AECOM

Islais Creek Bridge Replacement Project Construction Noise/Vibration Technical Memorandum (San Francisco, CA)

04-SF-0-CR, Existing Bridge No. 34C0024
Federal Project No. BHLO-5934 (168)

Prepared for:
Caltrans/San Francisco Public Works

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Acronyms and Abbreviations

ANSI	American National Standards Institute
dB	decibel
dBA	A-weighted decibels
Caltrans	California Department of Transportatiaon

EPA	United States Environmental Protection Agency
FTA	Federal Transit Administration
Hz	Hertz
in/sec	inch per second
ISO	International Organization for Standardization
LDL	Larson-Davis Laboratories
L_{eq}	equivalent noise level, an average of the sound energy occurring over a specified time period
L_{dn}	day-night sound level
L_{max}	maximum noise level, the highest instantaneous sound level measured during a specified period
LRT	light-rail transit
LT	long-term
µPa	micro-Pascals
OSHA	Occupational Safety and Health Administration
PC/PS	precast/prestressed
PPV	peak particle velocity
RMS	root mean square
SFMTA	San Francisco Municipal Transportation Agency
SLM	sound level meter
SPL	Sound Pressure Level
VdB	vibration decibel levels

1. Introduction

The purpose of this Construction Noise/Vibration Technical Memorandum is to identify potential noise and vibration impacts that may result from the proposed Islais Creek Bridge Replacement Project. The project is a not a Type I project as defined by Title 23 Code of Federal Regulations 772.5. Therefore, a Noise Study Report is not required, and this analysis is limited to potential construction-related noise and vibration impacts.

San Francisco Public Works (SFPW) is proposing to replace the superstructure of the Islais Creek Bridge (Bridge No. 34C0024) (officially named the Levon Hagop Nishkian Bridge) along Third Street in the City and County of San Francisco (CCSF). The bridge is approximately 1,700 feet east of Interstate 280, and approximately 3,300 feet west of San Francisco Bay (the Bay). The bridge spans the Islais Creek Channel, a dredged, channelized, tidal embayment with predominantly armored shorelines that extends from the Bay to the site of the former outfall of the now culverted and buried Islais Creek.

The existing bridge is a double-leaf bascule structure (drawbridge) constructed in 1949 with an open steel-grate roadway draining to the bay, and concrete abutments. It is approximately 114 feet long and 100 feet wide. A California Department of Transportation evaluation in 2004 determined that the bridge was significant as an example of Art Moderne style applied to a bridge.

The project area is very susceptible to seismic liquefaction and the condition of the bridge's structural system is poor. The bridge originally carried only vehicular traffic, but now additionally carries MUNI light-rail tracks. The deteriorated condition of the bridge makes the bridge deck susceptible to vibration induced by heavy vehicles, trucks, and light-rail vehicles crossing the span.

The areas surrounding Islais Creek are at risk of flooding from heavy rainfall events, coastal storm surge, and wave hazards, which will be exacerbated by sea-levels rise and rising groundwater. The steel sections of the bridge are increasingly subject to the deleterious effects of corrosion and saltwater intrusion.

The Standard Project Alternative will remove the existing drawbridge leaves, which have not been opened for navigation for over ten years, and all other drawbridge features. These will be replaced by a single-span concrete through-girder bridge with a concrete deck at a higher elevation to improve freeboard for flood flows and to accommodate sea-level rise.

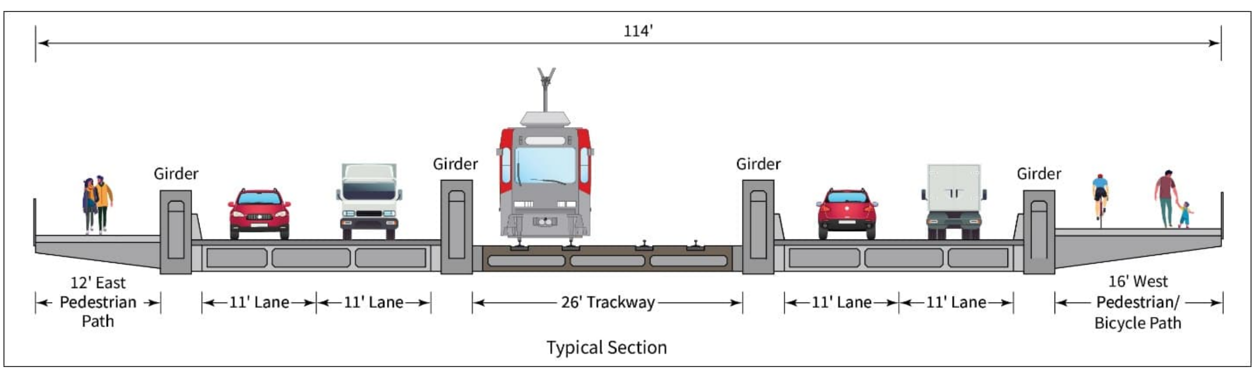


Figure 1 Proposed Bridge Cross Section

In addition to dedicated light-rail-vehicle trackways and two 11-foot travel lanes in each direction, the bridge will support a 12-foot-wide pedestrian path on its eastern side and a 16-foot-wide Class I shared pedestrian/bicycle path on its western side. The reconstructed trackway and roadway will be designed to convey surface runoff to the existing combined sewer/stormwater system. The control tower will be demolished down to the sidewalk level and the remaining portion will be used to create a public observation platform.

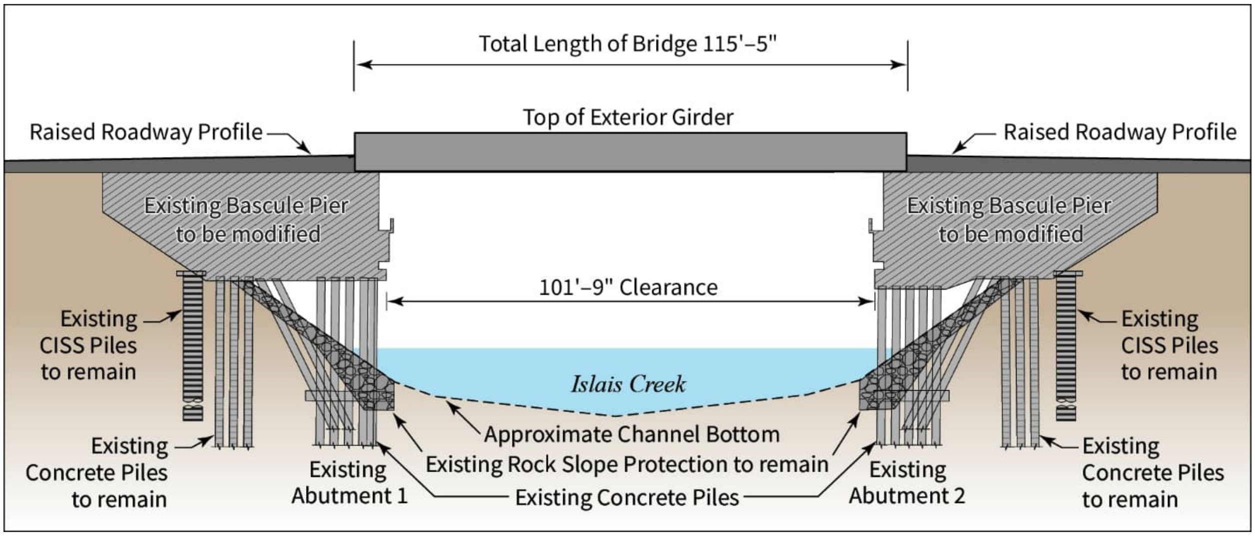


Figure 2 Proposed Bridge Longitudinal Section

The project's accommodation of a shared bicycle/pedestrian facility (Class I or Class IV) is based on advanced planning between the San Francisco Public Utilities Commission, Port of San Francisco, and the San Francisco Municipal Transportation Agency in response to opportunities presented by the removal of the bridge's drawbridge function per the City's *Islais Creek Southeast Mobility Adaptation Strategy*). Although not yet officially designated a bicycle facility, the Islais Creek Bridge and portion of Third Street connecting to Cargo Way will be adopted as part of the updated San Francisco Bicycle Network and citywide active transportation plan that is currently under way and expected to be completed in 2024.

Besides the **Standard** project alternative described above, there are two other alternatives under consideration.

