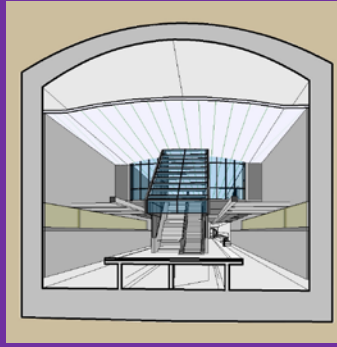


LOS ANGELES COUNTY METROPOLITAN TRANSPORTATION AUTHORITY
WESTSIDE PURPLE LINE EXTENSION PROJECT, SECTION 2
ADVANCED PRELIMINARY ENGINEERING

Contract No. PS-4350-2000



AAA Building Construction Noise and Vibration Assessment – Revision 1

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PREFACE

The AAA Building Noise and Vibration Assessment was shared with the City of Beverly Hills and the Beverly Hills Unified School District (BHUSD) in March 2017 as part of the Section 4(f) consultation process for the publicly used recreational facilities at Beverly Hills High School. This revised version of the memo addresses comments and concerns received in letters from the City of Beverly Hills on April 4, 2017 and BHUSD on April 7, 2017.

1.0 EXECUTIVE SUMMARY

The purpose of this study is to assess the potential impacts of the construction of the Century City Station on the American Automobile Association (AAA) Building which is designated as a Section 106 Historic Property. There three construction sites, AREA 2, AREA 3 and AREA 4 located on Century Park East in close proximity to the AAA Building (see Figure 3-1).

The modeled construction noise at the AAA Building includes a 20-foot high perimeter noise barrier wall for AREA 2 and AREA 3, and a 14-foot high perimeter noise barrier wall for AREA 4; these have been incorporated into the design of these construction sites at Century Park East (see Table 3-1 and Figure 3-2).

The predicted construction noise levels during the daytime hours of 7:00 a.m. to 6:00 p.m. for the AAA Building would not exceed the City of Los Angeles construction noise limit of 75 dBA.

Construction vibration was also assessed in terms of damage risk to the AAA Building. A threshold of 0.2 in/sec PPV was used to assess potential damage risk to the building. Table 7-1 presents the distance beyond which the damage risk criteria of 0.2 in/sec would not be exceeded for the major vibration-generating pieces of equipment likely to be used for the Project. Most of the equipment can be operated without risk of damage at distances of 8 feet or greater from the AAA Building except for a vibratory roller and large dozer which should be operated no closer than 25 to 40 feet.

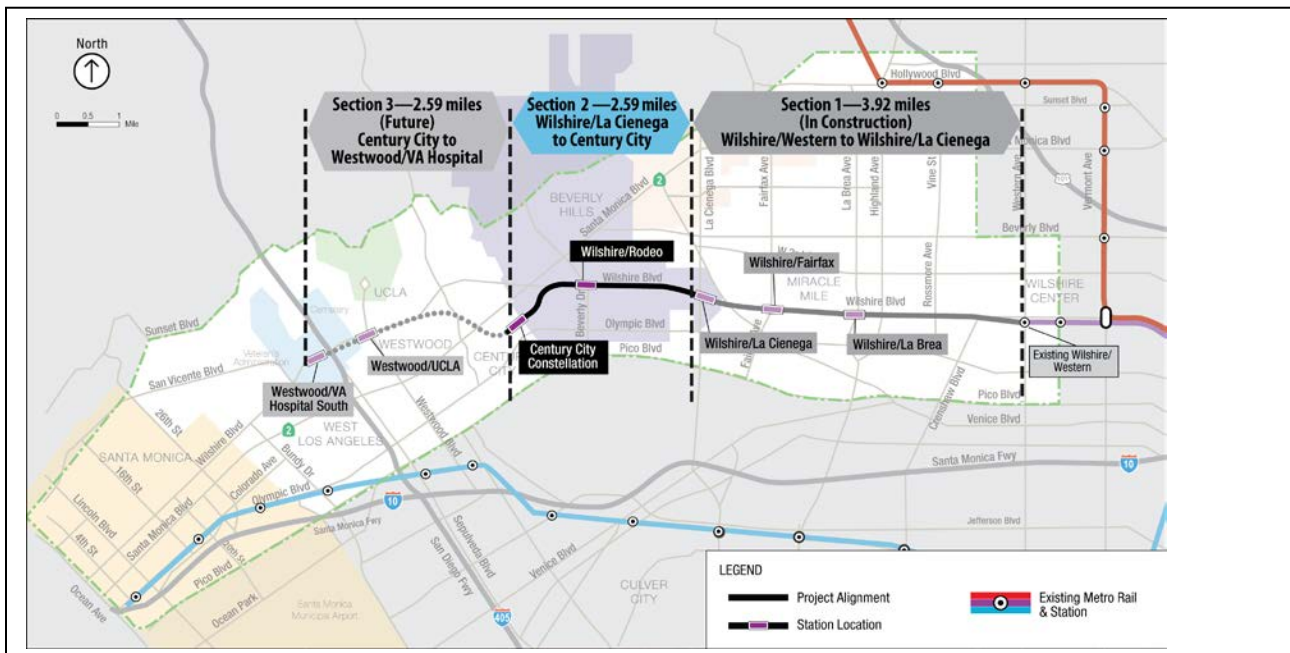
2.0 INTRODUCTION

The Westside Purple Line Extension Project (formerly the Westside Subway Extension Project) (the Project) is an approximately 9-mile heavy rail transit subway that will operate as an extension of the Metro Purple Line from its current western terminus at the Wilshire/Western Station to a new western terminus near the West Los Angeles Veterans Affairs (VA) Hospital (Figure 2-1). The Project lies within the Cities of Los Angeles and Beverly Hills and a part of unincorporated Los Angeles County in the vicinity of the Federal Building and the VA Hospital area.

