1951 SHATTUCK AVENUE – MULTI-FAMILY RESIDENTIAL

CONSTRUCTION NOISE AND VIBRATION REDUCTION PLAN

BERKELEY, CA

PREPARED FOR: Grosvenor

Sent via email: Landis Nasser

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1.0 Project Description

The proposed project is a 12-story mixed-use building consisting of a first-floor podium level below 11 floors of residential housing. Additionally, there are two levels of below grade parking accessed via Berkeley Way, a level 2 exterior courtyard space, and a rooftop terrace. In total, the project consists of 163-dwelling units and approximately 5,000 square-feet of retail space on the first level.

The existing project site consists of several two-level retail storefronts that will be demolished at the beginning of project construction activities. In addition to the demolition phase, project construction will also include a foundations/podium construction/structural concrete phase, a framing phase, an exterior finish phase, and a landscape/sitework phase. Construction schedules and details about construction operations have been provided by Grosvenor – this information has been used to estimate construction noise and vibration levels at the nearest sensitive receivers.

The City of Berkeley provided Conditions of Approval for this project. Items #15 and #16 of these Conditions of Approval require the project to provide a Construction Noise Reduction Program, and a review of Damage due to Construction Vibration, respectively. These items from the Conditions of Approval for this project are evaluated in the analysis below.

2.0 Construction Noise Standards

2.1 *Conditions of Approval for 1951 Shattuck Avenue – Item #15*

Item #15 of the Conditions of Approval provided for this project outlines requirements for construction noise, as follows:

> ***Construction Noise Reduction Program****: The applicant shall develop a site-specific noise reduction program prepared by a qualified acoustical consultant to reduce construction noise impacts to the maximum extent feasible, subject to review and approval of the Zoning Officer. The noise reduction program shall include the time limits for construction listed above, as measures needed to ensure that construction complies with BMC Section 13.40.070. The noise reduction program should include, but shall not be limited to, the following available controls to reduce construction noise levels as low as practical:*
>
> *A. Construction equipment should be well maintained and used judiciously to be as quiet as practical.*
>
> *B. Equip all internal combustion engine-driven equipment with mufflers, which are in good condition and appropriate for the equipment.*
>
> *C. Utilize "quiet" models of air compressors and other stationary noise sources where technology exists. Select hydraulically or electrically powered equipment and avoid pneumatically powered equipment where feasible.*
>
> *D. Locate stationary noise-generating equipment as far as possible from sensitive receptors when adjoining construction sites. Construct temporary noise barriers or partial enclosures to acoustically shield such equipment where feasible.*
>
> *E. Prohibit unnecessary idling of internal combustion engines.*
>
> *F. If impact pile driving is required, pre-drill foundation pile holes to minimize the number of impacts required to seat the pile (impact pile driving is not planned, this item does not apply to this project).*

G. *Construct solid wood plywood fences around construction sites adjacent to operational business, residences or other noise-sensitive land uses where the noise control plan analysis determines that a barrier would be effective at reducing noise.*

H. *Erect temporary noise control blanket barriers, if necessary, along building facades facing construction sites. This mitigation would only be necessary if conflicts occurred where were irresolvable by proper scheduling. Noise control blanket barriers can be rented and quickly erected.*

I. *Route construction related traffic along major roadways and away from sensitive receptors where feasible.*

2.2 *Berkeley Municipal Code – Construction Noise*

The Berkeley Municipal Code, Section 13.40.070.B.7, states the following:

> *Where technically and economically feasible, construction activities shall be conducted in such a manner that the maximum sound levels at affected properties will not exceed those listed in the following schedule:*

Table 1 reprints the quantitative noise standards provided in Table 13.40-4 (stationary equipment, duration of operation of 10 days or more):

Table 1: Berkeley Municipal Code – Construction Noise Standards (10 Days or More)

Receiving Land Use Type	Weekdays, 7 AM – 7 PM	Weekends (and Holidays), 9 AM – 8 PM
Multi-Family Residential	65	55
Commercial, Industrial	70	60
Berkeley Municipal Code Table 13.40-4		

2.3 *Construction Noise Standards – Summary*

Per the standards listed above:

- Project construction shall implement the construction noise mitigation measures listed in Section 2.1.
- Project construction is only allowed on weekdays between 7 AM and 7 PM, and on weekends and holidays between 9 AM and 8 PM.
- The Berkeley Municipal Code Noise Ordinance does not provide specific conditions in the event the construction noise limit is exceeded – aside from the noise management practices provided by the project's conditions of approval, this analysis will provide additional measures where the Berkeley Municipal Code noise limit is exceeded (see Section 7.0).

3.0 Construction Vibration Standards

3.1 *Conditions of Approval for 1951 Shattuck Avenue – Item #16*

Item #16 of the Conditions of Approval provided for this project outlines the project's requirement to evaluate construction-related vibration in terms of the potential of damage to nearby structures:

> ***Damage Due to Construction Vibration**: The project applicant shall submit screening level analysis prior to, or concurrent with demolition building permit. If a screening level analysis shows that the project has the potential to result in damage to structures, a structural engineer or other appropriate professional shall be retained to prepare a vibration impact assessment (assessment). The assessment shall take into account project specific information such as the composition of the structures, location of the various types*

of equipment used during each phase of the project, as well as the soil characteristics in the project area, in order to determine whether project construction may cause damage to any of the structures identified as potentially impacted in the screening level analysis. If the assessment finds that the project may cause damage to nearby structures, the structural engineer or other appropriate professional shall recommend design means and methods of construction that to avoid the potential damage, if feasible. The assessment and its recommendations shall be reviewed and approved by the Building and Safety Division and the Zoning Officer. If there are no feasible design means or methods to eliminate the potential for damage, the structural engineer or other appropriate professional shall undertake an existing conditions study (study) of any structures (or, in case of large buildings, of the portions of the structures) that may experience damage. This study shall:

- *Establish baseline condition of these structures, including, but not limited to, the location and extent of any visible cracks or spalls; and*
- *Include written descriptions and photographs*

The study shall be reviewed and approved by the Building and Safety Division and the Zoning Officer prior to the issuance of a grading permit. Upon completion of the project, the structures (or, in case of large buildings, of the portions of the structures) previously inspected will be resurveyed, and any new cracks or other changes shall be compared to the pre-construction conditions and a determination shall be made as to whether the proposed project caused the damage. The findings shall be submitted to the Building and Safety Division and the Zoning Officer to review.