Under the project's **No Build Alternative**, no modifications will be made to the Islais Creek Bridge; only routine maintenance will be performed. Deterioration will continue to be addressed through short-term remedies but existing bridge structural and seismic deficiencies will remain and worsen. There will be no increase in bridge freeboard, so flood risks to the bridge and light-rail operations will remain and will increase with sea-level rise.

The **Partial Preservation Alternative** includes the project features described above for the Proposed Project, but will include salvage, rehabilitation, and reinstallation of as many of the historic character-defining features of the original bridge as feasible. If it is determined that for reasons of safety, construction standards, or sound engineering practice any of the character-defining features are not salvageable for reinstallation, these elements will be replicated with substitute materials to recreate the historic appearance. The Control Tower will be retained, its foundation and window system retrofitted, and its damaged concrete repaired.

A more extensive description of the project and its alternatives is available in the project's Environmental Assessment.

Construction will last 24 months and is assumed to begin no sooner than spring 2025. Bridge closure is expected to last the duration of construction. Detours that will route traffic to arterials that have capacity for the additional vehicles will be established to re-route traffic around the construction site. Detour routes will be developed during final design. The City of San Francisco will develop plans for substitute forms of transit to provide a comparable level of service during construction. The most probable replacement for disrupted light-rail service is a temporary bus service. Construction is anticipated to use typical eight-hour work shifts during daylight hours; nighttime and weekend construction is not anticipated. In addition to staging areas on the bridge approaches and on anchored barges, three potential off-site construction staging area options owned by the Port of San Francisco that are currently used for Port-related industrial purposes have been identified.

To assist with the terminology and metrics used to describe noise, please refer to Appendix A. This appendix includes a glossary of acoustical terms used throughout this report to characterize the noise environment in the project area, and definitions that help frame the discussion of project-generated noises and their potential effect on the neighboring community. Appendix B describes applicable noise guidelines and standards that help identify when changes in noise levels may have adverse effects. Various agencies have established noise guidelines and standards to protect citizens from potential hearing damage and other adverse physiological and social effects associated with noise and vibration. Appendix B provides a discussion of federal, State, and local noise regulations and guidelines. This information is intended to provide the regulatory context against which existing and future noise conditions can be compared. Field survey photos are provided in Appendix C.

2. Regulatory Setting

The National Environmental Policy Act (NEPA) of 1969 provides the broad basis for analyzing and abating highway traffic noise effects. The intent of this law is to promote the general welfare and to foster a healthy environment. The requirements for noise analysis and consideration of noise abatement under NEPA are described below.

2.1 National Environmental Policy Act and 23 CRF 772

For highway transportation projects with Federal Highway Administration (FHWA) involvement (and the Department, as assigned), the Federal-Aid Highway Act of 1970 and its implementing regulations (23 CFR 772) govern the analysis and abatement of traffic noise impacts. The regulations require that potential noise impacts in areas of frequent human use be identified during the planning and design of a highway project. The regulations include noise abatement criteria (NAC) that are used to determine when a noise impact would occur. The NAC differ depending on the type of land use under analysis. For example, the NAC for residences (67 dBA) is lower than the NAC for commercial areas (72 dBA). The following table lists the noise abatement criteria for use in the NEPA/23 CFR 772 analysis.

Table 1: Noise Abatement Criteria		
Activity Category	**NAC, Hourly A- Weighted Noise Level, Leq(h)**	**Description of activity category**
A	57 (Exterior)	Lands on which serenity and quiet are of extraordinary significance and serve an important public need and where the preservation of those qualities is essential if the area is to continue to serve its intended purpose.
B[1]	67 (Exterior)	Residential.
C[1]	67 (Exterior)	Active sport areas, amphitheaters, auditoriums, campgrounds, cemeteries, day care centers, hospitals, libraries, medical facilities, parks, picnic areas, places of worship, playgrounds, public meeting rooms, public or nonprofit institutional structures, radio studios, recording studios, recreation areas, Section 4(f) sites, schools, television studios, trails, and trail crossings.
D	52 (Interior)	Auditoriums, day care centers, hospitals, libraries, medical facilities, places of worship, public meeting rooms, public or nonprofit institutional structures, radio studios, recording studios, schools, and television studios.
E	72 (Exterior)	Hotels, motels, offices, restaurants/bars, and other developed lands, properties, or activities not included in A–D or F.
F	No NAC—reporting only	Agriculture, airports, bus yards, emergency services, industrial, logging, maintenance facilities, manufacturing, mining, rail yards, retail facilities, shipyards, utilities (water resources, water treatment, electrical, etc.), and warehousing.
G	No NAC—reporting only	Undeveloped lands that are not permitted.

[1] Includes undeveloped lands permitted for this activity category.

Figure 3 lists the noise levels of common activities to enable readers to compare the actual and predicted highway noise levels discussed in this section with common activities.

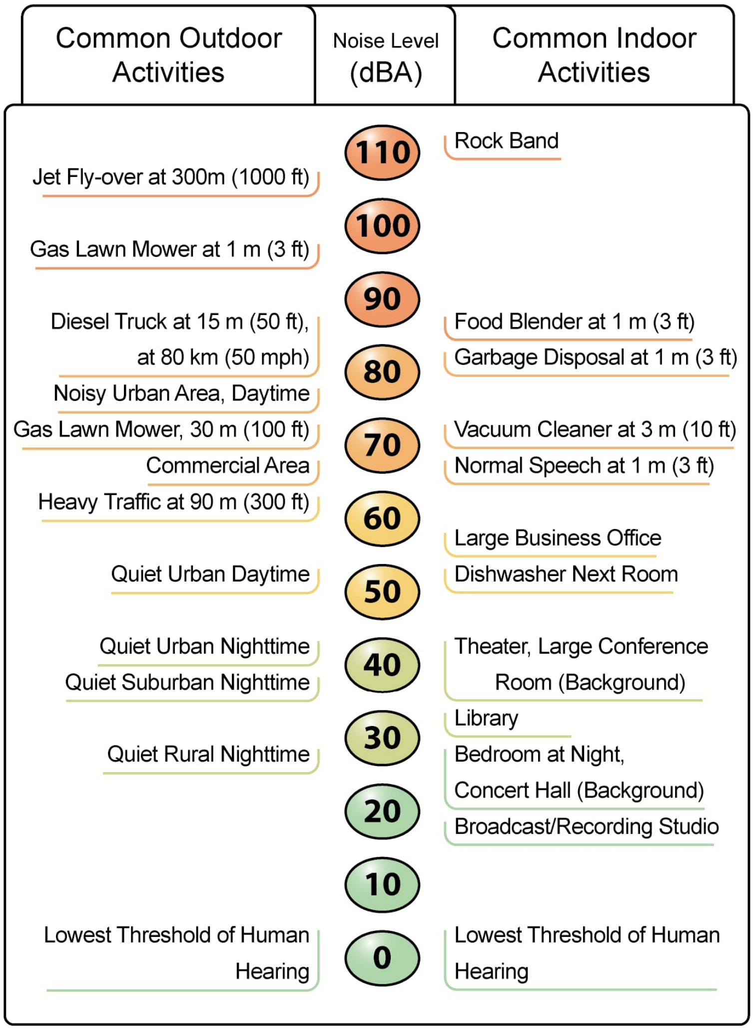


Figure 3: Noise Levels of Common Activities

According to the Department's Traffic Noise Analysis Protocol for New Highway Construction and Reconstruction Projects, May 2011, a noise impact occurs when the predicted future noise level with the project substantially exceeds the existing noise level (defined as a 12 dBA or more) or when the future noise level with the project approaches or exceeds the NAC. A noise level is considered to approach the NAC if it is within 1 dBA of the NAC.

If it is determined that the project will have noise impacts, then potential abatement measures must be considered. Noise abatement measures that are determined to be reasonable and feasible at the time of final design are incorporated into the project plans and specifications. This document discusses noise abatement measures that would likely be incorporated in the project.

The Department's Traffic Noise Analysis Protocol sets forth the criteria for determining when an abatement measure is reasonable and feasible. Feasibility of noise abatement is basically an engineering concern. Noise abatement must be predicted to reduce noise by at least 5 dB at an impacted receptor to be considered feasible from an acoustical perspective. It must also be possible to design and construct the noise abatement measure for it to be considered feasible. Factors that affect the design and constructability of noise abatement include, but are not limited to, safety, barrier height, topography, drainage, access requirements for driveways, presence of local cross streets, underground utilities, other noise sources in the area, and maintenance of the abatement measure. The overall reasonableness of noise abatement is determined by the following three factors: 1) the noise reduction design goal of 7 dB at one or more impacted receptors; 2) the cost of noise abatement; and 3) the viewpoints of benefited receptors (including property owners and residents of the benefited receptors).

