November 1, 2022

**Warmington Residential**
3090 Pullman Street
Costa Mesa, California 92626

Attention: **Moses Kim | Senior Project Manager**

Subject: **Jackson Street Development**
**Riverside, CA**
**Exterior Noise and Exterior Façade Acoustical Analysis and Vibration Analysis**
**Veneklasen Project No. 5798-009**

Dear Moses:

Veneklasen Associates, Inc. (Veneklasen) has completed our review of the Jackson Street Development project located in Riverside, California. This report predicts the exterior noise level at the site using measurements and computer modeling. Using this information, interior noise levels were calculated based on the exterior noise exposure and the construction types proposed. From this, the exterior façade design was determined. Ground vibration levels due to trains events were also measured. This report represents the results of our findings.

## 1.0 INTRODUCTION

This study was conducted to determine the impact of the exterior noise sources on the Jackson Street Development project in Riverside, California. Veneklasen's scope of work included calculating the exterior noise levels impacting the site and determining the method, if any, required to reduce the interior and exterior sound levels to meet the applicable code requirements of the State of California and the City of Riverside.

The project consists of 19 3 & 4-plex buildings with a total of 70 residential units. The project is bounded by Union Pacific Railroad (UPRR)/Burlington Northern Santa Fe Railroad (BNSF)/Metrolink 91 Perris Valley and Inland Empire Orange County Lines to the north, Jackson St to the east, and existing residential uses to the south and west. Veneklasen understands that client is planning to erect a sound barrier at the northern property limit, facing the railway, to block noise coming from train events and provide acoustical shielding to receptors on the first floor.

## 2.0 NOISE AND VIBRATION CRITERIA

Ldn (Day-Night Level) is the 24-hour equivalent (average) sound pressure level in which the nighttime (10 pm – 7 am) noise is weighted by adding 10 dB to the hourly level. Since this is a 24-hour metric, short-duration noise events (truck pass-by's, buses, trains, etc.) are not as prominent in the analysis.

Leq (equivalent continuous sound level) is defined as the steady sound pressure level which, over a given period of time, has the same total energy as the actual fluctuating noise.

Lmax (maximum sound level) is the highest sound level measured during a single noise event (such a truck or train pass by), in which the sound level change value as time goes on. All noise criteria presented below (Ldn for the State and City Municipal Code, and "Noise Level" on Table 1) are based on Leq values and not on Lmax values.

### 2.1 Interior Noise Levels - Residential

The State of California Building Code (CBC) (Section 1206.4) and the City of Riverside Municipal Code (Section 16.08.175, item B.2) states that interior Ldn values for residential land uses are not to exceed 45 Ldn in any habitable room.

The City of Riverside Municipal Code, Section 7.30.015, Interior Sound Level Limits, state that "no person shall operate or cause to be operated, any source of sound indoors which causes the noise level when measured inside another dwelling unit, school or hospital, to exceed… the interior noise standard for the applicable land use category, plus ten decibels or the maximum measured ambient noise level, for any period of time." The train passby event with the engine is present for a short period of time, below the values presented in the ordinance. For this reason, the interior noise standard + 10 dBA is applicable.

**Table 1 – Interior Noise Standard, City of Riverside**

| Land Use Category | Time Period | Noise Level |
|---|---|---|
| Residential | Night (10pm to 7am)<br>Day (7am to 10pm) | 35 dBA<br>45 dBA |
| School | 7am to 10pm (while school is in session) | 45 dBA |
| Hospital | Any Time | 45 dBA |

Given the instantaneous nature of train noise and section 7.30.015 of the City of Riverside Municipal Code, the applicable criteria for this project shall be that interior levels is the interior noise standard in Table 1 + 10 dBA meaning that the sound will not exceed 45 dBA during the nighttime (10pm to 7am) and 55 dBA during the daytime (7am to 10pm).

The interior 45 Ldn (per CBC section 1206.4 and Riverside Municipal Code Section 16.08.175, item B.2) is stricter than the City Noise Element. If the 45 Ldn is satisfied, then the City requirement (Municipal Code Section 7.30.015) is also satisfied.

If the windows must be closed to meet the noise criteria listed above, then a mechanical ventilating system or other means of natural ventilation may be required.

## 2.2 Exterior Noise Levels – Residential Common Areas

The City of Riverside Municipal Code, Section 7.25.010, Exterior Sound Level Limits, state that "it shall be unlawful for any person to cause or allow the creation of any noise which exceeds… the exterior noise standard for the applicable land use category, plus 20 decibels or the maximum measured ambient noise level, for any period of time." This is consistent with land use requirements set forth by the State of California.

**Table 2 – Interior Noise Standard, City of Riverside**

| Land Use Category | Time Period | Noise Level |
|---|---|---|
| Residential | Night (10pm to 7am)<br>Day (7am to 10pm) | 45 dBA<br>55 dBA |
| Office/Commercial | Any Time | 65 dBA |
| Industrial | Any Time | 70 dBA |

Given the instantaneous nature of train noise and section 7.25.010 of the City of Riverside Municipal Code, the applicable criteria for this project shall be that exterior levels at residential common areas is the exterior noise standard in Table 2 + 20 dBA meaning that the sound will not exceed 75 dBA, assuming that tenants will gather only during the daytime (7am to 10pm) in these areas.

### 2.3 Vibration Criteria

The "Transit Noise and Vibration Impact Assessment" report from the Federal Transit Administration, U.S. Department of Transportation, dated September 2018 ("FTA Report") states that for "Occasional Events" (defined as 30 to 70 events per day of the same source) in residences and buildings where people normally sleep the vibration levels will not exceed 75 VdB. However, FTA Guidelines states that "Rail car vibration from a typical line-haul freight train usually lasts for several minutes and can be characterized by the frequent events category (72 VdB maximum level). FTA guidelines are not enforced by the state or city code and compliance is not required.