Item #16 of the Conditions of Approval provided for this project require project-related construction vibration to be evaluated in terms of the potential of damage to nearby structures, however, does not provide a quantitative standard to determine the potential for damage. This analysis will use the building damage due to vibration guidelines outlined in the Federal Transit Administration Transit Noise and Vibration Impact Assessment Manual, see Section 3.2.

3.2 *Federal Transit Administration Vibration Damage Criteria*

The Federal Transit Administration (FTA) has adopted vibration standards that are used to evaluate potential building damage impacts related to construction activities. This standard will be used to quantify the Condition of Approval standard presented in Section 3.1. The vibration damage criteria adopted by the FTA are shown in Table 2.

Table 2: Construction Vibration – Damage Criteria

Building/Structural Category	Maximum Peak Particle Velocity (PPV), in/sec
I. Reinforced-concrete, steel or timber (no plaster)	0.5
II. Engineered concrete and masonry (no plaster)	0.3
III. Non-engineered timber and masonry buildings	0.2
IV. Buildings extremely susceptible to vibration damage	0.12
Federal Transit Administration, 2018. Transit Noise and Vibration Impact Assessment Manual (FTA Report No. 0123), Table 7-5	

3.3 *Construction Vibration (Building Damage) – Summary*

Per the Conditions of Approval provided for this project, this analysis will evaluate whether project construction has the potential to cause damage at nearby buildings. The Federal Transit Administration building damage due to vibration standard, presented in Table 2, is used to determine the level of significance for different building types.

4.0 Environmental Setting

The project site is surrounded by primarily multi-family residential, retail, and office/commercial uses. Noise from nearby roadways, including Shattuck Avenue, University Avenue, and Berkeley Way are the primary sources of noise around the project site.

4.1 *Sensitive Receivers*

The following receivers are representative of land uses expected to be impacted by project-related construction noise. Although other receivers within vicinity of the project site are expected to be exposed to project construction noise, the following receivers are expected to be impacted to the greatest extent and are therefore considered representative of less sensitive (more distant) receivers. Table 3 lists the receivers analyzed in this analysis, the applicable noise criteria, the applicable damage due to vibration criteria, and the average and minimum distances to the project site.

Table 3: Representative Receivers Impacted by Project Construction

Receptor	Weekday, Daytime (7 AM – 7 PM) Construction Noise Threshold[1]	Building Damage Due to Vibration Threshold[2]	Distance to Project Site (feet)	
			Average Distance[3]	Minimum Distance[4]
Modera Berkeley – 2119 University Ave.	(Residential) 65 dBA	(Non-eng. timber and masonry) PPV 0.2 in/sec	70	5
Bachenheimer Apartments - 2119 University Ave.	(Residential) 65 dBA	(Non-eng. timber and masonry) PPV 0.2 in/sec	70	10
Life Sciences/Offices – 2120 Berkeley Way	(Commercial) 70 dBA	(Eng. concrete and masonry) PPV 0.3 in/sec	85	15
UCB School of Public Health - 2121 Berkeley Way	(Commercial) 70 dBA	(Eng. concrete and masonry) PPV 0.3 in/sec	140	70
Restaurant Plaza – 1958-1958 Shattuck Ave.	(Commercial) 70 dBA	(Non-eng. timber and masonry) PPV 0.2 in/sec	140	90
Spats Restaurant – 1974 Shattuck Ave.	(Commercial) 70 dBA	(Non-eng. timber and masonry) PPV 0.2 in/sec	150	90
Turkish Kitchen – 1986 Shattuck Ave.	(Commercial) 70 dBA	(Non-eng. timber and masonry) PPV 0.2 in/sec	170	90
Missing Link Bicycle Co-op - 1988 Shattuck Ave.	(Commercial) 70 dBA	(Non-eng. timber and masonry) PPV 0.2 in/sec	190	100
George Morgan Building. – 2053 Berkeley Way	(Residential) 65 dBA	(Susceptible to vib. damage) PPV 0.12 in/sec	170	100
Office/Restaurant - 1930 Shattuck Ave	(Commercial) 70 dBA	(Non-eng. timber and masonry) PPV 0.2 in/sec	200	120

1. Berkeley Municipal Code Noise Ordinance – see Section 2.2
2. Federal Transit Administration Vibration Damage Criteria
3. Distance between center of project site to boundary of receiver site
4. Distance between boundary of project site to boundary of receiver site

Figure 1 shows the project site vicinity and the worst-case noise sensitive receivers considered in the analysis below.