3. Ambient Noise Measurements

3.1 Existing Noise Sources

The existing noise environment in the vicinity of the project is influenced by surface transportation and natural sources (wind, birds, etc.). Noise levels in the project area are affected by light rail operations and by vehicular traffic along 3rd Street, and the distant Interstate 280, which runs to the west of the project site.

3.2 Noise-Sensitive Land Uses

Noise-sensitive land uses are those uses for which quiet is an essential element of the purpose and function of the subject land use. Residential uses are of primary concern because of the potential for increased and prolonged exposure of individuals to both interior and exterior noise levels. Schools, places of worship, hotels, libraries, health facilities, and other places where low interior noise levels are essential are also considered noise-sensitive land uses. Parks, historic sites, cemeteries, and recreation areas are also considered sensitive to increases in exterior noise levels.

Land uses in the project area are a mix of commercial and light industrial. There is a San Francisco Municipal Transportation Agency (SFMTA) bus facility northwest of the bridge, a fire station (San Francisco Fire Station 25) in the southeastern quadrant, and a concrete batch plant and Port of San Francisco uses east of the bridge. Several wastewater treatment system assets are situated along the channel. The San Francisco Public Utilities Commission outfall from the Southeast Treatment Plant, and the Booster Pump Station are just southwest of the bridge. The outfall pipes run across the creek adjacent to the bridge (below the channel) and along the northern side of the channel to the Bay.

Bayview Gateway (which includes Rosa Parks Skate Plaza) on Illinois Street north of Cargo Way, Tulare Park on the north side of the channel between Third Street and Illinois Street, and Islais Creek Park at the corner of Third Street and Arthur Avenue are park, open space, and recreational areas owned and administered by the Port of San Francisco. Islais Creek Park also includes a high-freeboard dock accessible by gangway from the park.

Noise-sensitive receptors in the vicinity of the project site include single-family and multi-family residential uses, parks, and the Bayview Health Clinic.

3.3 Methodology

After a preliminary review of online aerial imagery and the project's design plans, several field noise survey location candidates were identified in the project vicinity. Four long-term (LT) and two short-term (ST) measurements were made to define ambient conditions in the project vicinity during the daytime and the nighttime hours. Noise-level measurements were completed using a Larson Davis Laboratories (LDL) Model 820 and 831 precision integrating sound-level meter. This equipment complies with all pertinent requirements of the American National Standards Institute for Class 1 sound-level meters (ANSI S1.4). Outdoor ambient noise level surveys were conducted on July 13 and 14, 2022, to document the noise environment. These surveys included the following activities:

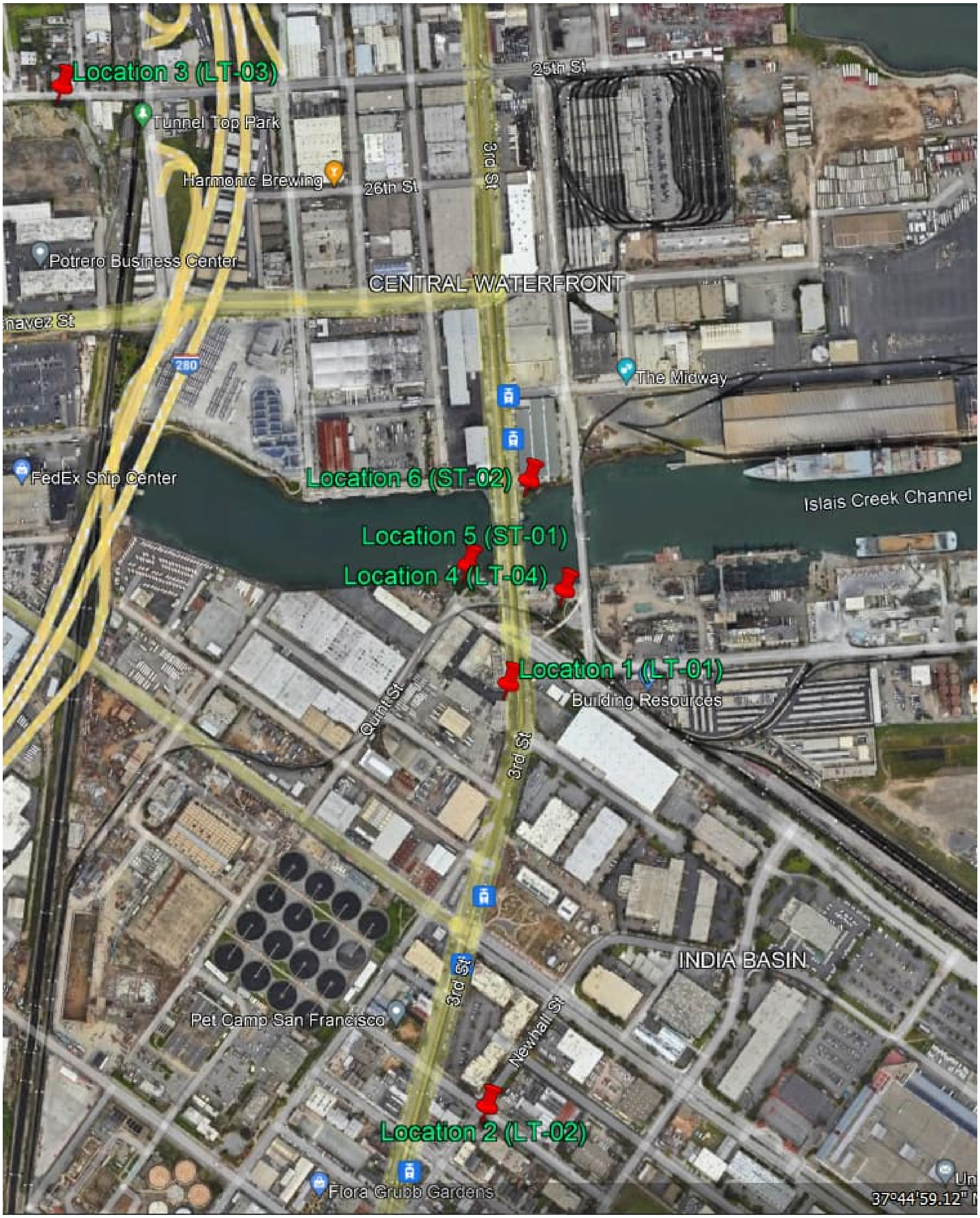
- Noise measurement locations were surveyed, selected, and planned for safe access and secure settings for sound level meters.
- LT measurement sets were deployed and left unattended between setup and retrieval (at least 24 hours).
- ST measurement sets over 15 minutes were completed.
- The meters were calibrated before the measurements using an LDL Model CAL200 acoustical calibrator.
- Sound pressure level (SPL) measurements were conducted using LDL Model 820 and 831 sound level meters (SLMs), all rated by the ANSI as Type 1 per ANSI S1.4-1983.
- SLM microphones were fitted with standard 3.5-inch-diameter spherical-shaped open-cell foam windscreens positioned roughly 5 feet above the ground.
- SLMs were set using slow time-response and the A-weighting scale.
- Where not already described, the sound level measurements were conducted in a manner guided by applicable portions of International Organization for Standardization (ISO) 1996 (parts 1, 2, and 3) standards (ISO 1982, 1987a, 1987b).

Photographs of the measurement locations, showing SLM installations, are provided in Appendix C.

3.4 Noise Survey Results

Ambient noise level survey locations are shown in Figure 4. The results for each noise level measurement location are summarized in Table 2.

As shown in Table 2, average daytime hourly noise levels documented during the 24-hour measurements ranged from approximately 62 A-weighted decibel (dBA) noise-level equivalent (L_{eq}) to 68 dBA L_{eq}, with maximum noise levels between 68 and 89 dBA maximum noise level (L_{max}). Average nighttime hourly noise levels documented during the 24-hour measurements ranged from approximately 57 dBA L_{eq} to 63 dBA L_{eq}, with maximum noise levels between 75 and 82 dBA L_{max}.