## 3.0 EXTERIOR NOISE AND VIBRATION ENVIRONMENT

### 3.1 Noise Measurements

Traffic on UPRR/BNSF/Metrolink lines and Jackson Street is the primary source of noise affecting the site. Veneklasen visited the site on Monday, July 11, 2022 and placed a sound level meter on the boundary of the project site to capture the hourly sound levels on the site for a 24-hour period. Veneklasen also made short-term noise measurements. Table 3 and Figure 1 show the location and summary of the noise measurements.

**Table 3 – Measured Sound Levels**

| Location | Approximate Distance to the Center of Railway/Center of Jackson St (ft) | Ldn | Nighttime LAeq (10 pm – 7 am) | Daytime LAeq (7 am – 10 pm) | LAeq | Lmax, dBA (Nighttime Train Events) |
|---|---|---|---|---|---|---|
| L1 | 35 / 135 | 81 | 75 | 73 | - | 98 |
| S1 | 100 / 35 | - | - | - | 65* | |
| S2 | 40 / 445 | - | - | - | 48* | |

*Level did not measure train event

**Figure 1 – Aerial View of Project Site Showing Measurement Locations**

### 3.2 UPRR/BNSF/Metrolink 91 Perris Valley Line and Inland Empire-Orange County Line

The UPRR/BNSF Freight Train Lines and Metrolink 91 Perris Valley and Inland Empire Orange County Lines is immediately to the north of the project site. The 24-hour noise/vibration measurements indicate that the Metrolink trains ran fifteen (15) times during daytime (7am-7am), three (3) times during the evening (7pm-10pm) and eight (8) times during nighttime (10pm-7am). Freight train ran 30 times all day. Since the railway crossing with Jackson St already has sound/light alarms for train passings, no horn noise was recorded during the survey.

### 3.3 Sound Barrier at Property Limit

Veneklasen understands that client is planning to erect a sound barrier at the c, facing the railway, to block noise coming from train events and provide acoustical shielding to receptors on the first floor. Veneklasen anticipates that sound barrier will be made of CMU and will have a minimum height of 10 feet.

### 3.4 Overall Exterior Exposure

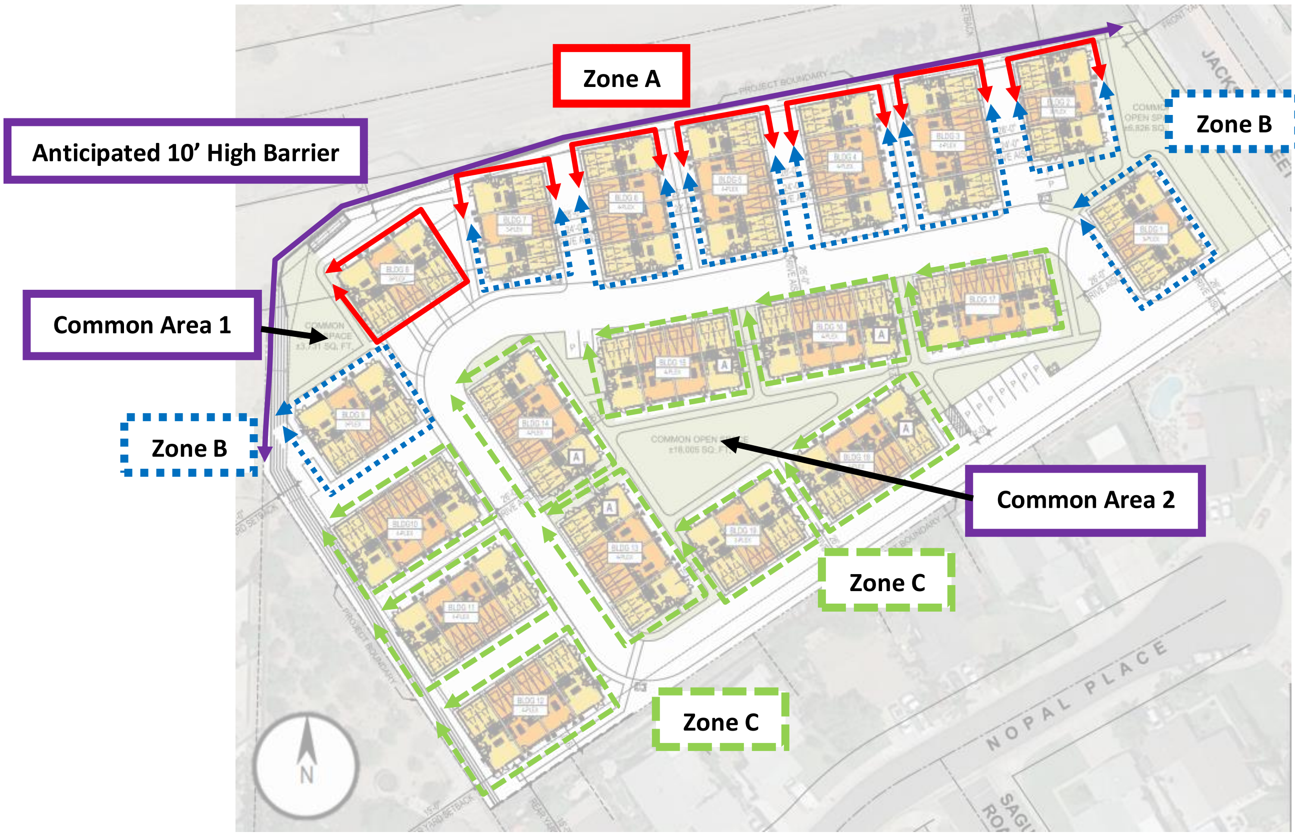
Based on drawings and elevations provided by the client, Veneklasen understands that future residential buildings will be located, approximately, at 55 feet from the center of the railways and at 10 feet from the sound barrier planned to be erected at the property limit. The railways are located around 6 feet below the finish grade of the future buildings. The trains height is approximately 16 feet. Therefore, the train height will be at 10 feet above the finish grade, and the planned 10 feet sound barrier will block the line of sight at the first floor.