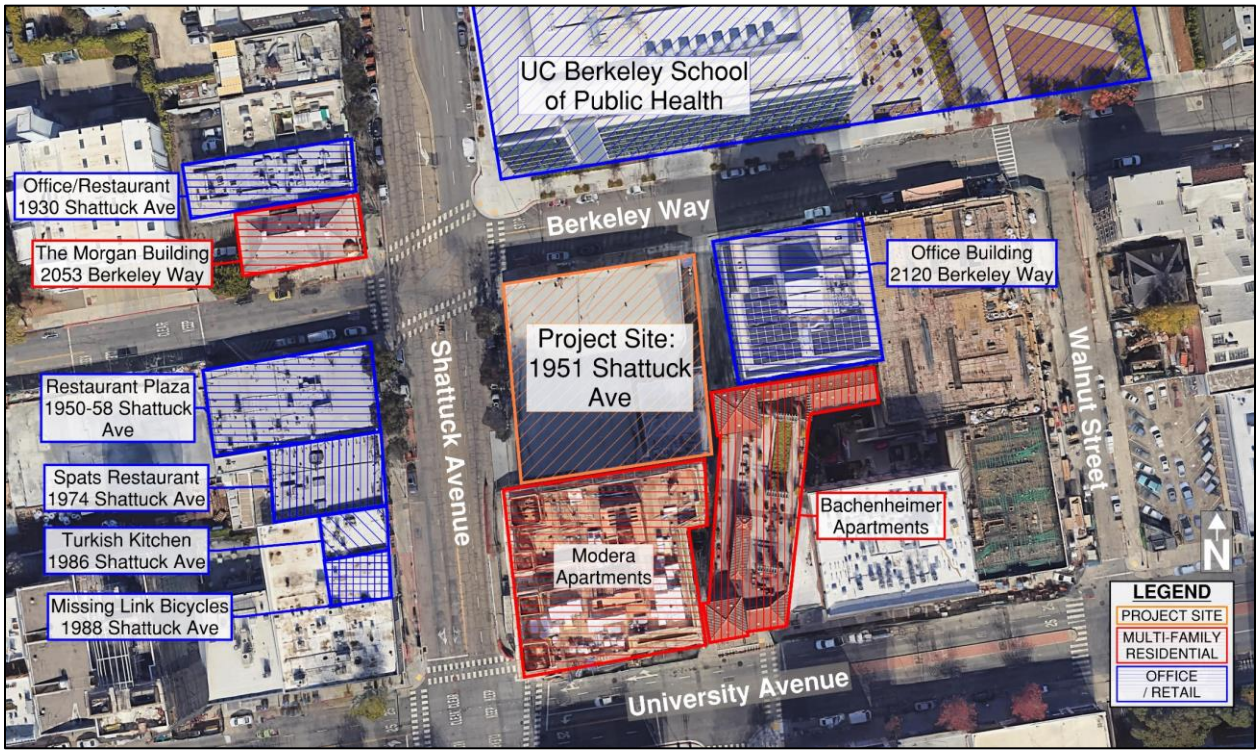

Figure 1: Project Site Vicinity + Sensitive Receivers

4.2 *Ambient Noise Level Measurements*

CSDA conducted long-term (weekdays, approximately 48-hour) measurements at the project site between September 26 and 27, 2019. The sound level meters used for these measurements were secured in lock boxes attached to a streetlight pole along Shattuck Avenue (Long-term Measurement 1, LT-1) and Berkeley Way (Long-term Measurement 2, LT-2). Sound level meters were positioned approximately 12 feet above street level.

4.2.1 Weather

During the measurements, the average wind speed was 13 miles per hour (mph); based upon a review of the noise levels during this time, wind noise did not affect the measurements. The temperature ranged from a low of 57°F to a high of 81°F, and averaged 65°F. The humidity level ranged from a low of 42% to a high of 87%, with no precipitation.

4.2.2 General Noise Conditions

During the measurement period, the noise environment was dominated by vehicle and pedestrian traffic on Shattuck Avenue and Berkeley Way. Table 4 presents the weekday noise measurement results over the planned hours of construction (weekdays, 7 AM to 7 PM). Note: per the Berkeley Municipal Code, construction activities are also allowed to occur on Saturdays, between 9 AM and 8 PM.

Table 4: Long-Term Noise Measurement Results

Measurement Location	Weekday noise Levels between 7 AM to 7 PM	
	Average 1-hour Noise Level	Minimum 1-hour Noise Level
LT-1: Shattuck Avenue	L_{EQ} 70 dBA	L_{EQ} 67 dBA
LT-2: Berkeley Way	L_{EQ} 61 dBA	L_{EQ} 58 dBA

Figures 3 and 4 represent the continuous sound levels throughout the measurement period for the long-term measurements along Shattuck Avenue and Berkeley Way, respectively.