Red Pins = Noise Measurement Sites

Figure 4 Noise Survey Locations for the Project

Table 2 Summary of Ambient Noise Level Survey Results (dBA) – July 2022

Site	Land Use	Address	Date		Start Time	Duration	Daytime (7 a.m.– 7 p.m.)		Nighttime (7 p.m.– 7 a.m.)		L_{dn}
			From	To			L_{eq}	L_{max}	L_{eq}	L_{max}	
LT-01	Health Facility	Bayview Health Clinic	7/14/22	7/13/22	14:30	24 Hours	68.0	88.9	63.1	82.4	70.6
LT-02	Residential	Southwest corner of Newhall Street and Galvez Avenue	7/14/22	7/13/22	15:30	24 Hours	62.6	84.5	58.6	76.5	65.8
LT-03	Residential	Across 1506 25th Street	7/14/22	7/13/22	16:30	24 Hours	64.7	86.8	61.2	81.7	68.3
LT-04	Office/Park	By Fire Station	7/14/22	7/13/22	17:00	24 Hours	67.1	80.4	57.4	74.7	67.2
ST-01	Park	Islais Creek Park	7/14/22		15:13	15:00 min utes	61.6	68.2	N/A	N/A	N/A
ST-02	Park	Bayview Health Clinic	7/14/22		15:38	15:00 min utes	65.7	78.3	N/A	N/A	N/A

Notes:

dBA = A-weighted Decibel
L_{dn} = day-night sound level
L_{eq} = noise-level equivalent
L_{max} = maximum noise level
N/A = not applicable

4. Short-Term Project Construction Noise and Potential Noise Reduction Measures

The construction methods and schedule for either the Standard Project Alternative or the Partial Preservation Alternative would be similar and would therefore result in similar construction noise impacts. As such, they are and are not discussed separately in this section.

A variety of trades would be active at the construction site during the different phases of the work, including forepersons, carpenters, iron workers, laborers, and equipment operators. It is anticipated that the total number of workers active on the site at a given time would vary from 10 to 40 individuals, with an average of 20 workers over the 18- to 24-month duration.

The following types of construction equipment would be used during demolition of the existing bridge and construction of the new bridge:

- barges
- concrete trucks
- asphalt rollers
- Prestressing Jacks
- Impact wrenches
- air compressor
- air tools
- asphalt pavers
- bituminous distributors
- brooms and sweeping equipment
- hand-guided compactors
- concrete pumps
- concrete vibrators
- curb-extrusion machines
- electric generators and light plants
- electric-powered hand tools

- graders
- demolition hammers
- crawler-mounted hydraulic cranes and excavators
- truck-mounted hydraulic cranes and excavators
- hydraulic personnel lifts and aerial-work platforms
- pile-driving template
- rubber-tire loaders
- diamond-blade pavement grinders
- tungsten-carbide-bit pavement grinders
- water hose pumps
- rubber-tire rollers
- vibratory rollers
- concrete and masonry saws
- crawler cranes
- truck-mounted cranes
- rubber-tire tractors
- equipment trailers
- trenching machines
- truck trailers
- dump trucks
- welding equipment
- vibratory pile hammer
- CIDH and pipe pile drilling equipment

Construction noise levels would fluctuate depending on the type, number, and duration of use for the various pieces of construction equipment. The effects of construction noise largely depend on the type of construction activities occurring on any given day, noise levels generated by those activities, distances to noise-sensitive receptors, and the existing ambient noise environment in the receptor’s vicinity.

Accounting for the use factor of individual pieces of equipment, project-related construction activities would generate a combined noise level of up to 87 dB L_{eq} at a distance of 50 feet by the simultaneous operation of the loudest pieces of equipment (see Table 4 and Appendix D). The nearest noise-sensitive land uses in the vicinity of the project are the daytime land uses at approximately 100 to 450 feet from construction activities (LT-01, LT-04, ST-01, and ST-02). Table 3 summarizes noise levels and construction noise thresholds for the measurement locations. As shown, project noise would exceed the applicable threshold for daytime uses represented by ST-01, and ST-02, and at daytime and nighttime use represented by LT-04.

Table 3 City-Defined Maximum Acceptable Noise Levels for Measurement Sites

Site	Land Use	Distance (Feet)	Threshold[1] (dB) Daytime/Nighttime	Project Noise Level, dBA, L_{eq}	Daytime Compatible?	Nighttime Ambient Noise Level, dBA, L_{eq}	Nighttime Compatible?
LT-01	Health Facility	450	80 dB	68	Yes	63.1	NA
LT-02	Residential	2,400	80 dB/Ambient + 5 dB	53	Yes	58.6	Yes
LT-03	Residential	2,500	80 dB/Ambient + 5 dB	53	Yes	61.2	Yes
LT-04	Office/Park	100	80 dB/Ambient + 5 dB	81	No	57.4	No
ST-01	Park	200	80 dB	75	Yes	N/A	NA
ST-02	Park	100	80 dB	81	No	N/A	NA

Notes:

1. See Appendix B, Construction Noise Thresholds

dB = decibels
L_{eq} = noise-level equivalent
N/A = not applicable

Construction could expose existing off-site sensitive receptors to equipment noise levels that result in a substantial temporary increase over ambient noise levels, causing annoyance and/or sleep disruption to occupants of the nearby existing noise-sensitive land uses. As shown in Table 3, project construction noise would exceed the ambient levels by 3 to 16 decibels (dB) at the noise-sensitive uses in the project vicinity.

Table 4 Ambient and Project Construction Noise Levels at Closest Sensitive Receptors

Receiver	Distance (feet) Between Noise-Sensitive Receiver locations and Proposed Construction Areas	Exterior Noise Level– Daytime Ambient Noise, dBA L_{eq}	Exterior Noise Level– Project Noise, dBA L_{eq}	Ambient + Project, dB	Increase above Ambient, dB
LT-01	450	68.0	68	71	3
LT-02	2,400	62.6	53	63	0
LT-03	2,500	64.7	53	65	0
LT-04	100	67.1	81	81	14
ST-01	200	61.6	75	75	14
ST-02	100	65.7	81	81	16

Notes:

dB = decibels
dBA = A-weighted decibel
Leq = noise-level equivalent
LT = Long-Term (24-hour) Measurement
ST= Short-Term (15 minutes) Measurement

Sources: Modeled by AECOM 2022; See Appendix D for modeling input parameters and output results.

Although construction would be of short duration, San Francisco Public Works will minimize noise caused by construction operations and employ abatement measures as necessary for protection of employees and the public. Such measures will include advance notification to the public detailing when construction will occur, the duration of construction activities, and where and who to contact for additional information or concerns; noise monitoring during construction, and complaint response procedures.

The following additional noise reduction measures in Table 5 could be considered by SFPW to reduce construction noise. These measures could be used individually or in combination to reduce construction noise. Measures 1 through 4 could be applied throughout the construction site. Measures 5 and 6 may be considered depending on the space available; the effectiveness of Measures 5 and 6 depends on blocking the line of sight from the sensitive receptors (i.e., the residents) and the noise source(s). Measure 7 applies the noise reduction measure to the receptor rather than the source, and may be less practicable.

Table 5 Possible Construction Noise Reduction Measures (Mitigation Measures 1)

Noise Control Measure	Potential Noise Reduction (in dB)
1. Maintain construction equipment per manufacturers' specifications and fitted with feasible noise suppression devices (e.g., mufflers, silencers, wraps). Shroud or shield all impact tools, and muffle or shield all intake and exhaust ports on power equipment.	5
2. Use less-noisy equipment (e.g., replace gasoline- or diesel-powered equipment with electric-powered equipment or use newer or smaller equipment).	5
3. Turn off construction equipment when not in use and do not idle for extended periods of time (more than 5 minutes) near noise-sensitive receptors.	5
4. Use noise control blanket barriers to shield or surround the construction equipment.	5
5. Locate fixed/stationary equipment (e.g., compressors, generators) as far as practicable from noise-sensitive receptors.	Depends on the distance from sensitive receptors and whether line-of-sight to the equipment from the receptor is interrupted or blocked. Doubling the distance would result in a 6 dB reduction.
6. Erect 12-foot-high (or as high as needed to block the equipment noise from direct line-of-sight to the sensitive receptor) plywood or similar material noise barrier with sound blankets or curtains between the construction area and the sensitive receptors.	10 to 15 Depends on available space to erect barriers and supports
7. Implement noise control by temporarily improving the noise reduction capability of residences (e.g., affixing sound curtains).	5 to 10 Last resort measure due to costs, residents' consent, and the number of units fronting the project.

