft surfaces, such as soft dirt or grass, can absorb sound, so an excess ground-attenuation value of 1.5 dB per doubling of distance is normally assumed. For line sources, an overall attenuation rate of 3 dB per doubling of distance is assumed.

Noise levels may also be reduced by intervening structures; generally, a single row of buildings between the receptor and the noise source reduces the noise level by about 5 dBA, while a solid wall or berm reduces noise levels by 5 to 10 dBA. The way older homes in California were constructed generally provides a reduction of exterior-to-interior noise levels of about 20 to 25 dBA with closed windows. The exterior-to-interior reduction of newer residential units is generally 30 dBA or more.

Human Response to Noise

The human response to environmental noise is subjective and varies considerably from individual to individual. Noise in the community has often been cited as a health problem, not in terms of actual physiological damage, such as hearing impairment, but in terms of inhibiting general well-being and contributing to undue stress and annoyance. The health effects of noise in the community arise from interference with human activities, including sleep, speech, recreation, and tasks that demand concentration or coordination. Hearing loss can occur at the highest noise intensity levels.

Noise environments and consequences of human activities are usually well represented by median noise levels during the day or night or over a 24-hour period. Environmental noise levels are generally considered low when the CNEL is below 60 dBA, moderate in the 60 to 70 dBA range, and high above 70 dBA. Examples of low daytime levels are isolated, natural settings with noise levels as low as 20 dBA and quiet, suburban, residential streets with noise levels around 40 dBA. Noise levels above 45 dBA at night can disrupt sleep. Examples of moderate-level noise environments are urban residential or semi-commercial areas (typically 55 to 60 dBA) and commercial locations (typically 60 dBA). People may consider louder environments adverse, but most will accept the higher levels associated with noisier urban residential or residential-commercial areas (60 to 75 dBA) or dense urban or industrial areas (65 to 80 dBA). Regarding increases in dBA, the following relationships should be noted:

- Except in carefully controlled laboratory experiments, a 1-dBA change cannot be perceived by humans.
- Outside of the laboratory, a 3-dBA change is considered a just-perceivable difference.
- A minimum 5-dBA change is required before any noticeable change in community response would be expected. A 5-dBA increase is typically considered substantial.
- A 10-dBA change is subjectively heard as an approximate doubling in loudness and would almost certainly cause an adverse change in community response.

Effects of Noise on People

Hearing Loss

While physical damage to the ear from an intense noise impulse is rare, a degradation of auditory acuity can occur even within a community noise environment. Hearing loss occurs mainly due to chronic exposure to excessive noise but may be due to a single event such as an explosion. Natural hearing loss associated with aging may also be accelerated from chronic exposure to loud noise. The Occupational Safety and Health Administration has a noise exposure standard that is set at the noise threshold where hearing loss may occur from long-term exposures. The maximum allowable level is 90 dBA averaged over 8 hours. If the noise is above 90 dBA, the allowable exposure time is correspondingly shorter.

Annoyance

Attitude surveys are used for measuring the annoyance felt in a community for noises intruding into homes or affecting outdoor activity areas. In these surveys, it was determined that causes for annoyance include interference with speech, radio and television, house vibrations, and interference with sleep and rest. The L_{dn} as a measure of noise has been found to provide a valid correlation of noise level and the percentage of people annoyed. People have been asked to judge the annoyance caused by aircraft noise and ground transportation noise. There continues to be disagreement about the relative annoyance of these different sources. A noise level of about 55 dBA L_{dn} is the threshold at which a substantial percentage of people begin to report annoyance[1].