Based on the computer model and measurements, Veneklasen calculated the noise level at different locations across the project site considering the shielding effect of the 10 foot sound barrier. To simplify the presentation of the exterior noise levels, Veneklasen has separated the site into locations based on the sound exposure and required mitigation. The predicted sound levels at each zone, shown in Figure 2, are listed in Table 4 below.

**Table 4 – Exterior Noise Levels**

| Location | Floor | Ldn | Exterior Noise Level, Nighttime, dBA | Exterior Noise Level, Daytime, dBA |
|---|---|---|---|---|
| Zone A | 1 | 72 | 66 | 64 |
| | 2 | 80 | 74 | 72 |
| Zone B | 1 | 66 – 67 | 60 – 61 | 59 – 60 |
| | 2 | 74 – 75 | 68 – 69 | 67 – 68 |
| Zone C | All | ≤ 73 | ≤ 67 | ≤ 66 |

**Figure 2 – Noise Zones. Floor 1 and 2.**




### 3.5 Vibration and Noise Measurements from Train Events

Long-term vibration measurements were also performed at measurement location V1 shown in Figure 1 above and plotted in Figure 3 below. Vibration levels were measured during a 24-hour period in the vertical direction, at property limit, at a distance of 38 feet from the center of the railways. During the survey, twenty-six (26) Metrolink trains and thirty (30) freight train events were recorded. Figure 3 and Figure 4 show the recorded levels from nine (9) worst Metrolink and freight train events, respectively. Considering that vibration measurements were performed at property limit (38 feet from the center of the railways) while the closest future residence will be located at 45 feet from the center of the railways, the vibration levels at closest future units will be equal or below 72 VdB. This satisfies the FTA's vibration criterion for "frequency events."

**Figure 3 – Measured Vibration Levels from Metrolink Train Events Compared to FTA Guidelines (75 VdB).**

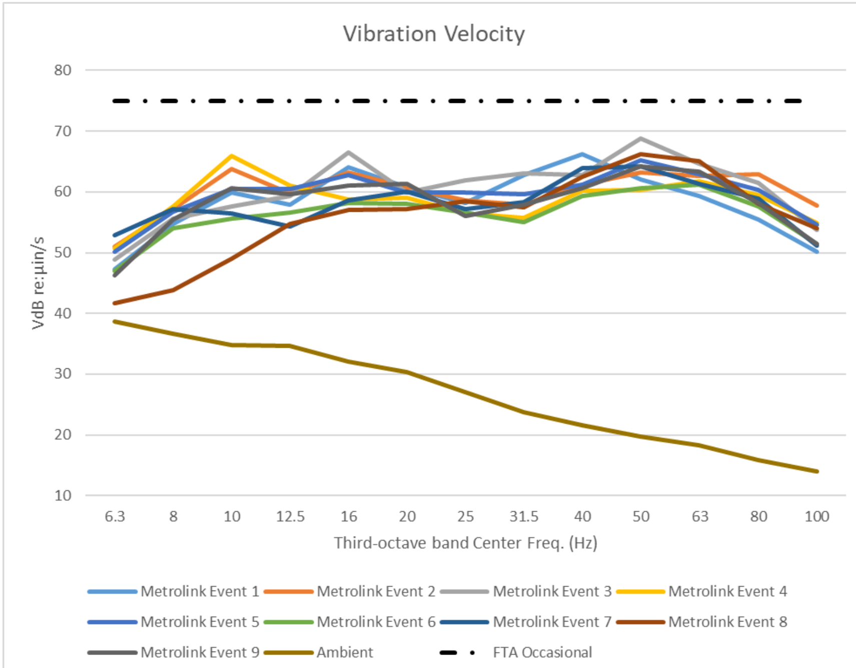
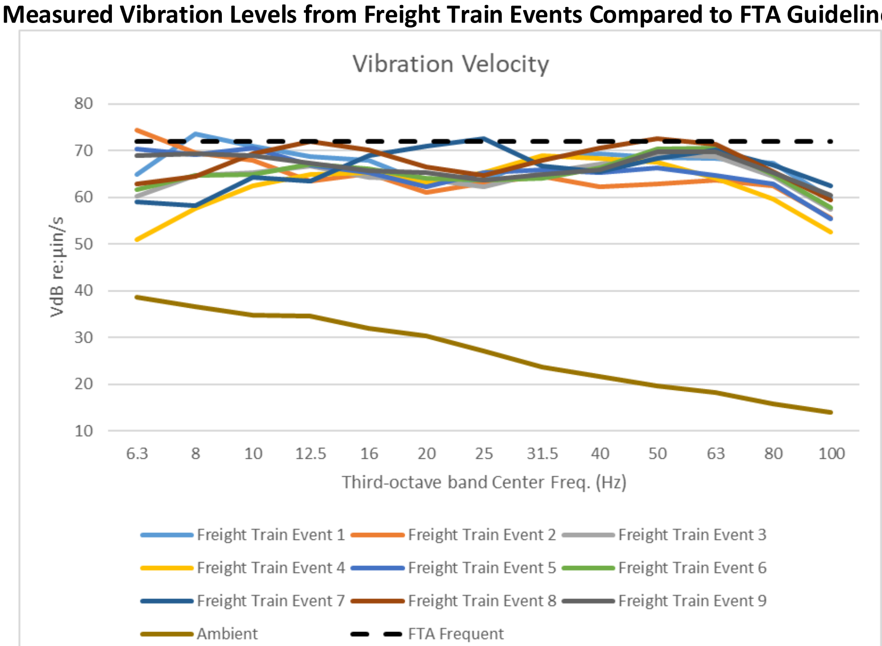



