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Memo

To: Ryan Murphy, Senior Planner, City of Redlands

CC: Cameron Hile and Bob Prasse, MIG

From: Kasey Kitowski and Chris Dugan

Date: July 7, 2023

SUBJECT: Noise and Vibration Analysis for Madera at Citrus Trail Project, Redlands, CA

MIG, Inc. (MIG) has prepared this memorandum at the request of the City of Redlands. This memorandum evaluates the potential noise and vibration impacts resulting from the implementation of the proposed Madera at Citrus Trail Project (proposed Project). As explained in this memorandum, the proposed Project has incorporated mitigation measures to ensure construction and operational activities would not exceed applicable noise and vibration standards, would not otherwise result in a substantial increase in ambient noise levels in the vicinity of the Project, and would not be subjected to excessive airport-related noise levels. The proposed Project, therefore, would not have the potential to result in significant noise or vibration impacts with mitigation incorporated.

PROJECT DESCRIPTION

The proposed Project involves the construction of 103 single family residential buildings on a parcel of undeveloped land in the eastern part of Redlands, California.

The approximately 9.01-acre Project site is located at the northwest corner of Colton Avenue and Wabash Avenue. The proposed Project would include 216,567 square feet of gross building space, 65,470 square feet of landscaped space for private yards and for a central common area, and 20,100 square feet of impervious surfaces such as walkways, drive aisles, driveways, and parking spaces. Each dwelling unit would range from approximately 1,544 to 1,858 square feet. The site would contain 206 garage stalls and 63 guest stalls. The site would be internally connected by A Street, which would run north to south, and by B Street and C Street, which would run east to west. Refer to Attachment 1 for the proposed Project site plan.

The Project site is bound on the north and west by single-family residential uses, on the east by Wabash Avenue and on the south by Colton Avenue. Commercial uses are located across Wabash Avenue, approximately 90 feet east of the site and single-family residential uses are located across Colton Avenue, approximately 100 feet south of the site. The Project site is located approximately 0.4 miles south of State Route (SR) 38, approximately 1.4 miles northeast of Interstate 10 (I-10), and approximately 3.4 miles east of the I-210. The nearest airport, Redlands Municipal Airport, is approximately 1.3 miles north of the Project site and the nearest school, Crafton Elementary School, is located approximately 960 feet south of the Project site. The nearest park, Orange Blossom Trail head, is located approximately 80 feet south of the Project site, across Colton Avenue.

The proposed Project would involve site preparation, grading, new building construction, paving, and architectural coating. Construction activities are assumed to begin in early-2024 and last approximately 14 months. The proposed Project's construction schedule and anticipated equipment usage is listed in Table 1.

Table 1: Madera at Citrus Trail Project Construction Activities		
Construction Phase	**Duration (Days)**	**Typical Equipment Used**
Site Preparation	10	Dozer, Tractor/Loader/Backhoe
Grading	20	Excavator, Grader, Dozer, Backhoe
Building Construction	230	Crane, Forklift, Backhoe, Generator, Welder
Paving	20	Paver, Roller, Paving Equipment
Architectural Coating	20	Air Compressor

The Project is expected to be operational in 2025. Once operational, the proposed Project would operate as a residential land use, similar to the existing residential uses in the area.

The following sections describe the ambient noise environment near the proposed Project and evaluate the proposed Project's potential to impact the existing noise environment near the Project. Please refer to Attachment 2 for background information on environmental noise and vibration, including commonly used terminology.

EXISTING NOISE ENVIRONMENT

The proposed Project is located in eastern Redlands, in an area classified and designated as Single-Family Residential and as Low Density Residential by the City's Zoning Code and General Plan, respectively. The City's General Plan identifies transportation corridors as noise sources that are of particular attention to the City and states that future residential development will need to meet land use compatibility and noise standards (City of Redlands, 2017).

Existing ambient noise levels in the Project area were monitored on May 30, 2023 (MIG, 2023; see Attachment 3). Noise levels were measured with one Larson Davis Model LxT, Type 1, sound level meter and one Piccolo II, Type 2 sound level meter. The meter's receiving microphone was set at a high of roughly five feet above ground level to approximate a human receptor. Noise monitoring was conducted in one-minute intervals. Conditions during the monitoring were partly cloudy with temperatures ranging from the high 60s to the low 70s, with light winds (not exceeding eight (8) miles per hour (mph)).