2.2 GROUNDBORNE VIBRATION

Sources of groundborne vibrations include natural phenomena (earthquakes, volcanic eruptions, sea waves, landslides, etc.) or man-made causes (explosions, machinery, traffic, trains, construction equipment, etc.). Vibration sources may be continuous (e.g. factory machinery) or transient (e.g. explosions). Ground vibration consists of rapidly fluctuating motions or waves with an average motion of zero. Several different methods are typically used to quantify vibration amplitude. One is the peak particle velocity (PPV); another is the root mean square (RMS) velocity. The PPV is defined as the maximum instantaneous positive or negative peak of the vibration wave. The RMS velocity is defined as the average of the squared amplitude of the signal. The PPV and RMS vibration velocity amplitudes are used to evaluate human response to vibration.

Table 3: Human Reaction and Damage to Buildings for Continuous or Frequent Intermittent Vibrations, displays the reactions of people and the effects on buildings produced by continuous vibration levels. The annoyance levels shown in the table should be interpreted with care since vibration may be found to be annoying at much lower levels than those listed, depending on the level of activity or the sensitivity of the individual. To sensitive individuals, vibrations approaching the threshold of perception can be annoying. Low-level vibrations frequently cause irritating secondary vibration, such as a slight rattling of windows, doors, or stacked dishes. The rattling sound can give rise to exaggerated vibration complaints, even though there is very little risk of actual structural damage. In high noise environments, which are more prevalent where groundborne vibration approaches perceptible levels, this rattling phenomenon may also be produced by loud airborne environmental noise causing induced vibration in exterior doors and windows.

Table 3: Human Reaction and Damage to Buildings from Vibration

Peak Particle Velocity (in/sec)	Approximate Vibration Velocity Level (VdB)	Human Reaction	Effect on Buildings
0.006-0.019	64-74	Range of threshold of perception	Vibrations unlikely to cause damage of any type
0.08	87	Vibrations readily perceptible	Recommended upper level to which ruins and ancient monuments should be subjected
0.1	92	Level at which continuous vibrations may begin to annoy people, particularly those involved in vibration sensitive activities	Virtually no risk of architectural damage to normal buildings
0.2	94	Vibrations may begin to annoy people in buildings	Threshold at which there is a risk of architectural damage to normal dwellings
0.4-0.6	98-104	Vibrations considered unpleasant by people subjected to continuous vibrations and unacceptable to some people walking on bridges	Architectural damage and possibly minor structural damage

Source: California Department of Transportation, *Transportation and Construction-Induced Vibration Guidance Manual*, 2004.

[1] Federal Interagency Committee on Noise, *Federal Agency Review of Selected Airport Noise Analysis Issues*, August 1992.

Ground vibration can be a concern in instances where buildings shake, and substantial rumblings occur. However, it is unusual for vibration from typical urban sources such as buses and heavy trucks to be perceptible. Common sources for groundborne vibration are planes, trains, and construction activities such as earth-moving which requires the use of heavy-duty earth moving equipment. For the purposes of this analysis, a PPV descriptor with units of inches per second (in/sec) is used to evaluate construction-generated vibration for building damage and human complaints.

3 REGULATORY SETTING

To limit population exposure to physically or psychologically damaging as well as intrusive noise levels, the Federal government, the State of California, various county governments, and most municipalities in the state have established standards and ordinances to control noise.

3.1 STATE OF CALIFORNIA

California Government Code

California Government Code Section 65302(f) mandates that the legislative body of each county and city adopt a noise element as part of its comprehensive general plan. The local noise element must recognize the land use compatibility guidelines established 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" noise levels for various land use types. Single-family homes are "normally acceptable" in exterior noise environments up to 60 CNEL and "conditionally acceptable" up to 70 CNEL. Multiple-family residential uses are "normally acceptable" up to 65 CNEL and "conditionally acceptable" up to 70 CNEL. Schools, libraries, and churches are "normally acceptable" up to 70 CNEL, as are office buildings and business, commercial, and professional uses.

3.2 LOCAL

Town of Moraga General Plan

The Moraga General Plan (2002) identifies goals and policies in the Noise Element that requires the Town to develop acoustical standards.

Goal: A peaceful and tranquil community.

OS6.1: Acoustical Standards. Develop acoustical standards that properly reflect acceptable sound emission levels.