5. Construction Vibration

The construction methods and schedule for either the Standard Project Alternative or the Partial Preservation Alternative would be similar and would therefore result in similar impacts related to vibration. As such, they are not discussed separately in this section.

Construction activities have the potential to result in varying degrees of temporary groundborne vibration, depending on the specific construction equipment used, the location of construction activities relative to sensitive receptors, and the operations/activities involved. Vibration generated by construction equipment spreads through the ground and diminishes in magnitude with increases in distance. The type and density of soil can also affect the transmission of energy. Table 6 provides vibration levels for high-vibration generating equipment that would be used during the demolition of the existing bridge and construction of the new bridge.

Table 6 Typical Vibration Levels for Construction Equipment

Equipment	PPV at 25 Feet (in/sec)	Approximate Lv (VdB) at 25 Feet
Hoe Ram	0.352	87
Jackhammer	0.138	79
Vibratory Roller	0.21	94

Sources: Caltrans 2020, FTA 2018

Notes:

in/sec = inches per second
Lv = the velocity level in decibels referenced to 1 micro-inch per second and based on the root-mean-square velocity amplitude
PPV = peak particle velocity
VdB = Vibration Decibel, logarithmic velocity unit

The movement and operation of the project's construction equipment may generate temporary groundborne vibration. The California Department of Transportation (Caltrans) has developed criteria that are commonly applied as an industry standard to determine the impacts of project vibration relative to human annoyance and structural damage. Caltrans determines that the vibration level of 80 vibration decibel levels (VdB; 0.04 inch per second [in/sec] peak particle velocity [PPV]) would be distinctly perceptible. Therefore, remaining less than 80 VdB at residential uses would avoid human annoyance. Also, Caltrans recommends staying below 0.3 in/sec PPV at older residential structures, and below 0.5 for new residential structures, to avoid structural damage (Caltrans 2020).

Vibratory rollers are frequently used for backfill and paving work. As shown in Table 6, vibratory rollers have a higher reference value of 0.21 in/sec PPV at 25 feet (Caltrans 2020). The vibration-sensitive uses (buildings) nearest to the construction sites are buildings approximately 50 feet away. The resulting vibration level from the vibratory roller would be 85 VdB and 0.074 in/sec PPV at a distance of 50 feet, which would be below the 0.5 in/sec PPV recommended by Caltrans for structural damage, and above the criteria of 80 VdB for annoyance. Therefore, short-term construction of the project would not exceed the threshold for structural damage, but would expose persons to or generate excessive groundborne noise or vibration.

Long-term project operation would not include any major new sources of groundborne noise or vibration that would be different from the existing condition, and the vibration levels would not increase due to project operation.

Mitigation Measure 2: Implement Vibration Control Measures

The lead agency and the general construction contractor would implement the following measures to reduce construction-generated vibration.

- Place stationary construction equipment as far as possible from developed areas.
- Use smaller construction equipment when practical, particularly smaller vibratory rollers that are as small as practicable, or have adjustable vibratory force features.
- Locate loading areas, staging areas, vibration-generating equipment, etc., as far as feasible from sensitive receptors.
- Prohibit the use of vibratory rollers close to structures, as practical.

- If vibratory rollers are required to be used and need to be used within 110 feet of structures, the contractor must use a vibratory roller whose vibratory force can be turned down or turned off.
- Prohibit using vibratory rollers during nighttime hours (7 p.m. to 7 a.m.) to avoid annoyance.
- Designate a “noise disturbance coordinator” who will be responsible for responding to any local complaints about construction vibration. The disturbance coordinator will determine the cause of any vibration complaint (e.g., human annoyance and structural damage) and require that reasonable measures be implemented to correct the problem. Post the disturbance coordinator’s telephone number at the construction site.

Implementation of Mitigation Measure 2 would serve to minimize vibration levels on adjacent land uses by ensuring that the associated equipment is operated properly, only when necessary, and as far as possible from the structures; by maximizing the distance between construction equipment and nearby uses; by using smaller construction equipment; and by designating a vibration disturbance coordinator who will be responsible for responding to any local complaints. Also, if a vibratory roller is required to be used and needs to be used within 110 feet of structures, the contractor will use a vibratory roller whose vibratory force can be turned down or turned off. Use of vibratory rollers will be avoided during nighttime hours, when vibration annoyance is likely to disturb residents who are sleeping.[1] These mitigation measures would reduce project-related construction vibration levels to below the applicable thresholds.

6. Statement of Limitations

This technical report is for the sole use and benefit of AECOM, Caltrans, and their authorized representatives. The scope of services performed in execution of this effort may not be appropriate to satisfy the needs of other users, and any use or reuse of this document or the findings, conclusions, or recommendations presented herein is at the sole risk of said user. No expressed or implied representation or warranty is included or intended in this document, except that the work was performed with the customary thoroughness and competence of professionals working in the same area on similar projects.

[1] Vibration impacts are normally only assessed in the structure (and especially residential structures where people sleep), not at outdoor areas or the property line. Therefore, human annoyance from vibration would be assessed at the structure and interior uses.

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Appendix A – Fundamentals of Acoustics and Environmental Noise

Sound, Noise, and Acoustics

Sound can be described as the mechanical energy of a vibrating object transmitted by pressure waves through a liquid or gaseous medium (e.g., air). Noise is generally defined as unwanted sound (i.e., loud, unexpected, or annoying sound). Acoustics is defined as the physics of sound. In acoustics, the fundamental scientific model consists of a sound (or noise) source, a receiver, and the propagation path between the two. The loudness of the noise source and obstructions or atmospheric factors affecting the propagation path to the receiver determines the sound level and characteristics of the noise perceived by the receiver. Acoustics addresses primarily the propagation and control of sound.

Frequency

The number of sound pressure peaks traveling past a given point in a single second is referred to as the frequency, expressed in cycles per second or Hertz (Hz). A given sound may consist of energy at a single frequency (pure tone) or in many frequencies over a broad frequency range (or band). Human hearing is generally affected by sound frequencies between 20 Hz and 20,000 Hz (20 kilohertz).

Sound having a high concentration of energy in a relatively narrow frequency band may be considered “tonal” in character. Sources of noise that may be tonal noise include fans, motors, transformers, and compressors. These sources generally have moving parts that rotate, oscillate, or vibrate at a given speed, producing a distinct tonal noise output directly related to that speed.

Amplitude

The amplitude of pressure waves generated by a sound source determines the perceived loudness of that source. Sound pressure amplitude is measured in micro-Pascals (µPa). One µPa is approximately one hundred billionths (0.00000000001) of normal atmospheric pressure. Sound pressure amplitudes for different kinds of noise environments can range from less than 100 µPa to 100,000,000 µPa. Because of this huge range of values, sound is rarely expressed in terms of pressure. Instead, a logarithmic scale is used to describe sound pressure level (SPL) in terms of decibels (dB). The threshold of human hearing (near total silence) is approximately 0 dB, which corresponds to 20 µPa.

Addition of Decibels

Because decibels are logarithmic units, SPL cannot be added or subtracted through ordinary arithmetic means. Under the decibel scale, a doubling of sound energy corresponds to a 3 dB increase. In other words, when two sources are each producing sound of the same loudness, the resulting sound level at a given distance would be approximately 3 dB higher than one of the sources under the same conditions. For example, if one automobile produces an SPL of 70 dB when it passes an observer, two cars passing simultaneously would not produce 140 dB – rather they would combine to produce 73 dB. Under the decibel scale, three sources of equal loudness together produce a sound level of approximately 5 dB louder than one source, and ten sources of equal loudness together produce a sound level of approximately 10 dB louder than the single source.

A-Weighted Decibels

Exhibit A-1 illustrates sound levels associated with common sound sources. The perceived loudness of sounds is dependent on many factors, including sound pressure level and frequency content. However, within the usual range of environmental sound levels, perception of loudness is relatively predictable, and can be approximated by frequency filtering using the standardized A-weighting network. There is a strong correlation between A-weighted sound levels (expressed as dBA) and community response to noise. For this reason, the A-weighted sound level has become the standard descriptor for environmental noise assessment. All noise levels reported in this report are A-weighted.