Four (4) short-term measurements were conducted to determine typical ambient noise levels in the vicinity of the Project area, provide direct observations of existing noise sources at and in the vicinity of the Project area, and evaluate Project noise levels at nearby sensitive receptors. The four monitoring locations are described below and shown in Figure 1.

- Location ST-1 was at the northeast corner of the Project site, approximately 28 feet west of the centerline of the outermost lane of Wabash Avenue.
- Location ST-2 was at the southeast corner of the Project site, at the intersection of Wabash Avenue and Colton Avenue. The meter was approximately 35 feet east of the centerline of the outermost lane of Wabash Avenue and approximately 30 feet north of the centerline of the outermost lane of Colton Avenue.
- Location ST-3 was at the southwest corner of the Project site, approximately 65 feet north of the centerline of the outermost lane of Colton Avenue.
- Location ST-4 was at the northwest corner of the Project site, approximately 680 feet north and west of the centerline of the outermost lanes of Colton Avenue and Wabash Avenue, respectively.

Figure 1: Ambient Noise Monitoring Locations

Based on observations made during the ambient noise monitoring, the existing noise environment in the Project vicinity consists primarily of vehicles on Wabash Avenue and Colton Avenue and overhead air traffic. Table 2 summarizes the results of the ambient noise monitoring.

Table 2: Measured Short-Term Ambient Noise Levels (dBA)

Monitor	Duration	Measured Noise Level		
		L_{eq}	L_{min}	L_{max}
ST-1	1 hour	64.3	41.9	83.7
ST-2	1 hour	65.3	46.1	83.1
ST-3	1 hour	59.3	42.7	80.3
ST-4	4 hours	47.6	34.4	76.1
Source: MIG, 2023 (See Attachment 3)				

As shown in Table 2, measured ambient noise levels were highest along Wabash Avenue (ST-1) and at the intersection of Wabash Avenue and Colton Avenue (ST-2). Noise levels along Colton Avenue (ST-3) were lower than along Wabash Avenue. Noise levels on the interior of the site (ST-4) were much lower than noise levels along Wabash Avenue and Colton Avenue and indicates traffic noise levels attenuation at rate of approximately 4.5 decibels per doubling of distance from the roadway centerline.

NOISE AND VIBRATION ANALYSIS

The proposed Project would generate noise during construction and operation of the proposed facilities. The following analysis evaluates if the Project would:

- Generate a substantial temporary or permanent increase in ambient noise levels in the vicinity of the Project in excess of the standards established in:
  - City of Redlands Municipal Code Section 8.06.070 (Exterior Noise Limits), Section 8.06.080 (Interior Noise Standards), Section 8.06.100 (Residential Air Conditioning Or Air Handling Equipment), or Section 8.06.120 (Exemptions); or
  - The City of Redlands General Plan Healthy Community Chapter;
- Generate excessive groundborne vibration or groundborne noise levels; or
- Expose people residing or working in the Project area to excessive airport-related noise levels.

With regard to item a), the City's Municipal Code and General Plan establish the following standards and policies that would apply to the proposed Project's construction and operational noise sources:

- Construction Noise (Redlands Municipal Code Title 8, Health and Safety, Chapter 8.06, Community Noise Control):
  - Section 8.06.120(G) exempts construction activity from noise regulations between the hours of 7 AM and 6 PM on Monday through Saturday. Construction shall not occur on Sundays and federal holidays.
  - Section 8.06.090 prohibits loading and unloading activities between the hours of 10 PM and 6 AM in such a manner as to cause a noise disturbance across a residential property line or at any time in violation of Municipal Code Section 8.060.030 (see below).
- Construction Noise (Redlands General Plan Healthy Communities Chapter):
  - Policy 9.0w requires limiting hours for all construction or demolition work where site-related noise is audible beyond the site boundary.
- Operational Noise (Redlands Municipal Code Title 8, Health and Safety, Chapter 8.06, Community Noise Control):
  - Section 8.060.070 (Exterior Noise Limits) sets forth the maximum permissible sound level that may be generated by a project at single-family and multi-family residential districts is 60 dBA L_{eq} during the daytime (7 AM to 10 PM) and 50 dBA L_{eq} during the nighttime (10 PM to 7 AM). The Municipal Code also establishes:
    - The noise standard is not to be exceed for a cumulative period of more than 30 minutes any hour.
    - The exterior noise standard plus five (5) dBA is not to be exceeded for a cumulative period of more than 15 minutes in any hour.
    - The exterior noise standard plus 10 dBA is not to be exceeded for a cumulative period of more than 5 minutes in any hour.
    - The exterior noise standard plus 15 dBA is not to be exceeded for a cumulative period of more than one (1) minute in any hour.