OS6.2: Noise Levels. Ensure that noise from all sources is maintained at levels that will not adversely affect adjacent properties or the community, especially during evening and early morning hours. Reasonable exceptions may be made in the interest of public safely.

OS6.3: Noise Sensitive Uses. Locate uses where they will be most acoustically compatible with elements of the man-made and natural environment.

OS6.4: Noise Impacts of New Development. Ensure that new development will not raise noise levels above acceptable levels on the Town's arterials and major local streets.

OS6.5: Acoustical Data with Development Applications. Require the submittal of acoustical data, when and where appropriate, as part of the development application process so that the noise impacts of proposed uses can be properly evaluated and mitigated.

OS6.6: Temporary Noise Sources. Permit temporary noise-generating activities such as construction only for the shortest reasonable duration and in locations that will have the least possible effect.

OS6.7: Vehicle Noise. Require that vehicles, including those used for recreational purposes, be used in such a manner that they will not intrude on the peace and quiet of residential areas. Reasonable exceptions may be made in the interest of public safety.

OS6.8: Public Information on Noise Pollution. Whenever appropriate, use public information programs to educate the public on the value of an environment that is free of noise pollution.

Town of Moraga Municipal Code

The Town of Moraga does not establish noise level standards. However, Chapter 7.12 *Noise Control* in the Moraga Municipal Code highlights the requirements pertaining to noise. According to Section 7.12.090 construction within 500 feet of a residential zone should not use equipment in a manner that a reasonable person of normal sensitiveness residing in the area is caused discomfort or annoyance, particularly between the hours of 5:00 p.m. and 8:00 a.m. Additionally, it is unlawful for a person to install, use or operate a loudspeaker or sound amplifying equipment where it causes annoyance or discomfort (7.12.120).

4 EXISTING CONDITIONS

4.1 EXISTING NOISE SOURCES

The Town is impacted by various noise sources. Mobile sources of noise, especially cars and trucks are the most common and significant sources of noise. Other noise sources are the various land uses (i.e. residential, commercial, institutional, and recreational and parks activities) throughout the Town that generate stationary-source noise. Significant noise sources in the Project vicinity are existing traffic on St. Mary's Road, Rheem Boulevard, and Bollinger Canyon Road.

4.2 SENSITIVE RECEPTORS

Noise exposure standards and guidelines for various types of land uses reflect the varying noise sensitivities associated with each of these uses. Residences, hospitals, schools, guest lodging, libraries, and churches are treated as the most sensitive to noise intrusion and therefore have more stringent noise exposure targets than do other uses, such as manufacturing or agricultural uses that are not subject to impacts such as sleep disturbance. Sensitive receptors near the Project site includes primarily existing single-family communities. Table 4: Sensitive Receptors, lists the distances and locations of sensitive receptors within the Project vicinity.

Table 4: Sensitive Receptors

Receptor Description	Distance and Direction from the Project Site
Single-family residential	80 feet north
Single-family residential	100 feet south
Single-family residential	710 feet east
Burton Valley Elementary School	1.12 miles northeast
Donald L. Rheem Elementary School	1.3 miles northwest
Moraga Valley Presbyterian Church	1.5 miles west
Pat Vincent Memorial Field Park	100 feet southwest
Saint Mary's College of California	800 feet southwest

5 SIGNIFICANCE CRITERIA AND METHODOLOGY

5.1 CEQA THRESHOLDS

Appendix G of the California Environmental Quality Act (CEQA) Guidelines contains analysis guidelines related to noise impacts. These guidelines have been used by the Town to develop thresholds of significance for this analysis. A project would create a significant environmental impact if it would:

- Generate a substantial temporary or permanent increase in ambient noise levels in the vicinity of the project in excess of standards established in the local general plan or noise ordinance, or applicable standards of other agencies;
- Generate excessive groundborne vibration or groundborne noise levels; and
- For a project located within the vicinity of a private airstrip or an airport land use plan or, where such a plan has not been adopted, within two miles of a public airport or public use airport, expose people residing or working in the project area to excessive noise levels.