**Figure 4 – Measured Vibration Levels from Freight Train Events Compared to FTA Guidelines (72 VdB).**




## 4.0 INTERIOR NOISE CALCULATION

### 4.1 Exterior Facade Construction

Exterior wall assembly has not been provided yet. Veneklasen has anticipated that the exterior wall will be of standard construction and consist of stucco over sheathing, on wood studs with a single layer of gypsum board on the interior and batt insulation in the cavity.

Veneklasen utilized the glazing ratings (glass, frame and seals) shown in Appendix I. Appendix I shall be the acoustical specification for the exterior windows and doors.

### 4.2 Interior Average Noise Level (Nighttime and Daytime Noise Levels)

Veneklasen calculated the interior level within the residential units given the measured noise environment and the exterior facade construction described above. Calculations were based on the plans dated June 9 and 28, 2022. Table 5 shows the predicted interior nighttime and daytime noise levels, respectively, based on the windows with STC ratings as shown and glazing construction as described in Appendix I.

Section 7.30.015 of The City of Riverside Municipal Code states the maximum interior noise levels at residential units. Given the instantaneous nature of train nature and section 7.30.015 of the Municipal Code, the applicable criteria for this project shall be that interior levels is the interior noise standard in Table 1 + 10 dBA meaning that the sound will not exceed 45 dBA during the nighttime (10pm to 7am) and 55 dBA during the daytime (7am to 10pm).

**Table 5 – Calculated Interior Nighttime Noise Levels**

| Location | Floor | Ldn | Exterior Noise Level, Nighttime LAeq | Exterior Noise Level, Nighttime LAeq | Window/ Door Rating | Ldn Interior Noise Level, dBA | Nighttime Interior Noise Level, dBA | Daytime Interior Noise Level, dBA |
|---|---|---|---|---|---|---|---|---|
| Zone A | 1 | 72 | 66 | 64 | STC 33 | ≤ 45 | < 45 | < 55 |
| | 2 | 80 | 74 | 72 | STC 37 | < 45 | < 45 | < 55 |
| Zone B | 1 | 66 – 67 | 60 – 61 | 59 – 60 | STC 30 | < 45 | < 45 | < 55 |
| | 2 | 74 – 75 | 68 – 69 | 67 – 68 | STC 33 | < 45 | < 45 | < 55 |
| Zone C | All | ≤ 73 | ≤ 67 | ≤ 66 | STC 30 | < 45 | < 45 | < 55 |

Veneklasen utilized the glazing ratings (glass, frame and seals) shown in Appendix I. Appendix I shall be the acoustical specification for the exterior windows and doors.

Any material used to construct the noise barrier must have a density of at least 3 lbs./ft$^2$. Metal, wood, concrete, brick or CMU are examples of materials that can be used for the barrier. Regardless of the wall material, any joints in the way must be properly sealed or overlapped such that there are no gaps in the wall. The wall should not be permeable for sound. This wall can be beautified with landscaping, wood veneer, or any other material more visually pleasing as long as it does not penetrate or otherwise compromise the acoustical performance of the wall. The wall, once designed, should be reviewed by Veneklasen for acceptability.

The 10 foot high barrier was used to best protect the occupants at ground level from the noise from the train. This height was a compromise between lower barrier heights (that would increase the exterior façade ratings) create less protection in the exterior areas and higher barriers that would be cumbersome and aesthetically challenge the site.

### 4.3 Exterior Average Noise Level (Daytime Noise Levels)

The calculated exterior noise levels at residential amenities Common Area 1 and 2 shown in Figure 2 indicates that future levels will be below the maximum of 75 dBA shown in Section 2.2. They were calculated to be below 65 dBA so they would be acceptable at night also, but are not anticipated for nighttime use. Therefore, no additional noise control measure is required other than planned sound barrier at the northern property limit

### 4.4 Mechanical Ventilation - Residential

Because the windows and doors must be kept closed to meet the noise requirements, mechanical or other means of ventilation may be required for all units. The ventilation system shall not compromise the sound insulation capability of the exterior facade assembly.

## 5.0 SUMMARY

The following summarizes the acoustical items required to satisfy the noise criteria as described in this report. The exterior areas will meet the requirements of the City of Riverside Municipal Code. The interior areas will meet the requirements of the City of Riverside Municipal Code and California State Building Code requirements as described.

**Residential**

- Exterior wall assembly is acceptable as described in Section 4.1.
- Barrier as shown in Figure 2.
- Windows and glass doors with minimum STC ratings as shown in Table 5 with Transmission Loss values and STC rating specified in Appendix I are required. Appendix I shall be the acoustical specification for the exterior windows and doors.
- Residential mechanical ventilation, or other means of natural ventilation, may be required for all units.

**Exterior Areas**

- Site plan orientation with buildings and barriers as shown in Figure 2
- Assemblies as defined within this report.

Various noise mitigation methods may be utilized to satisfy the noise criteria described in this report. Alteration of mitigation methods that deviate from requirements should be reviewed by the acoustical consultant.

If you have any questions or comments regarding this report, please do not hesitate to contact us.