        - The exterior noise standard plus 20 dBA, or the maximum measured ambient noise level, is not to be exceed at any period of time.
    - Section 8.060.080 (Interior Noise Limits) sets forth the maximum permissible sound level that may be generated by a project at single-family and multi-family residential districts is 45 dBA L_{eq} at any time. The Municipal Code also establishes:
        - The interior noise standard is not to be exceed for a cumulative period of more than five (5) minutes any hour.
        - The interior noise standard plus five (5) dBA is not to be exceeded for a cumulative period of more than one (1) minute in any hour.
        - The interior noise standard plus 10 dBA or the maximum measured ambient noise level, is not to be exceeded at any time.
    - Section 8.060.100 (Residential Air Conditioning or Air Handling Equipment) specifically identifies that it is unlawful to operate or permit the operation of any air conditioning or air handling equipment in such a manner as to exceed the exterior noise standards set forth in Municipal Code Section 8.06.070 (see above).
- Operational Noise (Redlands General Plan Healthy Communities Chapter):
    - Policy 9.0s requires mitigation to ensure that indoor noise levels for residential living spaces do not exceed 45 dBA CNEL due to the combined effect of all exterior noise sources.
    - Policy 9.0v considers the following increases in noise levels to be possibly significant:
        - An increase in exposure of four (4) dB or more if the resulting noise level would exceed that described as clearly compatible for the affected land use as established in General Plan Table 7-10 and Table 7-11.
        - Any increase of six (6) dB or more due to the potential for adverse community response.

With regard to item b), the City's Municipal Code establishes the following standards that would apply to the proposed Project's potential vibration sources:

- Groundborne Vibration and Noise (Redlands Municipal Code):
    - Section 8.06.090(G) prohibits the operating or permitting the operation of device that creates a vibration which is above the vibration perception threshold of an individual at or beyond the property boundary of the source if on private property or at one hundred fifty feet (150') from the source if on a public space or public right of way. Municipal Code Section 8.06.020 defines the vibration perception threshold of 0.01 inches/second peak particle velocity (PPV).

Increases in Ambient Noise Levels in Excess of Applicable Standards

<u>Project Construction</u>

The proposed Project involves construction activities including site preparation, grading, building construction, paving and architectural coating on an undeveloped parcel in an existing residential area of the City. Construction activities are anticipated to begin early 2024 and may last approximately 14 months in total.

In general, construction activities would involve the use of worker vehicles, delivery trucks, dump trucks, and heavy-duty construction equipment such as (but not limited to) backhoes, tractors, loaders, graders, excavators, rollers, cranes, material lifts, generators, and air compressors. These types of construction activities would generate noise and vibration from the following sources:

- Heavy equipment operations at different work areas. Some heavy equipment would consist of mobile equipment such as a loader and excavator that would move around work areas; other equipment would consist of stationary equipment (e.g., cranes or material hoists/lifts) that would generally operate in a fixed location until work activities are complete. Heavy equipment generates noise from engine operation, mechanical systems, and components (e.g., fans, gears, propulsion of wheels or tracks), and other sources such as back-up alarms. Mobile equipment generally operates at different loads, or power outputs, and produces higher or lower noise levels depending on the operating load. Stationary equipment generally operates at a steady power output that produces a constant noise level.
- Vehicle trips, including worker, vendor, and haul truck trips. These trips are likely to primarily occur on Colton Avenue and Wabash Avenue.

Typical construction equipment noise levels at different distances are shown in Table 3.

Table 3: Potential Project Construction Equipment Noise Levels

Typical Equipment	Noise Level at 50 feet (L_{max})(A)	Percent Usage Factor(B)	Predicted Equipment Noise Levels (L_{eq})(C)						
			50 Feet	75 Feet	100 Feet	150 Feet	200 Feet	250 Feet	300 Feet
Air Compressor	80	40	76	72	70	66	64	62	56
Bulldozer	85	40	81	77	75	71	69	67	65
Backhoe	80	40	76	72	70	66	64	62	56
Compact Roller	80	20	73	69	67	63	61	59	57
Concrete mixer	85	40	81	77	75	71	69	67	65
Crane	85	16	77	74	71	67	65	63	61
Excavator	85	40	81	77	75	71	69	67	65
Grader	85	40	81	77	75	71	69	67	65
Generator	82	50	79	75	73	69	67	65	66
Paver	85	50	82	78	76	72	70	68	66
Pneumatic tools	85	50	82	78	76	72	70	68	66
Scraper	85	40	81	77	75	71	69	67	65
Welder	73	40	69	65	63	59	57	55	53

Sources: Caltrans, 2013 and FHWA, 2010.