5.2 METHODOLOGY

Construction noise estimates are based upon noise levels from the FHWA and Federal Transit Administration (FTA) data as well as the distance to nearby receptors. Reference noise levels are used to estimate noise levels at nearby sensitive receptors based on a standard noise attenuation rate of 6 dB per doubling of distance (line-of-sight method of sound attenuation for point sources of noise). Construction noise level estimates do not account for the presence of intervening structures or topography, which may reduce noise levels at receptor locations. Therefore, the noise levels presented herein represent a conservative, reasonable worst-case estimate of actual temporary construction noise.

Groundborne vibration levels associated with construction-related activities for the Project were evaluated utilizing typical groundborne vibration levels associated with construction equipment, obtained from Federal Transit Administration (FTA) published data for construction equipment. Potential groundborne vibration impacts related to structural damage and human annoyance were evaluated, considering the distance from construction activities to nearby land uses and typically applied criteria for structural damage and human annoyance.

6 POTENTIAL IMPACTS AND MITIGATION

6.1 ACOUSTICAL IMPACTS

Threshold 6.1 Would the Project generate a substantial temporary or permanent increase in ambient noise levels in the vicinity of the Project in excess of standards established in the local general plan or noise ordinance, or applicable standards of other agencies?

Construction

Construction noise typically occurs intermittently and varies depending on the nature or phase of construction (e.g. land clearing, grading, excavation, paving). Noise generated by construction equipment, including earth movers, material handlers, and portable generators, can reach high levels. During construction, exterior noise levels could affect the residential neighborhoods surrounding the construction site. Project construction would occur adjacent to existing single-family residences to the east and west, with the closest receptors being approximately 100 feet away from construction. However, construction activities would occur throughout the Project site and would not be concentrated at a single point near sensitive receptors.

Construction activities would include demolition, site preparation, grading, paving, and architectural coating. Such activities would require graders, scrapers, and tractors during site preparation; graders, dozers, and tractors during grading; pavers, rollers, mixers, tractors, and paving equipment during paving; and air compressors during architectural coating. Typical operating cycles for these types of construction equipment may involve 1 or 2 minutes of full power operation followed by 3 to 4 minutes at lower power settings. Other primary sources of acoustical disturbance would be random incidents, which would last less than one minute (such as dropping large pieces of equipment or the hydraulic movement of machinery lifts). Noise generated by construction equipment, including earth movers, material handlers, and portable generators, can reach high levels. Typical noise levels associated with individual construction equipment are listed in Table 5: Typical Construction Noise Levels.

Table 5: Typical Construction Noise Levels

Equipment	Typical Noise Level (dBA) at 50 feet from Source	Typical Noise Level (dBA) at 80 feet from Source[1]	Typical Noise Level (dBA) at 100 feet from Source[1]
Air Compressor	80	76	74
Backhoe	80	76	74
Compactor	82	78	76
Concrete Mixer	85	81	77
Concrete Pump	82	78	76
Concrete Vibrator	76	72	79
Dozer	85	81	82
Generator	82	78	77
Grader	85	81	79
Impact Wrench	85	81	76
Jack Hammer	88	84	79
Loader	80	76	79
Paver	85	81	82
Pneumatic Tool	85	81	95
Pump	77	73	89
Roller	85	81	79
Saw	76	72	71

Table 5: Typical Construction Noise Levels

Equipment	Typical Noise Level (dBA) at 50 feet from Source	Typical Noise Level (dBA) at 80 feet from Source[1]	Typical Noise Level (dBA) at 100 feet from Source[1]
Scraper	85	81	84
Shovel	82	78	89
Truck	84	80	79

Note:
[1] Calculated using the inverse square law formula for sound attenuation: $dBA_2 = dBA_1 + 20Log(d_1/d_2)$
Where: dBA_2 = estimated noise level at receptor; dBA_1 = reference noise level; d_1 = reference distance; d_2 = receptor location distance

Source: Federal Transit Administration, *Transit Noise and Vibration Impact Assessment Manual*, September 2018.