Human Response to Changes in Noise Levels

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

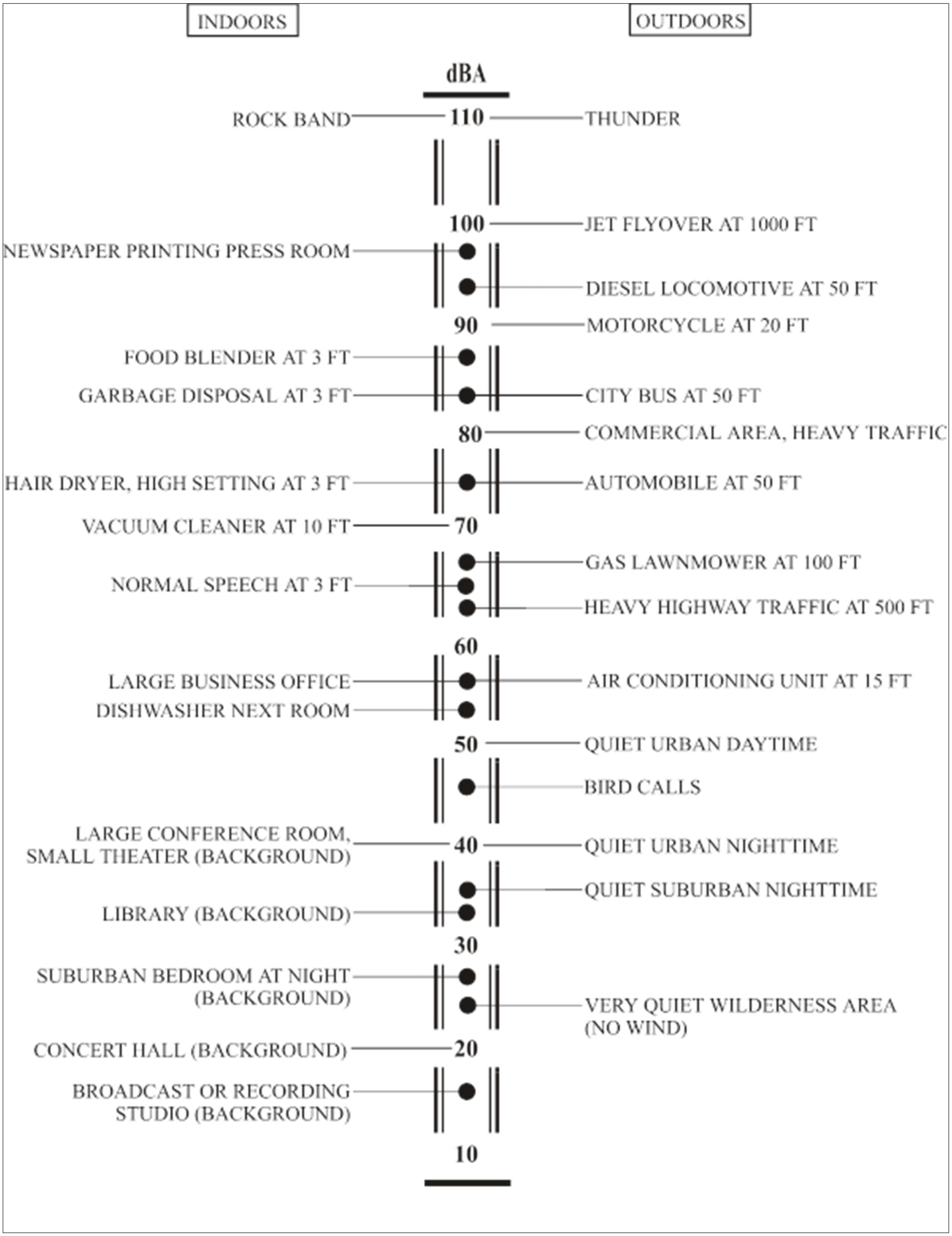
Under controlled conditions in a laboratory setting, the trained, healthy human ear is able to discern 1 dB changes in sound levels when exposed to steady, single-frequency (“pure-tone”) signals in the mid-frequency range (1,000 Hz to 8,000 Hz). In typical noisy environments, changes in noise of 1 to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

Noise-Sensitive Land Uses

Noise-sensitive land uses are generally defined as locations where people reside or where the presence of unwanted sound could adversely affect the use of the land. Noise-sensitive land uses typically include residences, hospitals, schools, transient lodging, libraries, and certain types of recreational uses. Noise-sensitive residential receivers are found throughout the study area.

Noise Descriptors

Noise in our daily environments fluctuates over time. Some fluctuations are minor, but some are substantial. Some noise levels occur in regular patterns, but others are random. Some noise levels fluctuate rapidly, but others slowly. Some noise levels vary widely, but others are relatively constant. Various noise descriptors have been developed to describe time-varying noise levels. The following are the noise descriptors most commonly used in environmental noise analysis, and may be applicable to this study.



Source: Caltrans 2013

Exhibit A-1 **Decibel Scale and Common Noise Sources**

Table A-1 Approximate Relationship Between Increases in Environmental Noise Level and Human Perception

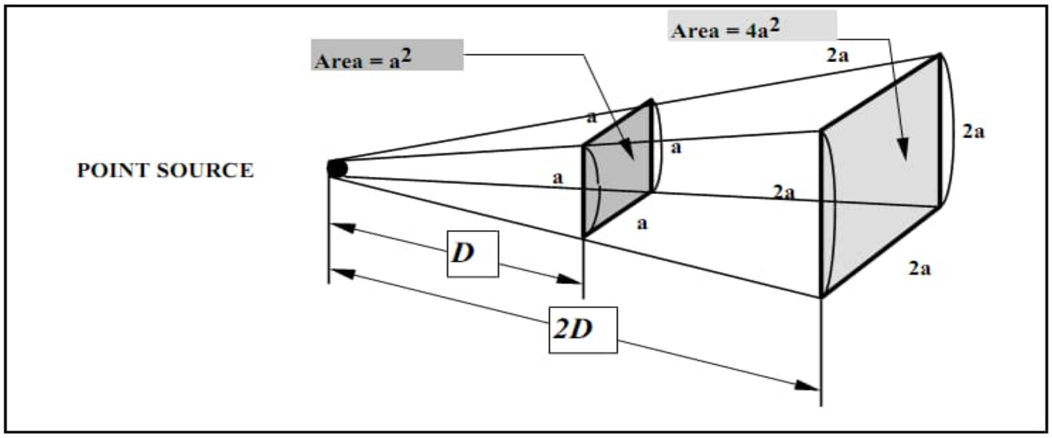
Noise Level Increase, (decibels)	Human Perception (Typical)
up to about 3	not perceptible
about 3	barely perceptible
about 5	distinctly noticeable
about 10	twice as loud
about 20	four times as loud

Source: Caltrans 2013.

- **Equivalent Sound Level (L_{eq}):** The L_{eq} represents an average of the sound energy occurring over a specified time period. In effect, the L_{eq} is the steady-state sound level containing the same acoustical energy as the time-varying sound that actually occurs during the same period. The 1-hour, A-weighted equivalent sound level (L_{eq}[h]) is the energy average of A-weighted sound levels occurring during a 1-hour period, and is the basis for noise abatement criteria (NAC) used by Caltrans and the FHWA.
- **Percentile-Exceeded Sound Level (L_n):** The L_n represents the sound level exceeded “n” percentage of a specified period (e.g., L_{10} is the sound level exceeded 10 percent of the time, and L_{90} is the sound level exceeded 90 percent of the time).
- **Maximum Sound Level (L_{max}):** The L_{max} is the highest instantaneous sound level measured during a specified period.
- **Day-Night Average Sound Level (L_{dn}):** The L_{dn} is the energy average of A-weighted sound levels occurring over a 24-hour period, with a 10 dB penalty applied to A-weighted sound levels occurring during nighttime hours (10 p.m. to 7 a.m.). The L_{dn} is often noted as the DNL.
- **Community Noise Equivalent Level (CNEL):** Similar to L_{dn}, CNEL is the energy average of the A-weighted sound levels occurring over a 24-hour period, with a 10 dB penalty applied to A-weighted sound levels occurring during the nighttime hours (10 p.m. to 7 a.m.), and a 5 dB penalty applied to the A-weighted sound levels occurring during evening hours (7 p.m. to 10 p.m.). The CNEL is usually within 1 dB of the L_{dn}, and for all intents and purposes, the two are interchangeable. Because it is easier to compute and of more common use, the L_{dn} is used as the long-term noise measure in this study.