The Project was planned to be constructed in three phases:

- Section 1: 3.92-mile section from the existing Wilshire/Western Station to Wilshire/La Cienega with three new stations: Wilshire/La Brea, Wilshire/Fairfax, and Wilshire/La Cienega
- Section 2: 2.59-mile section from Wilshire/La Cienega to Century City with two new stations: Wilshire/Rodeo and Century City Constellation
- Section 3: 2.59-mile section from Century City to Westwood/VA Hospital with two new stations: Westwood/University of California, Los Angeles and Westwood/VA Hospital

Figure 2-1: Project Sections



In November 2014, construction began for Section 1 of the Project, which is anticipated to be completed in 2024. Major construction activities for Section 2 of the Project, which is the subject of this limited scope Draft SEIS, could begin as early as January 2018 with expected completion in 2026. Construction for Section 3 is scheduled to begin in 2025 with project completion anticipated in 2035.

On November 8, 2016, Los Angeles County residents voted to approve a half-cent sales tax measure (Measure M—the Los Angeles County Traffic Improvement Plan), which is expected to provide funding to expedite construction of Section 3 of the Project.

Construction of the Project involves construction activities which could generate high noise levels and vibration levels at the AAA Building. This Report outlines the potential noise and vibration effects of construction that will occur at three sites within close proximity to the AAA Building. It describes possible construction methods, though the actual means and methods employed during construction will be determined by the construction contractors and may differ from those outlined in this document.

3.0 CONSTRUCTION ACTIVITIES

The Project’s plans call for lay down and staging Areas to support the station construction and tunneling activities. Site plans and more detailed descriptions of the activities to be conducted at each laydown site can be found in the Westside Purple Line Extension -Section 2 Construction Approach (June 2015). A brief description of the construction sites closest to the AAA Building, AREA 2, AREA 3, AREA 4 and the noise and vibration generating construction activities modeled in this Report follow below. The location of these construction Areas discussed below are shown in Figure 3-1.