As shown in Table 5, exterior noise levels resulting from construction site equipment could impact existing sensitive receptors in the vicinity. Sensitive uses near the Project include existing adjacent residential uses to the east and west as close as 80 feet from potential construction site noise sources. However, these noise sources are temporary and would occur during the daytime. Although construction noise would be acoustically dispersed throughout the Project site and not concentrated in one area near surrounding sensitive uses, mitigation is required to minimize impacts.

Mitigation Measure NOI-1 would ensure that all construction equipment is equipped with properly operating and maintained mufflers and other state required noise attenuation devices, helping to reduce noise at the source. The highest anticipated construction noise level of 97 dBA is expected to occur during the demolition phase. Mitigation Measures NOI-1 would attenuate construction site noise levels. Construction noise impacts would be less than significant with mitigation.

St. Mary's Road would remain open during construction; however, there may be temporary lane closures on St. Mary's Road, Rheem Boulevard, and Bollinger Canyon Road during non-commute times, and there may be one-way traffic control at night during stage construction switchovers. Access to adjacent and adjoining properties would be maintained during the duration of construction activities. Noise impacts during construction would be potentially significant. However, Mitigation Measure NOI-1 would further reduce construction vehicle trip noise because it requires construction equipment to be equipped with noise attenuation devices. Therefore, impacts due to construction vehicle trips would be less than significant.

Operations

Long-Term Mobile Noise Impacts

St. Mary's Road is an existing roadway with heavy congestion and inadequate intersection level of service (LOS). The Project would provide congestion relief at the St. Mary's Road and Rheem Boulevard and to improve stopping sight distance and visibility at the Rheem Boulevard and Bollinger Canyon Road intersections. The Project is proposed to alleviate the current congestion, reduce intersection delays and queues, improve multimodal safety and to better accommodate pedestrian and bicycle traffic.

The Project proposes improvements to two existing intersection Rheem Boulevard and Bollinger Canyon Road to alleviate traffic congestion. As stated above, construction of the proposed Project would include two roundabout intersection with diameters of 120 feet and 80 feet. Both roundabouts would have landscaped center medians, a circulating roadway and one lane approaches on St. Mary's Road. The Project does not propose any roadway expansions or additional lanes, and therefore would not increase vehicular capacity in the Project vicinity. Furthermore, the Project does not involve a trip generating land use. Thus, impacts would be less than significant in this regard. No mitigation is required.

Long-Term Stationary Noise Impacts

Construction noise impacts would cease upon Project completion. Long-term stationary source noise impacts would not occur because the Project would continue to operate at current noise levels and not cause an exceedance of an established noise standard. Moreover, no stationary equipment or other aboveground facilities would be constructed as part of the Project Therefore, no impact would occur in this regard.

Mitigation Measures:

NOI-1 Prior to Grading Permit issuance, the applicant shall demonstrate, to the satisfaction of the Town of Moraga Director of Public Works or Town Engineer that the Project complies with the following:

- Construction contracts specify that all construction equipment, fixed or mobile, shall be equipped with properly operating and maintained mufflers and other state required noise attenuation devices.
- Property owners and occupants located within 200 feet of the Project boundary shall be sent a notice, at least 15 days prior to commencement of construction of each phase, regarding the construction schedule of the proposed Project. A sign, legible at 50 feet shall also be posted at the Project construction site. All notices and signs shall be reviewed and approved by the Town of Moraga Development Services Department, prior to mailing or posting and shall indicate the dates and duration of construction activities, as well as provide a contact name and a telephone number where residents can inquire about the construction process and register complaints.
- Prior to issuance of any Grading or Building Permit, the Contractor shall provide evidence that a construction staff member will be designated as a Noise Disturbance Coordinator and will be present on-site during construction activities. The Noise Disturbance Coordinator is responsible for responding to local complaints about construction noise. When a complaint is received, the Noise Disturbance Coordinator shall notify the Town within 24-hours of the complaint, determine the cause (e.g. starting too early, bad muffler, etc.), and implement reasonable measures to resolve the complaint as deemed acceptable by the Public Works Department. All notices sent to residential units surrounding the construction site and all signs posted at the construction site shall include the contact name and the telephone number for the Noise Disturbance Coordinator.
- Prior to issuance of any Grading or Building Permit, the Project Applicant shall demonstrate to the satisfaction of the Town Engineer that construction noise reduction methods shall be used where feasible. These reduction methods include shutting off idling equipment, installing temporary acoustic barriers around stationary construction noise sources, maximizing the distance between construction equipment staging areas and occupied residential areas, and electric air compressors and similar power tools.

- Construction haul routes shall be designed to avoid noise sensitive uses (e.g. residences, convalescent homes, etc.) to the extent feasible.
- During construction, stationary construction equipment shall be placed such that emitted noise is directed away from sensitive noise receivers.

Level of Significance: Less than significant impact with mitigation.

Threshold 6.2 Would the Project generate excessive groundborne vibration or groundborne noise levels?

Construction

Since the Project will not have any groundborne vibration or noise associated with operational activities, increases in groundborne vibration levels from the Project would be primarily associated with short-term construction-related activities. Project construction has the potential to result in varying degrees of temporary groundborne vibration, depending on the equipment used and operations involved. The FTA has published standard vibration velocities for construction equipment operations. In general, the FTA architectural damage criterion for continuous vibrations (i.e. 0.2 in/sec) appears to be conservative. The types of construction vibration impacts include human annoyance and building damage. Human annoyance occurs when construction vibration rises significantly above the threshold of human perception for extended periods of time. Building damage can be cosmetic or structural. Ordinary buildings that are not particularly fragile would not experience cosmetic damage (e.g. plaster cracks) at distances beyond 30 feet. This distance can vary substantially depending on soil composition and underground geological layer between vibration source and receiver. In addition, not all buildings respond similarly to vibration generated by construction equipment. For example, for a building that is constructed with reinforced concrete with no plaster, the FTA guidelines show that a vibration level of up to 0.20 in/sec is considered safe and would not result in any construction vibration damage.

Table 6: Typical Construction Equipment Vibration Levels, lists vibration levels at 25 feet for typical construction equipment. Groundborne vibration generated by construction equipment spreads through the ground and diminishes in magnitude with increases in distance. As indicated in Table 7, based on FTA data, vibration velocities from typical heavy construction equipment operations that would be used during Project construction range from 0.003 to 0.089 in/sec PPV at 25 feet from the source of activity. The nearest sensitive receptors are the single-family residences approximately 80 feet from the active construction zone.

Table 6: Typical Construction Equipment Vibration Levels

Equipment	Peak Particle Velocity at 25 Feet (in/sec)	Peak Particle Velocity at 50 Feet (in/sec) [1]
Large Bulldozer	0.089	0.031
Loaded Trucks	0.076	0.027
Rock Breaker	0.059	0.021
Jackhammer	0.035	0.012
Small Bulldozer/Tractors	0.003	0.001

Notes:
1. Calculated using the following formula: $PPV_{equip} = PPV_{ref} \times (25/D)^{1.5}$, where: PPV_{equip} = the peak particle velocity in in/sec of the equipment adjusted for the distance; PPV_{ref} = the reference vibration level in in/sec from Table 7-4 of the Federal Transit Administration, *Transit Noise and Vibration Impact Assessment Manual*, 2018; D = the distance from the equipment to the receiver.

Source: Federal Transit Administration, *Transit Noise and Vibration Impact Assessment Manual*, September 2018.