Sincerely,
**Veneklasen Associates, Inc.**

John LoVerde, *FASA*
Principal

Elias Montoya
Associate

Zhuang Li, PhD
Associate

**APPENDIX I – GLAZING REQUIREMENTS**

In order to meet the predicted interior noise levels described in Section 4.0, the glazing shall meet the following requirements:

**Table 6 – Acoustical Glazing Requirements: Minimum Octave Band Transmission Loss and STC Rating**

| Nominal Thickness | Minimum Transmission Loss Octave Band Center Frequency (Hz) | | | | | | Min. STC Rating |
|---|---|---|---|---|---|---|---|
| | 125 | 250 | 500 | 1000 | 2000 | 4000 | |
| 1” dual | 21 | 18 | 27 | 34 | 37 | 32 | **30** |
| 1” dual | 22 | 21 | 30 | 36 | 37 | 36 | **33** |
| 1” dual | 24 | 27 | 35 | 39 | 40 | 42 | **37** |

The transmission loss values in the table above can likely be met with the following glazing assemblies:

1. STC 30: 1/8” monolithic – 3/4” airspace – 1/8” monolithic
2. STC 33: 3/16” monolithic – 11/16” airspace – 1/8” monolithic
3. STC 37: 7/16” laminated – 3/8” airspace – 3/16” monolithic

An assembly’s frame and seals may limit the performance of the overall system. Therefore, the window and door systems selected for the project shall not be selected on the basis of the STC rating of the glass alone, but on the entire assembly including frame and seals. Additionally, the assemblies given above are provided as a basis of design, but regardless of construction, the octave band Transmission Loss (TL) and STC value of the system selected must meet the minimum values in Table 6 above.

Independent laboratory acoustical test reports should be submitted for review by the design team to ensure compliance with glazing acoustical performance requirements. Laboratories shall be accredited by the Department of Commerce National Voluntary Laboratory Accreditation Program (NVLAP). Labs shall be pre-approved by Veneklasen Associates. Tests shall be required to be performed in North America. Lab tests and lab reports shall be in compliance with ASTM standard E90 and be no more than 10 years old from the date of submission for this project.

If test reports are not available for a proposed assembly, the assembly, including frame, seals and hardware, shall be tested at an independent pre-approved NVLAP-accredited laboratory to demonstrate compliance with the requirements of this report. Veneklasen shall be invited to witness acoustical testing completed and reserves the right to exclude test reports from laboratories that are not pre-approved by Veneklasen.

## APPENDIX II – MEASURED HOURLY NOISE LEVELS

| Time | Exterior Sound Level, 1-hour LAeq | Exterior Sound Level, 1-Hour LAFMax |
|---|---|---|
| | L1 | |
| 10am | 74 | 101 |
| 11am | 72 | 101 |
| 12pm | 56 | 75 |
| 1pm | 73 | 96 |
| 2pm | 73 | 95 |
| 3pm | 69 | 92 |
| 4pm | 72 | 98 |
| 5pm | 71 | 94 |
| 6pm | 76 | 102 |
| 7pm | 74 | 101 |
| 8pm | 76 | 100 |
| 9pm | 55 | 72 |
| 10pm | 77 | 100 |
| 11pm | 77 | 98 |
| 12am | 79 | 99 |
| 1am | 71 | 99 |
| 2am | 73 | 100 |
| 3am | 75 | 100 |
| 4am | 74 | 99 |
| 5am | 74 | 99 |
| 6am | 66 | 92 |
| 7am | 77 | 101 |
| 8am | 73 | 98 |
| 9am | 75 | 101 |

## APPENDIX III – GLOSSARY OF ACOUSTICAL TERMS

| Term | Definition |
|---|---|
| **Absorption** | A property of material referring to how much sound it absorbs (as opposed to reflecting). In the context of this report, absorption refers to the total quantity of absorption within the receiving space. Absorption is measure in sabins. |
| **A-weighting (dBA)** | The sound pressure level in decibels as measured in an A-weighting filter network. The A-weighting de-emphasizes the low frequency components of the sound in a manner similar to the frequency response of the human ear and correlates well with subjective reactions to noise. |
| **Decibel (dB)** | A unit describing the amplitude of sound equivalent to 20 times the logarithm, to the base 10, of the ratio of the pressure of the sound to the reference pressure of 20 μPa. Used to quantify sound pressure levels. |
| **Equivalent Sound Level (Leq)** | The time-weighted average noise level during the stated measurement period. |
| **Maximum Sound Level (Lmax)** | The highest sound level measured during a single noise event, in which the sound level change value as time goes on. |
| **Sabin** | A unit used to describe absorption within a space. One sabin is equal to the absorption of a one-square-foot open window. |
| **Sound Pressure Level (SPL)** | The amplitude of sound when compared to the reference sound pressure level of 20 μPa. SPL is measured in dB. |
| **Sound Transmission Class (STC)** | A single-number metric used to describe the transmission loss performance of a material or assembly across the frequency spectrum. It is intended for use primarily when speech is the noise source. |
| **Transmission Loss (TL)** | A measure of the reduction in sound level as a sound wave passes through a material. The higher the transmission loss, the better the material's sound insulating properties. |

## APPENDIX IV – ACOUSTICAL CALCULATION METHODS

Decibel Addition

Decibels are based on a logarithmic scale; defined as the logarithmic ratio between a measured sound pressure level and a reference sound pressure level. When decibels are added, they are not combined arithmetically, but logarithmically. Decibels are added according to the following equation.

$$SPL_{tot} = 10log\left(10^{\left(SPL_1/_{10}\right)}\right) + 10log\left(10^{\left(SPL_2/_{10}\right)}\right)$$

Where:
$SPL_{tot}$ = Total Sound Pressure Level (dB or dBA)
$SPL_1$, $SPL_2$ = Sound Pressure Level 1, 2 (dB or dBA)

A-Weighting

A-weighting a spectrum is completed by applying standardized weighting factors to a frequency spectrum, either in octave bands or third-octave bands. These resultant A-weighted levels are summed using decibel addition to generate the overall A-weighted level, noted as dBA. In a report, spectral data is typically presented un-weighted, and the overall level is presented with A-weighting.