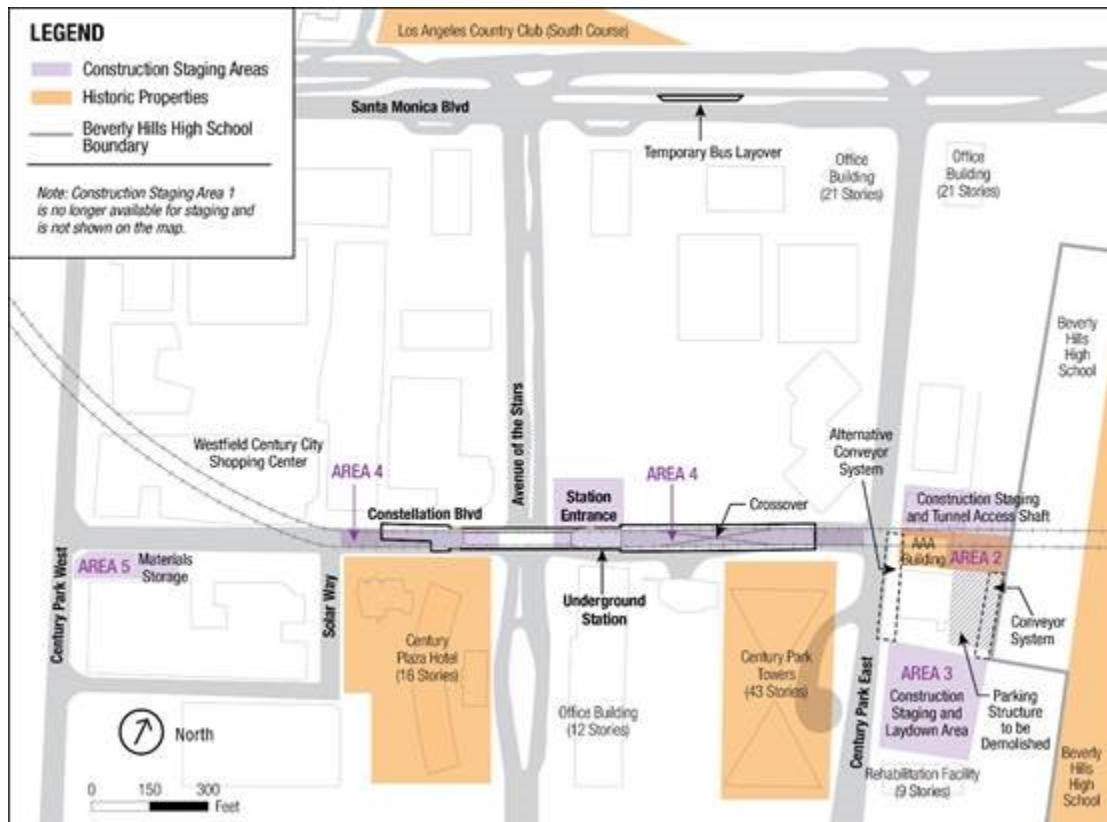


Figure 3-1. AREA 2 and AREA 3 Construction Sites near the AAA Building

The following construction activities at sites AREA 2, AREA 3 and AREA 4 have the potential to generate noise impacts:

- AREA 2 would be primarily used to support tunneling operations, receive materials, and support the mining of cross-passages and concreting. An access shaft would be located in AREA 2 to support tunneling operations for day and night shifts during tunneling. The access shaft facilitates removal of tunnel muck, as well as for deliveries of precast segments to rail-mounted cars below, which would be taken to the TBM’s rear trailing gear for installation as the tunnel liner. Other miscellaneous materials would also be delivered in this manner. This site also supports concreting of tunnels (invert and walkway) and cross-passages as well as mechanical, electrical and finishes for day shifts. During construction of the access shaft, the site would be used by excavating and hoisting equipment required for shaft construction. At the completion of tunnel construction, the shaft would be used to support rail welding. Stock rail would be delivered to the site by trucks. The rail

would be lowered down to track level through the shaft and placed in stockpiles. A portable rail welding plant would be set up at the bottom of the shaft to weld stock rail into continuous welded rail strings approximately 500-feet long. The continuous welded rail strings would also be stockpiled within the tunnels.

- AREA 3 would be primarily used for day and night stockpiling and off-hauling of tunnel muck for approximately two years. The site would also be used for equipment operation, material storage, and contractor offices. Upon completion of the tunneling operations, the site would be used to support concreting of tunnels, rail installation, mechanical and electrical finishing, and support the construction of the Century City/Constellation Station.
- AREA 4 is the main construction staging to support all construction operations necessary to construct Century City/Constellation station except for installing main deck beams and street decking which occurs continuously over the 56-hour weekend closures (21 weekend closures). The east side of the site near Century Park East is the location of the TBM launch box. As there are no spoils storage Areas available, all spoils are immediately loaded onto trucks and taken to disposal sites. This site is to be utilized for both day and night work shifts.

Equipment used during daytime construction operations is as follows:

- AREA 2: Tower crane, boom crane, pile rig drill, front end loader, Bobcat, drilling polymer plant, concrete pumps, generator, ready mix trucks, pick-up trucks, haul trucks, ventilation fans, street sweepers, telehandler, water treatment plant, conveyor system, segment carrier, roller compactor.
- AREA 3: Front end loader, boom crane, haul trucks, excavator, concrete pumps, shotcrete machine, lift hoist, water treatment plant, ventilation plant, compressor plant, foam plant, grout plant, conveyor system, mechanical shop, and electrical shop.
- AREA 4: *The following equipment pertains to the TBM Launch activities only.* Boom crane, rough terrain crane, pile drill rig, front end loader, Bobcat, drilling polymer plant, concrete pumps, generator, ready mix trucks, pick-up trucks, street sweeper, light plants, welding plants, fork lifts, excavator, haul trucks, dozer, ventilation fans, telehandler.

Mitigation measures for the different stages of construction at the AREA 2, AREA 3 and AREA 4 sites that will be implemented by the Contractor are listed in Table 3-1 and the noise barrier walls shown in Figure 3-2.

Table 3-1: Mitigation Measures

AREA 3 Xpass	No mitigation required
AREA 3 Tunneling	Low noise emission for Boom Crane only
AREA 2 Tunneling	All equipment low noise emission, plus hospital grade muffler on Tower Crane
AREA 2 Piling Muck	All equipment low noise emission, plus hospital grade mufflers on Long Boom Crane and Pile Drill Rigs
AREA 2 Excavation Muck	All equipment low noise emission, plus hospital grade muffler on Rough Terrain Crane
AREA 2 Stage 1 & 2 Concrete Muck	All equipment low noise emission
AREA 2 Concrete Wall Muck	All equipment low noise emission
AREA 2 Backfill Muck	All equipment low noise emission
AREA 2 Deck Slab	All equipment low noise emission
AREA 3 Excavate TBM Launch Box^(a)	All equipment low noise emission, plus hospital grade muffler on Rough Terrain and Boom Cranes
AREA 3 Decking TBM Launch Box^(a)	All equipment low noise emission, plus hospital grade muffler on Rough Terrain and Boom Cranes
Note: Low noise emission construction equipment shall not exceed the noise level limits of Metro's Specification Section 01 56 19. (a) Equipment at the TBM Launch Box should be positioned as far as reasonably possible from the intersection of Century Park East.	