Sound Propagation/Geometric Spreading

Sound from a localized source (i.e., point source), such as a construction area, propagates uniformly outward in a spherical pattern; therefore, this type of propagation is called *spherical spreading*. The sound level attenuates (or decreases) at a rate of 6 dB for each doubling of distance from a point/stationary source as its energy is continuously spread out over a spherical surface (see Exhibit A-2).



Source: Caltrans 2013

Exhibit A-2 Point Source Spreading with Distance

Vibration

Vibration is the periodic oscillation of a medium or object with respect to a given reference point. Sources of vibration include natural phenomena (earthquakes, volcanic eruptions, sea waves, landslides) and human activity (explosions; traffic; and operation of machinery, trains, or construction equipment). Vibration sources may be continuous (e.g., operating factory machinery) or transient (e.g., explosions).

Vibration amplitudes are commonly expressed in peak particle velocity (PPV) or root-mean-square (RMS) vibration velocity. PPV is defined as the maximum instantaneous positive or negative peak of a vibration signal. RMS is a measurement of the effective energy content in a vibration signal, expressed mathematically as the average of the squared amplitude of the signal. PPV is typically used in the monitoring of transient and impact vibration, and has been found to correlate well to the stresses experienced by buildings (FTA 2018; Caltrans 2020). PPV and RMS vibration velocity are normally described in inches per second (in/sec).

Although PPV is appropriate for evaluating the potential for building damage, it is not always suitable for evaluating human response to vibration. The response of the human body to vibration relates well to average vibration amplitude. Therefore, vibration impacts on humans are evaluated in terms of RMS vibration velocity, and like airborne sound impacts on humans, vibration velocity can be expressed in dB notation, as vibration decibels (VdB).[2]
Table A- summarizes the general human response to different levels of groundborne vibration.

Table A-2 Human Response to Different Levels of Groundborne Vibration

Vibration-Velocity Level	Human Reaction
65 VdB	Approximate threshold of perception.
75 VdB	Approximate dividing line between barely perceptible and distinctly perceptible. Many people find that transportation-related vibration at this level is unacceptable.
85 VdB	Vibration acceptable only if there is an infrequent number of events per day.

Source: FTA 2018

Note:

VdB = vibration decibels, referenced to 1 micro-inch per second and based on the root-mean-square vibration velocity

2 Vibration levels described in VdB are referenced to 1 micro-inch per second.

The effects of groundborne vibration include movement of building floors, rattling of windows, shaking of items that sit on shelves or hang on walls, and rumbling sounds. In extreme cases, vibration can damage buildings, although this is not a factor for most projects. Human annoyance from groundborne vibration often occurs when vibration exceeds the threshold of perception by only a small margin. A vibration level that causes annoyance can be well below the damage threshold for normal buildings. Table A- shows the general thresholds for structural responses to vibration levels.

Table A-3 Structural Responses to Vibration Levels

	Peak Vibration Threshold (in/sec PPV)	
Structure and Condition	**Transient Sources**	**Continuous/Frequent Intermittent Sources**
Extremely fragile historic buildings, ruins, ancient monuments	0.12	0.08
Fragile buildings	0.2	0.1
Historic and some old buildings	0.5	0.25
Older residential structures	0.5	0.3
New residential structures	1.0	0.5
Modern industrial/commercial buildings	2.0	0.5

Source: Table 19, Caltrans 2020.

Notes:

Transient sources, such as blasting or drop balls, create a single isolated vibration event. Continuous/frequent intermittent sources include impact pile drivers, pogo-stick compactors, crack-and-seat equipment, vibratory pile drivers, and vibratory compaction equipment.

in/sec = inches per second
PPV = peak particle velocity

Appendix B – Regulatory Setting and Noise Impact Criteria

Federal

Although not directly applicable to many projects, the research that supported the development of federal community noise standards is broadly applicable in understanding human response to different noise levels, and is summarized below for the reader's edification.

Below is a list of federal agencies with noise exposure criteria, related to the proposed project:

- United States Environmental Protection Agency (EPA): Noise standards to protect public health and welfare
- Federal Transit Administration (FTA): Noise standards for federally funded transit projects
- Occupation Safety and Health Administration (OSHA): Noise standards to protect employees.

EPA Guidance

The EPA has published a guideline that specifically addresses issues of community noise (EPA 1974). This guideline commonly referred to as the "levels document" contains goals for noise levels affecting residential land use: day-night sound level (L_{dn}) less than 55 A-weighted decibels (dBA) for exterior levels, and L_{dn} less than 45 dBA for interior levels. The United States Department of Housing and Urban Development Noise Guidebook, Chapter 2 Section 51.101(a)(8), also recommends that exterior areas of frequent human use follow the EPA guideline exterior limit of 55 L_{dn} (HUD 2009). Therefore, in the absence of a quantified noise threshold from local regulations, 55 dBA L_{dn} will be considered a guidance-based threshold for determining potential noise impacts at noise-sensitive receivers such as residences.

Federal Transit Administration Transit Noise and Vibration Impact Assessment Manual (FTA Report No. 0123)

No standardized criteria have been developed for assessing construction noise impact. Consequently, criteria must be developed on a project-specific basis unless local ordinances apply. Local noise ordinances are typically not very useful in evaluating construction noise. They usually relate to nuisance and hours of allowed activity, and sometimes specify limits in terms of maximum levels, but are generally not practical for assessing the impact of a construction project. Project construction noise criteria should account for the existing noise environment, the absolute noise levels during construction activities, the duration of the construction, and the adjacent land use. Although it is not the purpose of the FTA manual to specify standardized criteria for construction noise impact, the following criteria shown in Table B-1 can be considered reasonable criteria for assessment. If these criteria are exceeded, there may be adverse community reaction.

Table B-1 General Assessment Construction Noise Criteria

Land Use	L_{eq} (dBA)	
	Day	Night
Residential	90	80
Commercial	100	100
Industrial	100	100

Notes:
dBA = A-weighted decibels
L_{eq} = noise-level equivalent

Occupational Safety and Health Administration

OSHA Occupational Noise Exposure; Hearing Conservation Amendment (Federal Register 48 [46], 9738–9785 [1983]) stipulates that protection against the effects of noise exposure shall be provided for employees when average sound levels exceed 90 dBA over an 8-hour exposure period. Protection shall consist of feasible administrative or engineering controls. If such controls fail to reduce sound levels to within acceptable levels, personal protective equipment shall be provided, and used to reduce exposure of the employee. Additionally, a Hearing Conservation Program must be instituted by the employers whenever employee noise exposure equals or exceeds the Action Level of an 8-hour time-weighted average sound level of 85 dBA. The Hearing Conservation Program requirements consist of the periodic area and personal noise monitoring, performance and evaluation of audiograms, provision of hearing protection, annual employee training, and recordkeeping.