The octave band A-weighting correction factors are shown in the table below:

| | Octave Band Center Frequency (Hz) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 63 | 125 | 250 | 500 | 1000 | 2000 | 4000 | 8000 |
| A-weighting Correction Factor (dB) | -26 | -16 | -9 | -3 | 0 | +1 | +1 | -1 |

Acoustical Shielding

The presence of adjacent buildings or facades, changes in terrain, parapets, and other similar barriers provide acoustical shielding, reducing the sound level incident on the exterior facades. Common locations where acoustical shielding occurs include, but are not limited to, the roof, the back, and sides of the building that are not directly facing the noise source.

Acoustical shielding due to building geometry can be separated into two categories: reduction due to reduced area of exposure (side of a building) and shielding from barriers (such as a parapet or sound wall).

Reduction as a result of reduced area of exposure is calculated according to the following equation:

$$\Delta SPL = 10 \log_{10}\left(\frac{\theta_{exp}}{180}\right)$$

Where:
$\Delta SPL$ = Change in Sound Pressure Level (dB)
$\theta_{exp}$ = Angle of exposure (degrees)

Acoustical Attenuation due to Distance

Sound pressure level reduction due to distance is calculated according to the following equation:

$$SPL_2 = SPL_1 + C_S \log\left(\frac{r_1}{r_2}\right)$$

Where:
$SPL_1$ = Sound Pressure Level at Location 1 (dB or dBA)
$SPL_2$ = Sound Pressure Level at Location 2 (dB or dBA)
$C_S$ = Source Coefficient; 20 for point source, 10 for a line source
$r_1$ = Location 1 distance from source (ft.)
$r_2$ = Location 2 distance from source (ft.)

In some situations, the $C_S$ value is between 10 and 20; selection of this number is an engineering judgment based on the relationship between the source and receiver as well as the type of source.

Interior Noise Calculation

The interior noise calculation takes into account the exterior noise level, the transmission loss of the glazing (including glass, frame, and seals), wall, and roof/ceiling systems, the finishes within the space, and noise exposure due to building geometry and acoustic shielding. The interior sound level is calculated using the equation:

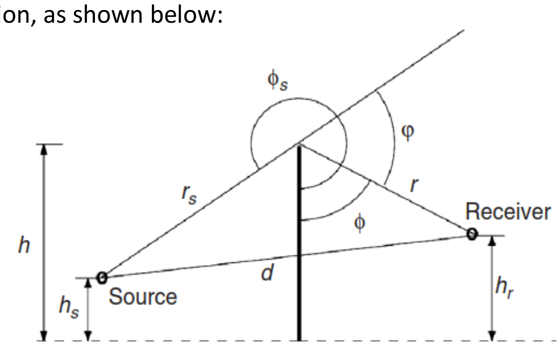
$$SPL_I = SPL_E + 10\, log_{10}(A) - 10 log_{10}(R) - TL + 6$$

Where:
$SPL_I$ = the Interior Sound Pressure Level (dB or dBA)
$SPL_E$ = Exterior Sound Pressure Level (dB or dBA)
A = Surface Area exposed to Exterior Noise (sq.ft.)
R = Room Absorption Coefficient (sabins)
TL = Sound Transmission Loss of Exterior Facade Assembly (dB)

This calculation is performed for each exposed facade individually. The total interior sound level is found by using decibel addition to sum the sound level from all exposed facades.

Sound Barrier Calculation

The sound attenuation provided by a barrier varies according to the location (or geometry) of the sound source, edge of the barrier and receptor location, as shown below:




Where:
$h_s$ = Source height (ft)
$r_s$ = Distance between the sound source and the top of the barrier (ft)
$h_r$ = Receiver height (ft)
r = Distance between the top of the barrier and the receiver (ft)

h = Barrier height (ft)
d = Distance between the source and the receiver (ft)

Then, the sound attenuation (per frequency band, in decibels dB) is given by:

$$\boldsymbol{Attenuation\ (dB) = 5 + C\ log_{10}\left(\frac{\sqrt{2\pi N}}{tanh\sqrt{2\pi N}}\right)}$$

Where:
C = 20 (for point sources) and 15 (for line sources)
N (Fresnel Number) = $\pm\frac{2}{\lambda}\ (rs + r + d)$
$\lambda$ = Frequency wavelength
tanh = Hyperbolic tangent function

This calculation is performed for each frequency band individually. The total sound attenuation is found by using decibel addition to sum the sound level from all attenuated frequency bands.