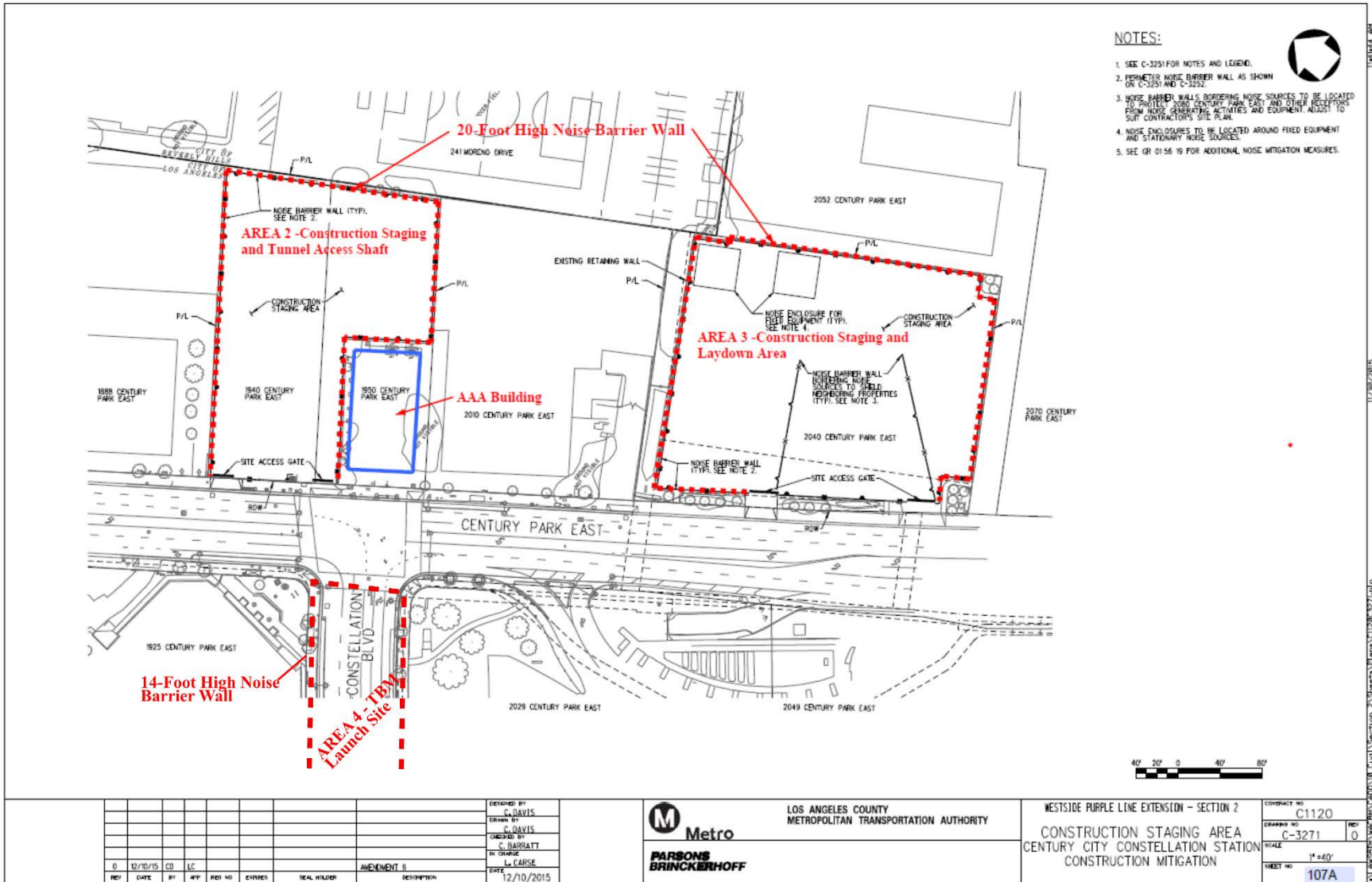


Figure 3-2: Noise Barrier Walls at AREA 2 and AREA 3 Construction Sites

WESTSIDE PURPLE LINE EXTENSION PROJECT

4.0 CONSTRUCTION NOISE LIMITS

The construction activities at the AAA Building is subject to the local noise limits set forth in the City of Los Angeles Municipal Code (LAMC). Section 112.05 of the LAMC sets a maximum noise level for powered equipment of 75 dBA at 50 feet when operated within 500 feet of a residential zone. However, compliance with this standard is not required where “technically infeasible”. Technically infeasible means that the established noise limits cannot be met with at the project site despite the use of mufflers, shields, sound barriers, and/or other noise reduction devices or techniques employed during the operation of equipment.

Section 111.02 of the LAMC provides procedures and criteria for the measurement and impact assessment of noise sources. Specifically, the procedures provide for a penalty of 5 dBA for steady high-pitched noise or repeated impulsive noises. Conversely, the procedures provide a credit of 5 dBA for noise occurring less than 15 minutes in a period of 60 consecutive minutes during the day because short-term noise events are typically less annoying than continuous noise sources.