City of San Francisco General Plan

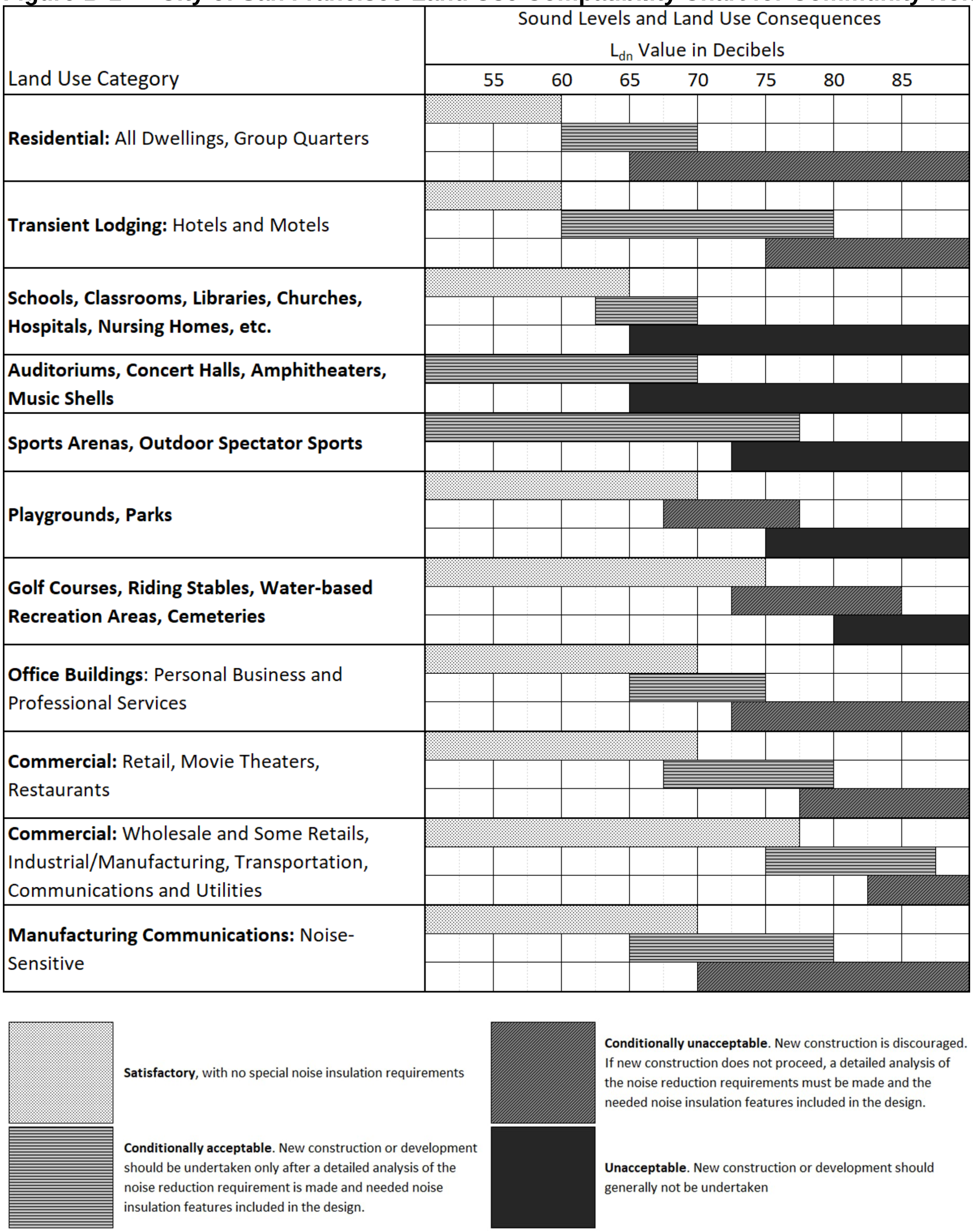
The San Francisco General Plan Environmental Protection Element contains a land use compatibility chart that identifies satisfactory noise conditions to maintain the health and welfare of people in their everyday activities. The plan provides officials and developers with a tool to control or prevent establishment of new land uses in areas where existing noise conditions may be considered unacceptable. The following page show the ranges of noise-level acceptability for various land uses (see Figure B1).

San Francisco Noise Control Ordinance

Article 29 of the San Francisco Police Code regulates noise generated by a variety of noise source types. The San Francisco Department of Public Health is jointly responsible for implementation of this police code; therefore, the Department of Public Health develops and maintains the Guidelines for Noise Control Ordinance Monitoring and Enforcement (article 29 guidelines), which provide both definitions for and guidance on the interpretation of the police code (City of San Francisco 2014). The following summary of the article 29 guidelines applies to the assessment of noise anticipated to be generated by project construction and implementation:

Construction Equipment (article 29, section 2907): Noise generated by any construction equipment on a permitted construction site, except for impact tools such as jackhammers, shall not exceed 80 dBA when measured at a distance of 100 feet from the equipment or the construction site boundary. Construction is allowed during daytime hours, defined as 7 a.m. to 8 p.m. every day of the week, and any work thereafter would be held to stipulations outlined in section 2908 unless permits are obtained from the San Francisco Department of Building Inspection or San Francisco Department of Public Works.

Figure B-1 City of San Francisco Land Use Compatibility Chart for Community Noise



Source: City of San Francisco 2014; compiled by AECOM

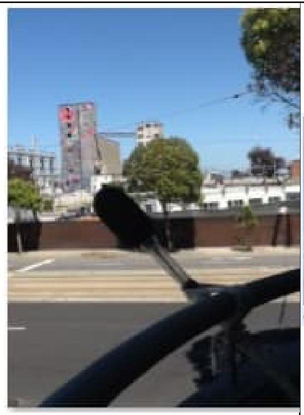
Construction Work at Night (article 29, section 2908): The cumulative operation of construction equipment on a permitted construction site during the nighttime hours, defined as 8 p.m. to 7 a.m., shall not increase ambient measured noise levels at the nearest property plane by greater than 5 dBA. Noise permits may be granted that allow exceedance of the noise standards by the San Francisco Department of Building Inspection, San Francisco Public Works, or the Port of San Francisco (for permits on Port property). Construction projects with night noise permits are subject to the limits detailed by the enforcing departments in the permit. In addition, section 2909(d) states that the maximum allowable interior noise levels in a dwelling unit are 45 dBA L_{eq} between the hours of 10 p.m. and 7 a.m., and 55 dBA L_{eq} between the hours of 7 a.m. and 10 p.m.

Fixed Residential Interior Noise Limits (article 29, section 2909[d]): The maximum allowable interior noise level produced from any combination fixed noise sources under one ownership/use originating from outside the receiving dwelling unit is 45 dBA, between the hours of 10 p.m. to 7 a.m., and 55 dBA between the hours of 7 a.m. and 10 p.m.

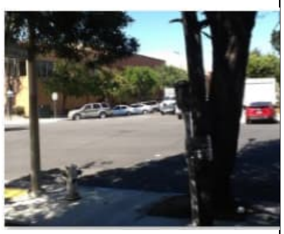
Exceptions (article 29, Appendix C): Certain noise sources do not violate local law and will not be investigated by any City of San Francisco department. Those specific to this noise analysis include, but are not limited to emergency generators, delivery and service trucks, vehicle and traffic noise, and public roadways.

Appendix C

Field Noise Measurement Photo Log

				Date: 07/13/22 Measurement Site: **LT-01**

Date: 07/13/22
Measurement Site: LT-02



Date: 07/14/22
Measurement Site: LT-03




Date: 07/14/22
Measurement Site: LT-04




				**Date:** 07/14/22 **Measurement Site:** ST-01
				**Date:** 07/14/22 **Measurement Site:** ST-02

Appendix D – Construction Noise

AECOM

Project-Generated Construction Source Noise Prediction Model

60526895 – Islais Creek Bridge Phase 2

Location	Distance to Nearest Receiver in feet	Combined Predicted Noise Level (L_{eq} dBA)		Assumptions:	Reference Emission Noise Levels (L_{max}) at 50 feet[1]	Usage Factor[1]
Threshold*	872	City (45 Int+25)	70	Roller	80	0.2
	276	City	80	Pneumatic Tools	85	0.5
	276	FTA	80	Compressor (air)	78	0.4
				Paver	77	0.5
	50	87		Vacuum Street Sweeper	82	0.1
LT-01	450	68		Compactor (ground)	83	0.2
LT-02	2400	53		Generator	81	0.5
LT-03	2500	53		Grader	85	0.4
LT-04	100	81		Crane	81	0.16
ST-01	200	75		Ground Type	Hard	
ST-02	100	81		Ground Factor	0.00	

Predicted Noise Level [2]	L_{eq} dBA at 50 feet[2]
Roller	73.0
Pneumatic Tools	82.0
Compressor (air)	74.0
Paver	74.0
Vacuum Street Sweeper	72.0
Compactor (ground)	76.0
Generator	78.0
Grader	81.0
Crane	73.0
Combined Predicted Noise Level (L_{eq} dBA at 50 feet)	
86.9	

Sources:

[1] Obtained from the FHWA Roadway Construction Noise Model, January 2006.

[2] Based on the following from the Federal Transit Noise and Vibration Impact Assessment, 2018.

L_{eq}(equip) = E.L.+10*log (U.F.) - 20*log (D/50) – 10*G*log (D/50)

Where: E.L. = Emission Level;

U.F.= Usage Factor;
G = Constant that accounts for topography and ground effects; and
D = Distance from source to receiver.
*Project-specific threshold

Notes:

dBA = A-weighted decibels
FTA = Federal Transit Administration
L_{eq} = noise-level equivalent
L_{max} = maximum noise level
LT = Long-Term (24-hour) Measurement
ST = Short-Term (15 minutes) Measurement