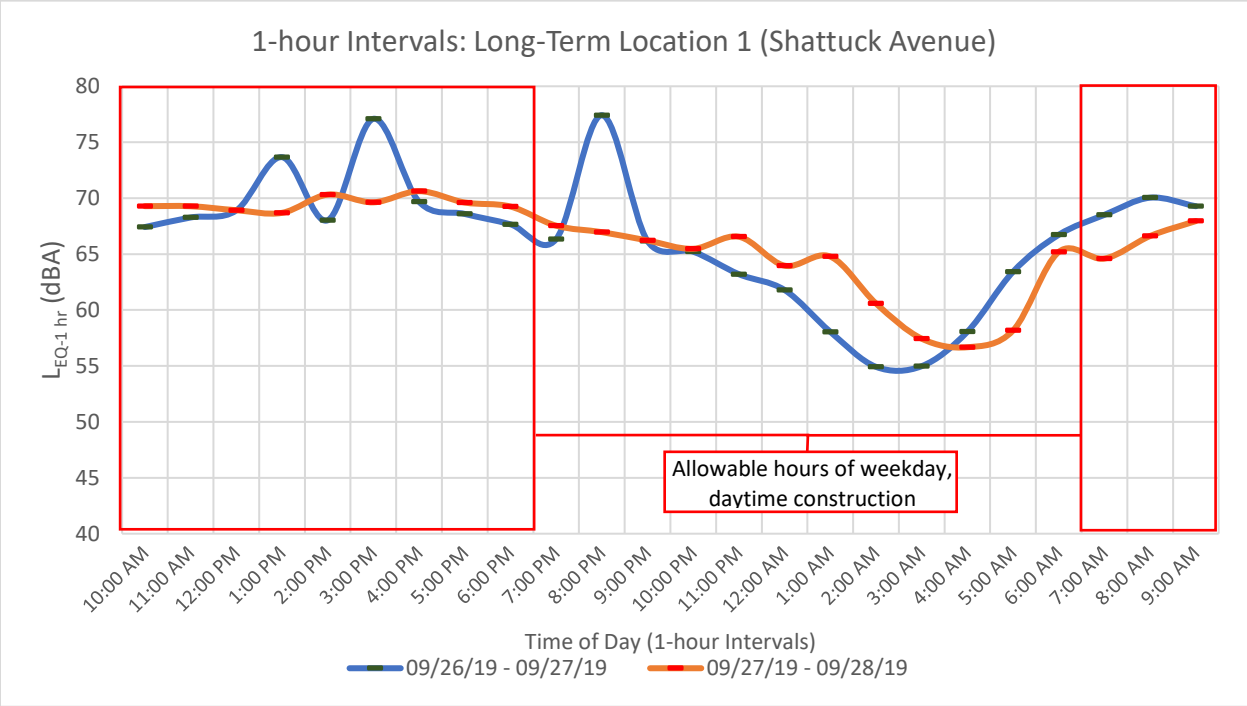

Figure 2: LT-1, Continuous Ambient Noise Levels at the Project Site

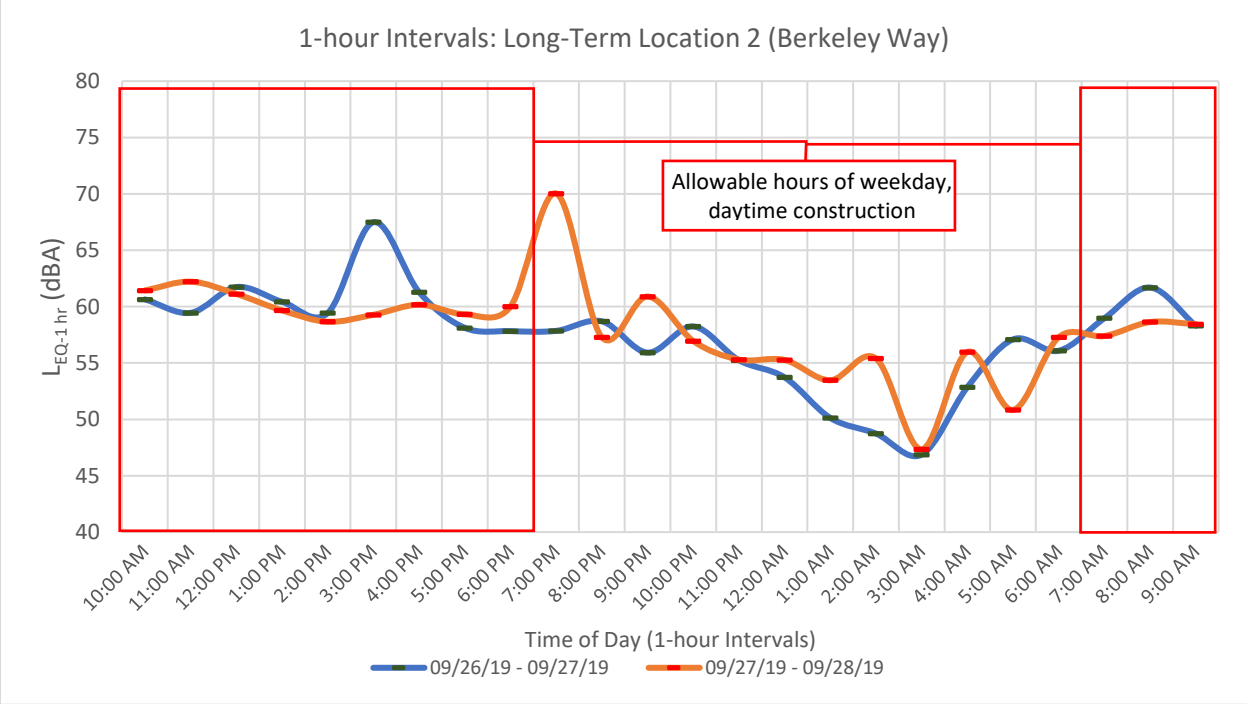

Figure 3: LT-2, Continuous Ambient Noise Levels at the Project Site

5.0 Construction Noise Analysis

5.1 *Construction Noise Methodology*

The primary construction noise impacts would occur from noise generated by the operation of heavy equipment on the project site. Noise impacts would also result from trucks arriving to and departing from the site, which would be an intermittent source of noise. Construction activities associated with the project would include a demolition/ earthwork/ utilities phase, a foundations/ podium construction/ structural concrete phase, a framing phase, an exterior finish phase, and a landscape/ sitework phase. Equipment typically used in these activities includes bulldozers, excavators, graders, backhoes, and concrete trucks. No pile driving is planned – instead project construction will use a drilled shoring rig. Table 5 presents the provided equipment mix for each and the equivalent equipment type and reference L_{EQ} noise levels at 50 feet (from the Federal Highway Administration, FHWA) – data provided by Grosvenor. Most of the heavy construction equipment will not be running at full capacity throughout each construction period and will not be restricted to one location. To account for this variation in usage, a usage factor (assigned to each piece of equipment in the by the FHWA "Roadway Construction Noise Model") has been incorporated to the reference noise levels presented in Table 5.[1]

Table 5: Planned Equipment Items per Phase, and Reference Noise Levels for Equipment Items

Phase	Planned Equipment Items	Equipment (Equivalent FHWA Reference)	Reference Noise Level at 50 feet (L_{EQ} dBA)[1]
Demolition/ Earthwork/ Underground Utilities	Backhoe	Backhoe	80
	Backhoe w/ Hydraulic Ram	Hydra Break Ram	90
	Bulldozer	Dozer	85
	Skip Loader	Front End Loader	80
	Grader	Grader	85
	Pad Foot Compactor	Compactor	80
	Dual Drum Loader	Drum Mixer	80
	Scraper	Scraper	85
	Water Truck	Dump Truck	84
	Excavator (x2)	Excavator (x2)	85
Foundation/Podium Construction/ Structural Concrete	Drilled Shoring Rig	Drill Rig Truck	84
	Forklift	Pickup Truck (x2)	55
	Backhoe/Mini Excavator	Backhoe	80
	Air Compressor	Compressor	80
	Concrete Pump	Concrete Pump Truck	82
	Concrete Trucks	Concrete Mixer Truck	85
Framing	Forklift Grade-All	Gradall	85
	Generator	Generator	82
	Scissor Lift	Manlift	85
	High Reach JLG	Manlift	85
	Hand Tools	Equipment > 5 HP	85
	Air Compressor	Compressor	80
	Crane	Crane	85
	Manlift	Manlift	85
Exterior Finish/ Skin	Forklift	Pickup Truck (x2)	55
	High Reach JLG	Manlift	85
	Hand Tools	Equipment > 5 HP	85
Landscape/ Site Work	Forklift	Pickup Truck (x2)	55
	Hoist	Manlift	85