The LAMC also restricts the hours of construction activities. Section 41.40 prohibits construction between the hours of 9:00 P.M. and 7:00 A.M. Monday through Friday, 6:00 P.M and 8:00 A.M on Saturday, and at any time on Sunday. Construction during nighttime hours or on Sunday requires a noise variance. If a noise variance is obtained, construction can be conducted during nighttime hours with a noise limit of 5 decibels above the measured ambient.

A summary of the different construction noise limits is presented in Table 4-1. The noise limits are applied at the facade of the AAA Building.

Table 4-1: Summary of Construction Noise Limits

Construction Activity	Noise Limit ¹ , dBA
City of Los Angeles Daytime (7:00 A.M.-9:00 P.M.), general activities	75 dBA
City of Los Angeles Daytime (7:00 A.M.-9:00 P.M.), steady high-pitch noise or repeated impulsive noises	70 dBA
City of Los Angeles Daytime (7:00 A.M.-9:00 P.M.), less than 15 minute duration in a period of 60 consecutive minutes	80 dBA
City of Los Angeles Nighttime (9:00 P.M.-7:00 A.M.), all activities	Nighttime Ambient + 5dB
Notes: ¹ Noise limit applies to the facade of the closest noise sensitive property.	

5.0 CONSTRUCTION VIBRATION LIMITS

The primary concern regarding construction vibration relates to risk of damage. Vibration is generally assessed in terms of peak particle velocity (PPV) for risk of building damage. PPV is the appropriate metric for evaluating the potential of building damage and is often used when monitoring blasting and construction vibration because it relates to the stresses that are experienced by the buildings.

Vibration damage risk thresholds from the Westside Subway Extension Final EIS/EIR are presented in Table 5-1. The table presents PPV thresholds for different building categories. The ‘Structural Building Damage’ category is the level above which there is a risk that structural damage may occur. The ‘Architectural Building Damage’ category is the level above which there is a risk that superficial building damage, such as small cracks, may occur. The third category, ‘Damage Risk to Historic Buildings and Cultural Resource Structures’ is meant to apply to historic buildings that are particularly susceptible to damage. The upper range of the threshold for historic buildings of 0.2 PPV is used to assess damage risk to the AAA Building. The lower range of the threshold of 0.12 PPV would be used for fragile historic buildings and fragile cultural resources. Where the PPV is expected to exceed 0.2, monitoring is required. When the construction vibration exceeds 0.2 PPV mitigation measures such as using alternative construction approaches, are considered.

Table 5-1: Construction Vibration Damage Risk Thresholds

Building Category	Peak Particle Velocity (in/sec)
Structural Building Damage	2.0
Architectural Building Damage	0.5
Damage Risk to Historic Buildings and Cultural Resource Structures	0.12 to 0.2
Source: Westside Subway Extension Final EIS/EIR, LAMTA, March 2012.	

6.0 CONSTRUCTION NOISE PREDICTIONS

6.1 Noise Prediction Methodology

The projected daytime construction noise levels were modeled using CadnaA version 4.0, a three dimensional graphics oriented noise modeling program that uses the International Standards Organization (ISO) 9613, a general purpose standard for outdoor noise propagation. CadnaA incorporates the following elements:

- An emission model to determine the noise generated by the equipment at a reference distance.
- A propagation model that calculates how the noise level varies with distance.
- A prediction model that sums the noise of each source at sensitive locations.

The noise modeling includes the effects of ground cover, the shielding of building structures, and the reduction provided by a noise barrier wall (if one is specified in the construction plans). The source noise levels used in the model for different pieces of construction equipment are based on the actual measured noise level data presented in Table 6-1. This data is from the Federal Highway Administration (FHWA) Roadway Construction Noise Model.

The noise levels were predicted at the facades of the AAA Building as shown in Figure 6-1. Predicted noise levels at each of the four facades of the AAA Building are presented in Table 6-2 for the tunneling activities at AREA 2 and AREA 3, and TBM Launch Box decking and excavation at AREA 4 which would generated the highest construction noise.

Table 6-1: Construction Equipment Noise Emission Levels

Equipment Description	Lmax Noise Limit at 50 ft., dB Slow	Is Equipment an Impact Device?
Auger Drill Rig	85 dBA	No
Backhoe	80 dBA	No
Boring Jack Power Unit	80 dBA	No
Chain Saw	85 dBA	No
Clam Shovel	93 dBA	Yes
Compactor (ground)	80 dBA	No
Compressor (air)	80 dBA	No
Concrete Mixer Truck	85 dBA	No
Concrete Pump Truck	82 dBA	No
Concrete Saw	90 dBA	No
Crane (mobile or stationary)	85 dBA	No
Dozer	85 dBA	No
Dump Truck	84 dBA	No
Excavator	85 dBA	No
Flat Bed Truck	84 dBA	No
Front End Loader	80 dBA	No
Generator (25 KVA or less)	70 dBA	No
Generator (more than 25 KVA)	82 dBA	No
Gradall	85 dBA	No
Horizontal Boring Hydraulic Jack	80 dBA	No
Impact Pile Driver (diesel or drop)	95 dBA	Yes
Jackhammer	85 dBA	Yes
Mounted Impact Hammer (hoe ram)	90 dBA	Yes
Paver	85 dBA	No
Pickup Truck	55 dBA	No
Pneumatic Tools	85 dBA	No
Pumps	77 dBA	No
Rock Drill	85 dBA	No
Scraper	85 dBA	No
Slurry Plant	78 dBA	No
Slurry Trenching Machine	82 dBA	No
Soil Mix Drill Rig	80 dBA	No
Tractor	84 dBA	No
Vacuum Excavator (Vac-Truck)	85 dBA	No
Vacuum Street Sweeper	80 dBA	No
Vibratory Concrete Mixer	80 dBA	No
Vibratory Pile Driver	95 dBA	No
Welder	73 dBA	No
Source: Federal Highway Administration (FHWA) Roadway Construction Noise Model, 2006		