## APPENDIX V – SAMPLE CALCULATION (BARRIER, 1st FLOOR AT UNITS FACING RAILWAY)

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Barrier Insertion Loss for Line Source** | | | | | | | | | | | | | |
| (Use same units as sound speed in cell M4) | | | | | | | | | | | | | |
| Source to barrier distance | 45 | | A | 45.0 | | | | | | | **Speed of Sound** | 1126 | ft/s |
| Source height | 10 | | B | 10.2 | | | | | | | | | |
| Observer to barrier distance | 10 | | C | 55.0 | | | | | | | | | |
| Observer height | 8 | | | | | | | | | | | | |
| Barrier height | 10 | | | | | | | | | | | | |
| Barrier: 0, Berm: 1 | 0 | | | | | | | | | | | | |
| Zone | Shadow | | | | | | | | | | | | |
| Distance from Source | 55 | | | | | | | | | | | | |
| Octave band (Hz) | **63** | **125** | **250** | **500** | **1000** | **2000** | **4000** | **8000** | **dBA** | | | | |
| PWL at source | 115 | 115 | 112 | 109 | 107 | 104 | 102 | 99 | 112 | | | | |
| Directivity (10log(Q)) OR | | | | | | | | | | | | | |
| Directivity (Q) | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | | | | | |
| SPL at receiver (distance loss only) | 82 | 82 | 79 | 76 | 74 | 71 | 69 | 66 | 80 | | | | |
| Attenuation due to barrier (dB) | 5 | 5 | 6 | 7 | 8 | 9 | 11 | 14 | 8 | | | | |
| SPL at receiver with barrier | 77 | 77 | 73 | 70 | 66 | 62 | 58 | 53 | 72 | | | | |
| Fresnel Number | 0.02 | 0.04 | 0.07 | 0.14 | 0.29 | 0.57 | 1.15 | 2.30 | | | | | |

Note: Since barrier only covers 1st floor, windows at 2nd floor do not have any acoustic shielding effect from the barrier.

## APPENDIX VI – SAMPLE CALCULATIONS (EXTERIOR TO INTERIOR NOISE CALCULATION)

### Zone A, 1st Floor

| | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Project Name:** | **Riveside Jackson** | Dif | -8 | | | | | | | | | | | | | | | | | | |
| | Zone | A | | | | | | | | | | | | | | | | | | | | |
| | Plan, room | 1st Floor | | | | | | | | | | | | | | | | | | | | |
| | | | | **Room absorption** | **63** | **125** | **250** | **500** | **1000** | **2000** | **4000** | **8000** | | | **63** | **125** | **250** | **500** | **1000** | **2000** | **4000** | **8000** |
| **Receiving Room Absorption** | | | | Medium-Dead | 0.20 | 0.23 | 0.24 | 0.25 | 0.28 | 0.27 | 0.26 | 0.25 | | Medium-Live | 0.18 | 0.17 | 0.15 | 0.15 | 0.15 | 0.15 | 0.15 | 0.15 |
| Length | 13 | | | | | | | | | | | | | Medium | 0.18 | 0.19 | 0.19 | 0.20 | 0.20 | 0.20 | 0.20 | 0.20 |
| Width | 13 | | | **Room Absorption** | 156 | 179 | 187 | 195 | 218 | 211 | 203 | 195 | | Medium-Dead | 0.20 | 0.23 | 0.24 | 0.25 | 0.28 | 0.27 | 0.26 | 0.25 |
| Height | 8.5 | | | | | | | | | | | | | 0.5 seconds | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | 0.16 | 0.15 | 0.11 |
| | | | | **Exterior Noise Level** | | | | | | | | | | | | | | | | | | |
| Volume | 1437 | | Level | Source type | **63** | **125** | **250** | **500** | **1000** | **2000** | **4000** | **8000** | **dBA** | 4MV | 0 | 0 | 0 | 0 | 0 | 6 | 15 | 51 |
| F/C area | 169 | **Side A average** | 72 | L1 Ldn with Barrier | 77 | 77 | 73 | 70 | 67 | 63 | 58 | 53 | **72.2** | Reverb time | 0.40 | 0.35 | 0.33 | 0.31 | 0.27 | 0.28 | 0.28 | 0.26 |
| Wall area | 442 | **Side B average** | 69 | L1 Ldn with Barrier | 74 | 74 | 70 | 67 | 64 | 60 | 55 | 50 | **69.2** | | | | | | | | | |
| Total area | 780 | | Level | Source type | **63** | **125** | **250** | **500** | **1000** | **2000** | **4000** | **8000** | **dBA** | | | | | | | | | |
| **Total Interior Level:** | | **44.8** | | | | | | | | | | | | | | | | | | | | |
| (excluding 63 Hz): | | 44.2 | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | **Average Interior Levels** | | | | | | | | | **Octave Band TL** | | | | |
| | | **Exterior Assemblies, side A** | Area | Assembly Type | **63** | **125** | **250** | **500** | **1000** | **2000** | **4000** | **8000** | **dBA** | **A-weighted NR** | **63** | **125** | **250** | **500** | **1000** | **2000** | **4000** | **8000** |
| | | wall | 93 | VA Typical Wall (stucco,ply,2x4ws,5/8gyp) wyle | 59.3 | 49.5 | 38.4 | 26.5 | 15.2 | 6.6 | 0.1 | -5.6 | **37.4** | 34.8 | 21.5 | 30.4 | 37.9 | 45.9 | 53.7 | 58.5 | 60.6 | 61.0 |
| | | glazing | 17.5 | WEAL STC 33 no lam average | 52.5 | 49.7 | 47.1 | 35.1 | 25.7 | 20.8 | 17.5 | 9.2 | **40.8** | 31.4 | 21.0 | 23.0 | 22.0 | 30.0 | 36.0 | 37.0 | 36.0 | 39.0 |
| | | door | | <N/A> | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | **0.0** | | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | | | | <N/A> | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | **0.0** | | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | | | | <N/A> | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | **0.0** | | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | | | | Side A Total | 60.2 | 52.6 | 47.6 | 35.7 | 26.0 | 20.9 | 17.6 | 9.3 | **42.4** | 29.8 | | | | | | | | |
| | | **Exterior Assemblies, side B** | | | | | | | | | | | | | | | | | | | | |
| | | wall | 80.5 | VA Typical Wall (stucco,ply,2x4ws,5/8gyp) wyle | 55.7 | 45.9 | 34.8 | 22.9 | 11.6 | 2.9 | -3.5 | -9.2 | **33.8** | 38.4 | 21.5 | 30.4 | 37.9 | 45.9 | 53.7 | 58.5 | 60.6 | 61.0 |
| | | glazing | 30 | WEAL STC 33 no lam average | 51.9 | 49.0 | 46.4 | 34.5 | 25.0 | 20.1 | 16.8 | 8.5 | **40.1** | 32.1 | 21.0 | 23.0 | 22.0 | 30.0 | 36.0 | 37.0 | 36.0 | 39.0 |
| | | door | | <N/A> | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | **0.0** | | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | | | | <N/A> | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | **0.0** | | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | | | | <N/A> | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | **0.0** | | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | | | | Side B Total | 57.2 | 50.7 | 46.7 | 34.8 | 25.2 | 20.2 | 16.9 | 8.6 | **41.0** | -41.0 | | | | | | | | |
| | | | | **Total** | **61.9** | **54.8** | **50.2** | **38.3** | **28.6** | **23.6** | **20.2** | **12.0** | **44.8** | | | | | | | | | |
| | | | | A-weighted | 35.9 | 28.8 | 24.2 | 12.3 | 2.6 | -2.4 | -5.8 | -14.0 | | | | | | | | | | |