[1] Federal Highway Administration Roadway Construction Noise Model Noise Emission Reference Level Database, 2006

Phase	Planned Equipment Items	Equipment (Equivalent FHWA Reference)	Reference Noise Level at 50 feet (L_{EQ} dBA)[1]
	Dump Truck	Dump Truck	84
	Delivery Truck	Pickup Truck	55
	Concrete Pump	Concrete Pump Truck	82
	Concrete Truck	Concrete Mixer Truck	85

Source: *Federal Highway Administration Roadway Construction Noise Model Noise Emission Reference Level Database*
1. Includes standard usage factor provided by FHWA

5.2 *Construction Noise Calculation Results*

The primary construction noise impacts would be generated by the operation of heavy equipment on the project site. By using the reference noise levels and associated usage factor for each planned equipment item, the estimated project-related construction noise levels were calculated for each receiver location. Note this analysis does not account for noise reduction provided by existing structures – barrier reduction would result in lower noise levels than what is presented below.

Construction noise levels are calculated in terms of average noise levels (L_{EQ}) and maximum noise levels (L_{MAX}).

- Average noise levels (L_{EQ}) consider all equipment items included in each phase, the typical usage factor (assigned to each piece of equipment in the by the FHWA "Roadway Construction Noise Model") and is presented in terms of the average distance between the project site and the boundary of the receiver property.
- Maximum noise levels (L_{MAX}) consider the loudest equipment item per phase operating at the minimum distance between source and receiver (i.e., an equipment item operating at the boundary of the project site closest to each individual receiver). Maximum noise levels do not consider usage factor.

5.3 *Results – Construction Noise*

CSDA understands that project-related construction activities will occur within the allowable hours of construction included in Section 2.22.1. Information on the project construction schedule, as well as planned equipment with typical noise levels, are summarized in Table 6. Tables 6 and 7 represent project-generated construction noise, per phase, at each of the representative receiver location, in terms of average noise levels (L_{EQ}) and maximum noise levels (L_{MAX}), respectively.

Table 6: Estimated Construction Equipment Noise Per Phase (Average Daily Noise Levels)

Receivers	Average Noise Levels at Receivers, per Construction Phase (L_{EQ}, dBA)				
	Demolition/ Earthwork/ Utilities	Foundation/ Podium Const/ Struct Concrete	Framing	Exterior Finish/ Skin	Landscape/ Site Work
Modera Berkeley – 2119 University Ave.	**88**	**82**	**85**	**81**	**82**
Bachenheimer Apartments - 2119 University Ave.	**88**	**82**	**85**	**81**	**82**
Life Sciences/Offices – 2120 Berkeley Way	**86**	**80**	**83**	**79**	**80**
UCB School of Public Health - 2121 Berkeley Way	**82**	**76**	**79**	**75**	**76**
Restaurant Plaza – 1958-1958 Shattuck Ave.	**82**	**76**	**79**	**75**	**76**
Spats Restaurant – 1974 Shattuck Ave.	**81**	**75**	**79**	**74**	**76**
Turkish Kitchen – 1986 Shattuck Ave.	**80**	**74**	**77**	**73**	**74**
Missing Link Bicycle Co-op - 1988 Shattuck Ave.	**79**	**73**	**76**	**72**	**73**
George Morgan Bldg. – 2053 Berkeley Way	**80**	**74**	**77**	**73**	**74**
Office/Restaurant - 1930 Shattuck Ave	**79**	**73**	**76**	**71**	**73**

Average noise levels are based on the average noise level of all equipment (including a usage factor over typical construction day) in terms of the average distance between the project site and each receiver
Bold levels indicate an exceedance of criteria – see Table 1; Equipment inventory from Grosvenor – see Table 5

Table 7: Estimated Construction Equipment Noise Per Phase (Maximum Noise Levels)

Receivers	Maximum Noise Levels at Receivers, per Construction Phase (L_{MAX}, dBA)				
	Demolition/ Earthwork/ Utilities	Foundation/ Podium Const/ Struct Concrete	Framing	Exterior Finish/ Skin	Landscape/ Site Work
Modera Berkeley – 2119 University Ave.	**110**	**105**	**110**	**105**	**105**
Bachenheimer Apartments - 2119 University Ave.	**104**	**99**	**104**	**99**	**99**
Life Sciences/Offices – 2120 Berkeley Way	**100**	**95**	**100**	**95**	**95**
UCB School of Public Health - 2121 Berkeley Way	**87**	**82**	**87**	**82**	**82**
Restaurant Plaza – 1958-1958 Shattuck Ave.	**85**	**80**	**85**	**80**	**80**
Spats Restaurant – 1974 Shattuck Ave.	**85**	**80**	**85**	**80**	**80**
Turkish Kitchen – 1986 Shattuck Ave.	**85**	**80**	**85**	**80**	**80**
Missing Link Bicycle Co-op - 1988 Shattuck Ave.	**84**	**79**	**84**	**79**	**79**
George Morgan Bldg. – 2053 Berkeley Way	**84**	**79**	**84**	**79**	**79**
Office/Restaurant - 1930 Shattuck Ave	**82**	**77**	**82**	**77**	**77**

Maximum noise levels are based on the loudest equipment item per phase, operating at the boundary of the project site closest to each individual receiver
Bold levels indicate an exceedance of criteria – see Table 1; Equipment inventory from Grosvenor – see Table 5

As shown in the results above, all phases of construction are expected to exceed the Berkeley Municipal Code noise limits (see Section 2.2). As such, in addition to the Item #15 Conditions of Approval provided for this project (see Section 2.1), we recommend implementing additional construction noise measures to reduce project-related construction noise to the maximum extent feasible. All construction noise control measures are outlined Section 7.0.