Figure 6-1: Noise Modeling Locations at AAA Building Facades

6.2 Construction Noise Predictions

Table 6-2 presents the predicted construction noise levels for the tunneling construction during the daytime hours of 7:00 a.m. to 6:00 p.m. for the AAA Building. As shown in Table 6-2, the daytime construction noise levels at the AAA Building would not exceed the 75 dBA LAMC noise limit.

Table 6-2: Predicted Daytime Construction Noise at AAA Building

Location at AAA Building Facade	Noise Level, Leq(h) (dBA)
A	70
B	70
C	69
D	67

7.0 CONSTRUCTION VIBRATION PREDICTIONS

7.1 Prediction Methodology

For this study, the FTA analytical/empirical construction vibration prediction model was used to estimate vibration levels propagate from construction equipment to vibration sensitive locations. The vibration model is based on a combination of previous works including measured equipment vibration emission data from the FTA and the Central Artery/Tunnel project in Boston, and ground transmissibility relationships found in Charles Dowding's reference textbook Construction Vibrations. The fundamental equation used in the model is based on propagation relationships of vibration through average soil conditions and distance, as follows:

$$PPV_{receiver} = PPV_{ref} * \left(\frac{100}{Dist_{receiver}} \right)^n,$$

where:

$PPV_{receiver}$ = predicted PPV at the receiver,

PPV_{ref} = reference PPV of equipment at 100 feet,

$Dist_{receiver}$ = distance from the receiver to the equipment in feet, and

$n = 1.5$ (the vibration attenuation rate through the soil).

The suggested value for n in the FTA Manual is 1.5. The value for n can lie between 1.0 and 2.0 and a value of 1.5 is commonly used in general models. The value of 1.5 is considered appropriate for this model because the project Area has soft soils which generally have a higher value of n .

Equipment vibration emission levels used for the predictions were gathered from measurements performed and published from several projects including the FTA Manual, Central Artery/Tunnel Project in Boston, and Dowding's textbook.

7.2 Prediction Results and Impact Assessment

Table 7-1 presents the distance beyond which the damage risk criteria of 0.20 in/sec would not be exceeded for the major vibration-generating pieces of equipment likely to be used for the Project. Most of the equipment used at AREA 2, AREA 3 and AREA 4 can be operated without risk of damage at distances of 8 feet or greater from the AAA Building except for a vibratory roller, and large dozer which should be operated no closer than 25 to 40 feet.

Table 7-1: Distance to Construction Vibration Impact Thresholds

Equipment	PPV Ref Level at 100 ft (in/sec)	Distance to Impact Threshold of 0.2 in/sec PPV
Cranes	0.001	3 ft
Dozer	0.04 to 0.07	25 ft to 40 ft
Front End Loader	0.011	8 ft
Vibratory Roller	0.059	35 ft
Excavator	0.011	8 ft
Augur Drill Rig	0.011	8 ft

8.0 MITIGATION

No additional mitigation is required to meet the LAMC daytime construction noise level limits at the AAA Building.

8.1 General Noise Control Measures

The following are general noise and vibration control measures that shall be implemented by the Contractor at AREA 2 and AREA 3 construction sites:

- Readily visible signs indicating “Noise Control Zone” would be prepared.
- Noise-control devices that meet original specifications and performance would be used.
- Fixed noise-producing equipment would be used to comply with regulations in the course of project activity.
- Mobile or fixed noise-producing equipment that are equipped to mitigate noise to the extent practical would be used.
- Electrically-powered equipment would be used to the extent practical.
- Temporary noise barriers and sound-control curtains would be erected where project activity is unavoidably close to noise-sensitive receivers.
- Designated haul routes would be used based on the least overall noise impact Route heavily-loaded trucks away from residential streets, if possible. Identification of haul routes would consider streets with the fewest noise sensitive receivers if no alternatives are available.
- Non-noise sensitive, designated parking Areas for project-related vehicles would be used.
- Earth-moving equipment, fixed noise-generating equipment, stockpiles, staging Areas, and other noise-producing operations would be located as far as practicable from noise-sensitive receivers.
- The use of air horn type devices, including but not limited to vehicle mounted or hand held, shall not be used to communicate signals from one Area of the project site to another. Compliance with the requirements of the Tunnel Safety Orders for signaling systems shall be obtained using other auditory or visual systems other than the use of air horn type devices.
- Use of horns, whistles, alarms, and bells would be limited.
- All noise-producing project equipment and vehicles would be required to use internal combustion engines equipped with mufflers and air-inlet silencers, where appropriate, and kept in good operating condition that meet or exceed original factory specifications. Mobile or fixed “package” equipment (e.g., arc-welders, air compressors) would be equipped with shrouds and noise control features that are readily available for that type of equipment.
- Any project-related public address or music system would not be audible at any adjacent receiver.
- Demolition, earth moving, and ground impacting operations would be phased so as not to occur in the same time.
- Impact pile driving would be avoided. Drilled pile drivers would be used where the geological conditions permit their use.