### Zone A, 2nd Floor

| | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Project Name:** | **Jackson Riverside** | Dif | | | | | | | | | | | | | | | | | | | |
| | Zone | A | | | | | | | | | | | | | | | | | | | | |
| | Plan, room | Bedroom 2nd Floor | | | | | | | | | | | | | | | | | **Average absorption coefficient (alpha-bar)** | | | | |
| | | | | **Room absorption** | **63** | **125** | **250** | **500** | **1000** | **2000** | **4000** | **8000** | | | **63** | **125** | **250** | **500** | **1000** | **2000** | **4000** | **8000** |
| **Receiving Room Absorption** | | | | Medium-Dead | 0.20 | 0.23 | 0.24 | 0.25 | 0.28 | 0.27 | 0.26 | 0.25 | | Medium-Live | 0.18 | 0.17 | 0.15 | 0.15 | 0.15 | 0.15 | 0.15 | 0.15 |
| Length | 11 | | | | | | | | | | | | | Medium | 0.18 | 0.19 | 0.19 | 0.20 | 0.20 | 0.20 | 0.20 | 0.20 |
| Width | 11 | | | **Room Absorption** | 123 | 142 | 148 | 154 | 172 | 166 | 160 | 154 | | Medium-Dead | 0.20 | 0.23 | 0.24 | 0.25 | 0.28 | 0.27 | 0.26 | 0.25 |
| Height | 8.5 | | | | | | | | | | | | | 0.5 seconds | 0.15 | 0.15 | 0.15 | 0.15 | 0.15 | 0.14 | 0.13 | 0.08 |
| | | | | **Exterior Noise Level** | | | | | | | | | | | | | | | | | | |
| Volume | 1029 | | Level | Source type | **63** | **125** | **250** | **500** | **1000** | **2000** | **4000** | **8000** | **dBA** | 4MV | 0 | 0 | 0 | 0 | 0 | 6 | 15 | 51 |
| F/C area | 121 | **CNEL, LDN, or average:** | 80 | L1 Ldn | 82 | 82 | 79 | 76 | 74 | 72 | 70 | 66 | **80.0** | Reverb time | 0.37 | 0.31 | 0.30 | 0.28 | 0.25 | 0.25 | 0.25 | 0.22 |
| Wall area | 374 | | | | | | | | | | | | | | | | | | | | | |
| Total area | 616 | | Level | Source type | **63** | **125** | **250** | **500** | **1000** | **2000** | **4000** | **8000** | **dBA** | | | | | | | | | |
| **Total Interior Level:** | | **45.0** | | | | | | | | | | | | | | | | | | | | |
| (excluding 63 Hz): | | 43.8 | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | **Average Interior Levels** | | | | | | | | | **Octave Band TL** | | | | |
| | | **Exterior Assemblies** | Area | Assembly Type | **63** | **125** | **250** | **500** | **1000** | **2000** | **4000** | **8000** | **dBA** | **A-weighted NR** | **63** | **125** | **250** | **500** | **1000** | **2000** | **4000** | **8000** |
| | | wall | 87 | VA Typical Wall (stucco,ply,2x4ws,5/8gyp) wyle | 65.3 | 55.7 | 45.1 | 33.9 | 23.8 | 16.8 | 12.4 | 8.8 | **43.7** | 36.3 | 21.5 | 30.4 | 37.9 | 45.9 | 53.7 | 58.5 | 60.6 | 61.0 |
| | | glazing | 6.5 | WEAL STC 37 average | 55.5 | 50.9 | 44.7 | 33.5 | 27.2 | 24.0 | 19.7 | 13.6 | **40.0** | 40.0 | 20.0 | 24.0 | 27.0 | 35.0 | 39.0 | 40.0 | 42.0 | 45.0 |
| | | door | | <N/A> | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | **0.0** | | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | | | | <N/A> | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | **0.0** | | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | | | | <N/A> | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | **0.0** | | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | | | | **Total** | **65.7** | **56.9** | **47.9** | **36.7** | **28.8** | **24.7** | **20.4** | **14.8** | **45** | 34.8 | | | | | | | | |
| | | | | A-weighted | 39.7 | 40.9 | 38.9 | 33.7 | 28.8 | 25.7 | 21.4 | 13.8 | | | | | | | | | | |