6.0 Construction Vibration Analysis

6.1 *Construction Vibration Methodology*

The primary construction vibration generation would occur from the operation of heavy equipment on the project site. Construction activities associated with the project would include a demolition / earthwork / utilities phase, a foundations / podium construction / structural concrete phase, a framing phase, an exterior finish phase, and a landscape / sitework phase. Equipment typically used in these activities includes bulldozers, excavators, graders, backhoes, and concrete trucks. No pile driving is planned – instead project construction will use a drilled shoring rig.

The following construction vibration analysis for building damage is in line with the methods presented in the Federal Transit Administration Transit Noise and Vibration Impact Assessment Manual (2018). Additionally, the equipment reference levels and calculation procedures established by the FTA and utilized in this analysis provide a reasonable estimate for a wide range of soil conditions – this method satisfies the project's condition of approval regarding the requirement to account for specific soil characteristics in the project area. Table 8 presents the provided equipment mix for each phase (from Grosvenor), and the equivalent equipment type and reference vibration levels at 25 feet (from the Federal Transit Administration).

Table 8: Typical Vibration Levels from Construction Equipment

Phase	Planned Equipment Items	Equipment (Equivalent FTA Reference)	Reference Vibration Level at 25 feet (PPV, inches/second)[1]
Demolition/ Earthwork/ Underground Utilities	Backhoe	Large Bulldozer	0.089
	Backhoe w/ Hydraulic Ram	Hoe Ram	0.089
	Bulldozer	Large Bulldozer	0.089
	Skip Loader	Large Bulldozer	0.089
	Grader	Large Bulldozer	0.089
	Pad Foot Compactor	Jackhammer	0.035
	Dual Drum Loader	Large Bulldozer	0.089
	Scraper	Large Bulldozer	0.089
	Water Truck	Loaded Trucks	0.076
	Excavator (x2)	Large Bulldozer	0.089
Foundation/Podium Construction/ Structural Concrete	Drilled Shoring Rig	Caission Drilling	0.089
	Forklift	Small Bulldozer	0.003
	Backhoe/Mini Excavator	Large Bulldozer	0.089
	Air Compressor	*n/a*	-
	Concrete Pump	Loaded Trucks	0.076
	Concrete Trucks	Loaded Trucks	0.076
Framing	Forklift Grade-All	Small Bulldozer	0.003
	Generator	*n/a*	-
	Scissor Lift	*n/a*	-
	High Reach JLG	*n/a*	-
	Hand Tools	*n/a*	-
	Air Compressor	*n/a*	-
	Crane	*n/a*	-
	Manlift	*n/a*	-
Exterior Finish/ Skin	Forklift	*n/a*	-
	High Reach JLG	*n/a*	-
	Hand Tools	*n/a*	-
Landscape/ Site Work	Forklift	*n/a*	-
	Hoist	*n/a*	-
	Dump Truck	Loaded Trucks	0.076
	Delivery Truck	Loaded Trucks	0.076
	Concrete Pump	Loaded Trucks	0.076
	Concrete Truck	Loaded Trucks	0.076

Source: *Federal Highway Administration Roadway Construction Noise Model Noise Emission Reference Level Database*
Note: equipment items such as forklifts and air compressors are not expected to generate significant levels of vibration

1. Includes standard usage factor provided by FHWA

6.2 *Construction Vibration Calculation Results – Building Damage*

By using the reference vibration levels for each planned equipment item, the estimated construction vibration levels with respect to building damage have been calculated for each receiver location, as shown in Tables 9 through 12 (separated by construction phase).

As shown in the tables below, construction activities have the potential to cause building damage only at the directly adjacent residential buildings (i.e., Modera Berkeley, Bachenheimer Apartments). This is due to the very close distance between the construction site and these buildings. Based on the methods described in Section 6.1, all other receiver buildings are not at risk for vibration damage due to project construction. For the Modera Berkeley and Bachenheimer Apartments buildings, refer to the measures outlined in Section 8.0.

Table 9: Estimated Building Damage Potential due to Construction Vibration – Demolition/ Earthwork/ Underground Utilities

Receptor	Applicable Limit (PPV, in/sec)	Minimum Distance to Project Boundary (feet)	Large Bulldozer (Backhoe, Bulldozer, Skip Loader, Grader, Dual Drum Loader, Scraper, Excavator)	Hoe Ram (Backhoe w/ Hydraulic Ram)	Loaded Trucks (Water Trucks)	Jackhammer (Pad Foot Compactor)
Reference Vibration at 25 ft	-	*25*	0.089	0.089	0.076	0.035
Modera Berkeley – 2119 University Ave.	0.2	5	**1.00**	**1.00**	**0.85**	0.39
Bachenheimer Apartments - 2119 University Ave.	0.2	10	**0.35**	**0.35**	**0.30**	0.14
Life Sciences/Offices – 2120 Berkeley Way	0.3	15	0.19	0.19	0.16	0.08
UCB School of Public Health - 2121 Berkeley Way	0.3	70	0.02	0.02	0.02	0.01
Restaurant Plaza – 1958-1958 Shattuck Ave.	0.2	90	0.01	0.01	0.01	0.01
Spats Restaurant – 1974 Shattuck Ave.	0.2	90	0.01	0.01	0.01	0.01
Turkish Kitchen – 1986 Shattuck Ave.	0.2	90	0.01	0.01	0.01	0.01
Missing Link Bicycle Co-op - 1988 Shattuck Ave.	0.2	100	0.01	0.01	0.01	< 0.01
George Morgan Bldg. – 2053 Berkeley Way	0.12	100	0.01	0.01	0.01	< 0.01
Office/Restaurant - 1930 Shattuck Ave	0.2	120	0.01	0.01	0.01	< 0.01

***Bold** levels indicate an exceedance of criteria*

Table 10: Estimated Building Damage Potential due to Construction Vibration – Foundation/ Podium Const./ Struct. Concrete