- Demolition methods would be selected to minimize noise impact where possible.
- Use of vibratory rollers and packers would be avoided near vibration sensitive Areas.
- An elastomer isolator would be installed between the floor of the tunnel and the rails and ties on which the tunnel train carrying excavated materials operates. If the Metro ground-borne noise limits or ground-borne vibration limits are exceeded, the Contractor shall be required to take action to reduce vibrations to acceptable levels. Such action could include reducing the tunnel train speed, additional rail and tie isolation, and more frequent rail and wheel maintenance.
- Enclosures for fixed equipment such as TBM slurry processing plants would be required to reduce noise.

Metro Baseline Specifications Section 01565, Construction Noise and Vibration Control requires that the contractor shall, among other provisions

- Hire or retain the services of an Acoustical Engineer to be responsible for preparing and overseeing the implementation of the Noise Control and Monitoring Plans.
- Prepare a Noise Control Plan that includes an inventory of construction equipment used during daytime and nighttime hours, estimate of projected construction noise levels, and locations and types of noise abatement measures that may be required to meet the specified noise limits.
- In the case of nighttime construction, the contractor shall comply with the provisions of the nighttime noise variance issued by the local jurisdictions.
- Conduct periodic noise measurement in accordance with an approved Noise Monitoring Plan, specifying monitoring locations, equipment, procedures, and schedule of measurements and reporting methods to be used.
- During nighttime hours, use equipment at the surface of the construction site that, operating under full load, is certified to meet specified lower noise level limits than standard equipment.
- For nighttime construction activities, erect Metro designed noise barrier walls at each construction site prior to the start of any construction activities.

9.0 VIBRATION MONITORING

The Contractor is required to submit a Vibration Monitoring Plan prepared, stamped, and administered by the Contractor's Acoustical Engineer. Vibration monitoring shall be performed at the AAA Building closest to the locations where equipment and/or construction activities generate a substantial amount of groundborne vibration. Vibration monitoring at the AAA Building shall consist of continuous measurements of vibration at the closest building façade to the construction activities. All vibration monitors used should be equipped with an “alarm” feature to provide notification that the 0.2 PPV vibration damage risk threshold has been approached or exceeded.