As shown in Table 6, the highest vibration levels are achieved during demolition and grading. This construction activity is expected to take place during the removal of existing pavement. As construction would not located closer than 50 feet from adjacent sensitive receptors, construction equipment vibration velocities would not exceed the FTA's 0.20 PPV threshold. In general, other construction activities would occur throughout the Project site and would not be concentrated at the point closest to the nearest residential structure. Therefore, vibration impacts associated with the Project would be less than significant.

Mitigation Measures: No mitigation is required.

Level of Significance: Less than significant impact.

Threshold 6.3 For a Project located within the vicinity of a private airstrip or an airport land use plan or, where such a plan has not been adopted, within two miles of a public airport or public use airport, would the Project expose people residing or working in the Project area to excessive noise levels?

The nearest airports to the Project site are the Oakland International Airport located approximately 12 miles southwest of the Project and Buchanan Field Airport located approximately 10 miles northeast of the site. The Project is not within 2.0 miles of a public airport or within an airport influence zone. Additionally, there are no private airstrips located within the Project vicinity. Therefore, the Project would not expose people residing or working in the Project area to excessive airport- or airstrip-related noise levels and no mitigation is required.

Mitigation Measures: No mitigation is required.

Level of Significance: Less than significant impact.

6.2 CUMULATIVE NOISE IMPACTS

Noise by definition is a localized phenomenon, and drastically reduces as distance from the source increases. Cumulative noise impacts involve development of the Proposed Project in combination with ambient growth and other related development projects. As noise levels decrease as distance from the source increases, only projects in the nearby area could combine with the proposed Project to potentially result in cumulative noise impacts.

Cumulative Construction Noise

The Project's construction activities, when properly mitigated, would not result in a substantial temporary increase in ambient noise levels. The Town of Moraga does not have noise level standards, however it recommends construction not occur between 5:00 p.m. and 8:00 a.m. There would be periodic, temporary, noise impacts that would cease upon completion of construction activities. The Project would contribute to other proximate construction noise impacts if construction activities were conducted concurrently. However, based on the noise analysis above, the Project's construction-related noise impacts would be less than significant following compliance with local regulations and mitigation measures outlined in this study. Construction activities at other planned and approved projects would be required to take place during daytime hours, and the Town and project applicants would be required to evaluate construction noise impacts and implement mitigation, if necessary, to minimize noise impacts. Each project would be required to comply with the applicable Town of Moraga Municipal Code limitations on allowable hours of construction. Therefore, Project construction would not contribute to cumulative impacts and impacts in this regard are not cumulatively considerable.

Cumulative Operational Noise

As discussed above, operational noise caused by the proposed Project would be less than significant. The proposed Project is a roadway improvement project and therefore would not generate new noise sources. The Project's cumulative noise contribution would be less than significant. Thus, cumulative operational noise impacts from related projects, in conjunction with Project specific noise impacts, would not be cumulatively significant.

7 REFERENCES

1. California Department of Transportation, *California Vehicle Noise Emission Levels*, 1987.
2. California Department of Transportation, *Traffic Noise Analysis Protocol*, 2011.
3. California Department of Transportation, *Technical Noise Supplement to the Traffic Noise Analysis Protocol*, 2013.
4. California Department of Transportation, *Transportation Related Earthborne Vibrations*, 2002.
5. California Department of Transportation, *Transportation and Construction-Induced Vibration Guidance Manual*, 2004.
6. Town of Moraga, *General Plan*, 2002.
7. Town of Moraga, *Municipal Code*, 2019.
8. Federal Highway Administration, *Roadway Construction Noise Model*, 2006.
9. Federal Highway Administration, *Roadway Construction Noise Model User's Guide Final Report*, 2006.
10. Federal Interagency Committee on Noise, *Federal Agency Review of Selected Airport Noise Analysis Issues*, 1992.
11. Federal Transit Administration, *Transit Noise and Vibration Impact Assessment Manual*, September 2018.
12. United States Environmental Protection Agency, *Protective Noise Levels (EPA 550/9-79-100)*, 1979.