Receptor	Applicable Threshold (PPV, in/sec)	Minimum Distance to Project Boundary (feet)	Cassion Drilling (Drilled Shoring Rig)	Large Bulldozer (Backhoe/Mini Excavator)	Loaded Trucks (Concrete Pump, Concrete Trucks)	Small Bulldozer (Forklift)
Reference Vibration at 25 ft	-	*25*	0.089	0.089	0.076	0.003
Modera Berkeley – 2119 University Ave.	0.2	5	**1.00**	**1.00**	**0.85**	0.03
Bachenheimer Apartments - 2119 University Ave.	0.2	10	**0.35**	**0.35**	**0.30**	0.01
Life Sciences/Offices – 2120 Berkeley Way	0.3	15	0.19	0.19	0.16	0.01
UCB School of Public Health - 2121 Berkeley Way	0.3	70	0.02	0.02	0.02	< 0.01
Restaurant Plaza – 1958-1958 Shattuck Ave.	0.2	90	0.01	0.01	0.01	< 0.01
Spats Restaurant – 1974 Shattuck Ave.	0.2	90	0.01	0.01	0.01	< 0.01
Turkish Kitchen – 1986 Shattuck Ave.	0.2	90	0.01	0.01	0.01	< 0.01
Missing Link Bicycle Co-op - 1988 Shattuck Ave.	0.2	100	0.01	0.01	0.01	< 0.01
George Morgan Bldg. – 2053 Berkeley Way	0.12	100	0.01	0.01	0.01	< 0.01
Office/Restaurant - 1930 Shattuck Ave	0.2	120	0.01	0.01	0.01	< 0.01

***Bold** levels indicate an exceedance of criteria*

Table 11: Estimated Building Damage Potential due to Construction Vibration – Framing

Receptor	Applicable Threshold (PPV, in/sec)	Minimum Distance to Project Boundary (feet)	Small Bulldozer (Forklift Grade-All)
Reference Vibration at 25 ft	-	*25*	0.003
Modera Berkeley – 2119 University Ave.	0.2	5	0.03
Bachenheimer Apartments - 2119 University Ave.	0.2	10	0.01
Life Sciences/Offices – 2120 Berkeley Way	0.3	15	0.01
UCB School of Public Health - 2121 Berkeley Way	0.3	70	< 0.01
Restaurant Plaza – 1958-1958 Shattuck Ave.	0.2	90	< 0.01
Spats Restaurant – 1974 Shattuck Ave.	0.2	90	< 0.01
Turkish Kitchen – 1986 Shattuck Ave.	0.2	90	< 0.01
Missing Link Bicycle Co-op - 1988 Shattuck Ave.	0.2	100	< 0.01
George Morgan Bldg. – 2053 Berkeley Way	0.12	100	< 0.01
Office/Restaurant - 1930 Shattuck Ave	0.2	120	< 0.01

***Bold** levels indicate an exceedance of criteria*

Table 12: Estimated Building Damage Potential due to Construction Vibration – Landscape/Site Work

Receptor	Applicable Threshold (PPV, in/sec)	Minimum Distance to Project Boundary (feet)	Loaded Trucks (Dump Truck, Delivery Truck, Concrete Pump, Concrete Truck)
Reference Vibration at 25 ft	-	*25*	0.076
Modera Berkeley – 2119 University Ave.	0.2	5	0.85
Bachenheimer Apartments - 2119 University Ave.	0.2	10	0.30
Life Sciences/Offices – 2120 Berkeley Way	0.3	15	0.16
UCB School of Public Health - 2121 Berkeley Way	0.3	70	0.02
Restaurant Plaza – 1958-1958 Shattuck Ave.	0.2	90	0.01
Spats Restaurant – 1974 Shattuck Ave.	0.2	90	0.01
Turkish Kitchen – 1986 Shattuck Ave.	0.2	90	0.01
Missing Link Bicycle Co-op - 1988 Shattuck Ave.	0.2	100	0.01
George Morgan Bldg. – 2053 Berkeley Way	0.12	100	0.01
Office/Restaurant - 1930 Shattuck Ave	0.2	120	0.01

***Bold** levels indicate an exceedance of criteria*

7.0 Noise Reduction Measures

As outlined in Section 5.2, all phases of project construction are expected to exceed the Berkeley Municipal Code construction noise ordinance provided in Section 13.40.070.B.7. Due to the high-density nature of the surrounding land uses, there are no feasible construction measures that would reduce project construction noise at nearby receivers to 65 dBA or less. Project construction shall therefore implement all available construction noise mitigation techniques to reduce construction noise to the maximum extent feasible.

Per item #15 of the Conditions of Approval provided for this project, all phases of project construction shall implement the measures outlined in the items below.

1. Construction activities should be limited to weekday hours between 7 AM and 7 PM, and weekend hours between 9 AM and 8 (allowable hours of construction defined by Berkeley Municipal Code, Section 13.40.070.B.7).
   - Since all phases of project construction are expected to exceed the applicable construction noise limit, and since the municipal code applies a stricter noise limitation to construction activities occurring on weekends, **construction work on weekends should be minimized where the schedule allows**. Additionally, project construction should not be allowed on holidays.
2. Construction equipment should be well maintained and used judiciously to be as quiet as practical.
3. Equip all internal combustion engine-driven equipment with mufflers, which are in good condition and appropriate for the equipment.
4. Utilize “quiet” models of air compressors and other stationary noise sources where technology exists. Select hydraulically or electrically powered equipment and avoid pneumatically powered equipment where feasible.
5. Locate stationary noise-generating equipment as far as possible from sensitive receptors when adjoining construction sites. Construct temporary noise barriers or partial enclosures to acoustically shield such equipment where feasible.
6. Prohibit unnecessary idling of internal combustion engines.
7. Construct solid wood plywood fences around construction sites adjacent to operational business, residences or other noise-sensitive land uses where the noise control plan analysis determines that a barrier would be effective at reducing noise.
   - This measure should only apply to ground level construction activities (i.e., the majority of framing and exterior finish activities would be greater than 10-feet above grade, and would be unaffected by sound barriers)
8. Erect temporary noise control blanket barriers, if necessary, along building facades facing construction sites. This mitigation would only be necessary if conflicts occurred where were irresolvable by proper scheduling. Noise control blanket barriers can be rented and quickly erected.
9. Route construction related traffic along major roadways and away from sensitive receptors where feasible.