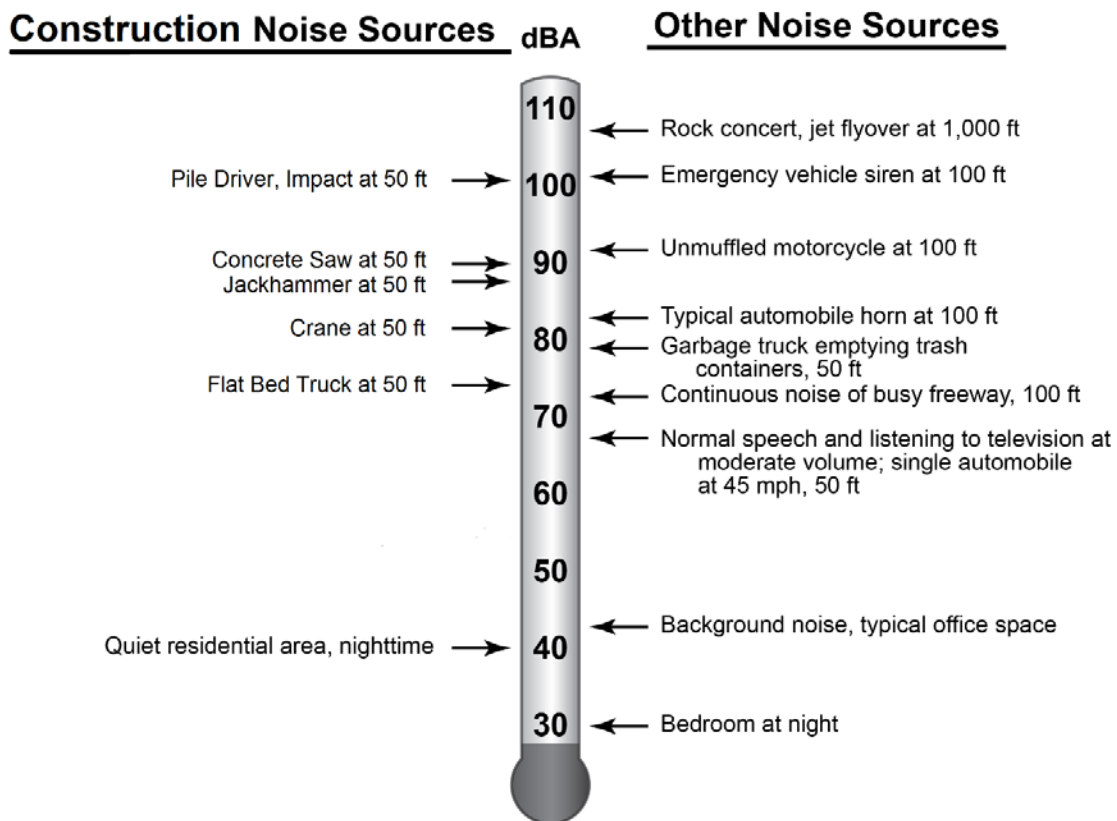
APPENDIX A FUNDAMENTALS OF NOISE

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Sound is mechanical energy transmitted by pressure waves in a compressible medium such as air. Noise is generally defined as unwanted or excessive sound. Sound can vary in intensity by over one million times within the range of human hearing. Therefore, a logarithmic scale, known as the decibel scale (dB), is used to quantify sound intensity and compress the scale to a more manageable range.

Sound is characterized by both its amplitude and frequency (or pitch). The human ear does not hear all frequencies equally. In particular, the ear deemphasizes low and very high frequencies. To better approximate the sensitivity of human hearing, the A-weighted decibel scale has been developed. A-weighted decibels are abbreviated as “dBA.” On this scale, the human range of hearing extends from approximately 3 dBA to around 140 dBA. As a point of reference, Figure A-1 includes examples of A-weighted sound levels from common indoor and outdoor sounds.

Figure 9-1: Typical Outdoor and Indoor Noise Levels



Using the decibel scale, sound levels from two or more sources cannot be directly added together to determine the overall sound level. Rather, the combination of two sounds at the same level yields an increase of 3 dBA. The smallest recognizable change in sound level is approximately 1 dBA. A 3-dBA increase is generally considered perceptible, whereas a 5-dBA increase is readily perceptible. A 10-dBA increase is judged by most people as an approximate doubling of the perceived loudness.

Two of the primary factors that reduce levels of environmental sounds are increasing the distance between the sound source and the receiver and having intervening obstacles, such as walls, buildings, or terrain features that block the direct path between the sound source and the receiver. Factors that act to increase the loudness of environmental sounds include the proximity of the sound source to the receiver, sound enhancements caused by reflections, and focusing caused by various meteorological conditions.

Brief definitions of the measures of environmental noise used in this report are:

- **Equivalent Sound Level (Leq):** Environmental sound fluctuates constantly. The equivalent sound level (Leq), sometimes referred to as the energy-average sound level, is the most common means of characterizing community noise. Leq represents a constant sound that, over the specified period, has the same sound energy as the time-varying sound.
- **Day-Night Sound Level (Ldn):** Ldn is basically a 24-hour Leq with an adjustment to reflect the greater sensitivity of most people to nighttime noise. The adjustment is a 10-dB penalty for all sound that occurs between the hours of 10 P.M. and 7 A.M. The effect of the penalty is that, when calculating Ldn, any event that occurs during the nighttime is equivalent to 10 of the same event during the daytime. Ldn is the most common measure of total community noise over a 24-hour period.
- **Maximum Sound Level (Lmax):** The maximum sound level over a period of time or for a specific event can also be a useful parameter for characterizing specific noise sources. Standard sound level meters have two settings, fast and slow, which represent different time constants. Lmax using the fast setting will typically be 1 to 3 dB greater than Lmax using the slow setting.
- **Percent Exceedance Level (Lxx):** This is the sound level that is exceeded for xx percent of the measurement period. For example, L99 is the sound level exceeded 99 percent of the measurement period. For a one-hour period, the sound level is less than L99 for 36 seconds of the hour and the sound level is greater than L1 for 36 seconds of the hour. L1 represents typical maximum sound levels, L33 is approximately equal to Leq when free-flowing traffic is the dominant noise source, L50 is the median sound level, and L99 is close to the minimum sound level.
- **Sound Exposure Level (SEL):** SEL is a measure of the total sound energy of an event. In essence, all sound from the event is compressed into a one-second period. This means that SEL increases as the event duration increases and as the event sound level increases. SEL is useful for estimating the Ldn that would be caused by individual events such as train passbys.

Often it is necessary to determine the contribution at different frequencies when evaluating vibration or noise signals. The 1/3-octave band spectrum is the most common procedure used to evaluate frequency components of acoustic signals. The term “octave” has been borrowed from music where it refers to a span of eight notes. The ratio of the highest frequency to the lowest frequency in an octave is 2:1. For a 1/3-octave band spectrum, each octave is divided into three bands where the ratio of the lowest frequency to the highest frequency in each 1/3-octave band is $2^{1/3}:1$ (1.26:1). An octave consists of three 1/3 octaves.

The 1/3-octave band spectrum of a signal is obtained by passing the signal through a bank of filters. Each filter excludes all components except those that are between the upper and lower range of one 1/3-octave band. The FTA Guidance Manual is a good reference for additional information on transit noise and vibration and the technical terms used in this section.