In addition to the noise control measures provided by Item #15 of the Conditions of Approval provided for this project, to reduce construction noise impact to the extent feasible, we recommend implementing the following noise control measures:

10. Equipment and trucks used for project construction shall utilize the best available noise control techniques (e.g., improved mufflers, equipment redesign, use of intake silencers, ducts, engine enclosures and acoustically-attenuating shields or shrouds) wherever feasible.
11. Except as provided herein, impact tools (e.g., jack hammers, pavement breakers, and rock drills) used for project construction shall be hydraulically or electrically powered to avoid noise associated

with compressed air exhaust from pneumatically powered tools. However, where use of pneumatic tools is unavoidable, an exhaust muffler on the compressed air exhaust shall be used; this muffler can lower noise levels from the exhaust by up to about 10 dBA. External jackets on the tools themselves shall be used, if such jackets are commercially available, and this could achieve a reduction of 5 dBA. Quieter procedures shall be used, such as drills rather than impact equipment, whenever such procedures are available and consistent with construction procedures.

12. Applicant shall use temporary power poles instead of generators where feasible.
13. All equipment shall be turned off if not in use for more than 5 minutes.
14. Air compressors:
    a. Utilize quiet air compressors with manufacturer's sound level of 65 dBA or less at 50' and maintain minimum distance of 35' to sensitive receptor property lines OR
    b. Utilize construction sound blankets with a minimum surface density of one pound per square foot and fully enclose the air compressors; blankets to be 3' taller than top of compressor. Maintain minimum distance of 35' to sensitive receptor property lines.

To further reduce the impact of project construction noise on the surrounding community, the project applicant should notify the community of significant noise levels, and administer a set of procedures to track and respond to noise complaints, as follows:

15. The project applicant shall submit to the City for review and approval a set of procedures for responding to and tracking complaints received pertaining to construction noise and shall implement the procedures during construction. At a minimum, the procedures shall include:
    a. Designation of an on-site construction complaint and enforcement manager for the project;
    b. A large on-site sign near the public right-of-way containing permitted construction days/hours, complaint procedures, and phone numbers for the project complaint manager and City Code Enforcement unit;
    c. Protocols for receiving, responding to, and tracking received complaints; and
    d. Maintenance of a complaint log that records received complaints and how complaints were addressed, which shall be submitted to the City for review upon the City's request.

8.0 Building Damage due to Vibration – Control Measures

As described in Section 6.2, the use of large construction equipment within close proximity to the nearest residential buildings to the south and east of the project site (Modera Berkeley and Bachenheimer Apartments, 2119 University Ave) is expected to generate vibration levels that have the potential to cause building damage. The following construction equipment items, when operating near the south and east project boundaries, have the potential to cause building damage at the surrounding residential buildings, Modera Berkeley and Bachenheimer Apartments:

- **Demolition/ Earthwork/ Underground Utilities Phase**
  - Backhoe
  - Backhoe with Hydraulic Ram
  - Bulldozer
  - Skip Loader
  - Grader
  - Dual Drum Loader
  - Scraper
  - Water Truck (loaded trucks)
  - Excavator
- **Foundation/ Podium Construction/ Structural Concrete Phase**

- Drilled Shore Rig
- Backhoe/ Mini Excavator
- Concrete Pump Truck
- Concrete Trucks

- **Landscape/ Sitework Phase**
  - Dump Truck (loaded trucks)
  - Delivery Truck (loaded trucks)
  - Concrete Pump Truck
  - Concrete Trucks

The project construction activities listed above have the potential to cause building damage due to vibration at the nearest residential buildings (Modera Berkeley and Bachenheimer Apartments, see Figure 1). Per item #16 of the Conditions of Approval provided for this project, the following measures should be applied to the phases and equipment usage listed above:

1. The structural engineer or other appropriate professional shall recommend design means and methods of construction to avoid the potential damage, if feasible. This should include an assessment of the project site conditions, including detail on the composition of neighboring structures, soil characteristics in the project area, and location of the various types of equipment used during each phase of the project (see bullet list above) relative to the nearest residential buildings (Modera Berkeley and Bachenheimer Apartments, see Figure 1). The assessment and its recommendations shall be reviewed and approved by the Building and Safety Division and the Zoning Officer. If there are no feasible design means or methods to eliminate the potential for damage, the structural engineer or other appropriate professional shall undertake an existing conditions study (study) of any structures (or, in case of large buildings, of the portions of the structures) that may experience damage. This study shall:
   - Establish baseline condition of these structures, including, but not limited to, the location and extent of any visible cracks or spalls; and
   - Include written descriptions and photographs.

   Upon completion of the project, the structures previously inspected will be resurveyed, and any new cracks or other changes shall be compared to pre-construction conditions and a determination shall be made as to whether the proposed project caused the damage. The findings shall be submitted to the Building and Safety Division and the Zoning Officer for review. If it is determined that project construction has resulted in damage to the structure, the damage shall be repaired to the pre-existing condition by the project sponsor, provided that the property owner approves of the repair.

This concludes our construction noise and vibration reduction plan for the 1951 Shattuck Avenue project in Berkeley, CA; please contact us with questions.

Appendix A: Acoustical Definitions

- **A-Weighted Sound Level (dBA):** A standard frequency weighting that filters the microphone signal in a manner which compares relative loudness of various sounds. A-weighting is standardized by the American National Standards Institute (ANSI). A 10-dB increase in sound level is generally perceived to be approximately twice as loud. All noise data in this report are A-weighted.
- **Decibel (dB):** The most generally used logarithmic scale for describing sound levels. A decibel value denotes the ratio between two quantities that are proportional to power; the decibel value is ten times the logarithm (to the base 10) of this ratio. The term "Sound Level," "Noise Level" and "Sound Pressure Level" (SPL) all imply a standardized reference level near the threshold of human hearing (0 decibels).
- **L_{eq}:** The equivalent steady-state A-weighted sound level that, in a stated period of time, would contain the same acoustic energy as the time-varying sound level during the same time period.
- **Peak Particle Velocity (PPV):** The peak signal value of an oscillating vibration velocity waveform, usually expressed in inches/second