(A) L_{max} noise levels based on manufacturer's specifications.

(B) Usage factor refers to the amount (percent) of time the equipment produces noise over the time period

(C) Estimate does not account for any atmospheric or ground attenuation factors. Calculated noise levels based on Caltrans, 2013: L_{eq} (hourly) = L_{max} at 50 feet – 20log (D/50) + 10log (UF), where: L_{max} = reference L_{max} from manufacturer or other source; D = distance of interest; UF = usage fraction or fraction of time period of interest equipment is in use.

With regard to construction noise, site preparation and grading phases typically result in the highest temporary noise levels due to the use of heavy-duty equipment such as dozers, excavators, graders, loaders, and trucks. Construction noise impacts generally occur when construction activities occur in areas immediately adjoining noise sensitive land uses, during noise sensitive times of the day, or when construction durations last over extended periods of time.

Construction activities associated with the proposed Project would last approximately 14 months. Construction activities would, at times, occur directly adjacent to existing residential properties to the north and west. As shown in Table 3, estimated worst case hourly L_{eq} and L_{max} construction equipment noise levels are predicted to be approximately 82 and 85 dBA, respectively, at 50 feet; however, the magnitude of the Project's temporary and periodic increase in ambient noise levels would depend on the nature of the construction activity (i.e., grading, building construction, paving) and the distance between the construction activity and sensitive receptors/outdoor use areas. Sensitive residential receptors would be within 25 feet of work areas for specific but limited times (e.g., site grading along the property line), at which distance construction equipment may generate noise levels up to 88 dBA L_{eq}. Project construction in the middle of the site would be approximately 300 feet from sensitive receptors to the north and west. At a distance of 300 feet, construction equipment could generate noise levels of 66 dBA L_{eq} at sensitive receptor locations The concurrent operation of two or more pieces of equipment could, depending on the equipment being operated, increase estimated noise levels by 2 dBA to 4 dBA L_{eq}.

There is an existing, approximately three- (3) to six (6)-foot-tall concrete wall on the western boundary of the Project site that may provide up to 5 dBA of shielding and construction noise attenuation for residences bordering the Project site to the west; however, not all residences would receive shielding, as the concrete wall changes height over the length of the site boundary. Specifically, the residences adjacent to the southwest corner of the Project site would be exposed to higher noise levels than residences adjacent to the northwest corner of the Project site because of the difference in height of the existing concrete wall.

The City's Municipal Code (Section 8.06.120(G)) limits construction activities to the hours of 7 AM and 6 PM on Monday through Saturday; however, neither the City's General Plan nor Municipal Code establish a specific numeric noise standard (e.g., 90 dBA L_{eq}) for construction noise levels. As discussed above, the Project's potential exterior construction noise levels would range from approximately 66 dBA L_{eq} to 88 dBA L_{eq} depending on the specific equipment in use and the distance between the equipment and adjacent residential properties. These noise levels would be approximately 1 dB to 40 dB above the existing ambient noise levels measured at the Project site (see Table 2). Although the City does not maintain a specific construction noise level standard, the temporary increase in noise levels associated with the proposed construction activities could, at times, be substantial and have the potential to annoy adjacent residential receptors and/or interfere with the receptors normal use and enjoyment of their property.

Although the proposed Project's construction activities may result in a substantial temporary increase in ambient noise levels, they are not anticipated to result in physical harm (e.g., temporary or permanent hearing loss or damage) to any adjacent sensitive residential noise receptor for several reasons. First, the construction phases using the most large equipment - site preparation and grading - are anticipated to occur for no more than 30 total days (not necessarily consecutive) out of the anticipated 14-month construction schedule. In addition, the estimated worst-case noise levels would only occur when equipment operations occur directly adjacent to a receptor. As equipment moves along the property line and throughout the site, noise levels would decrease at one receptor and increase at a different receptor. Worst-case conditions (i.e., equipment operating directly adjacent to a specific receptor), are estimated to occur up to four (4) hours per day for no more than several days. Thus, any individual receptor would not be continuously exposed to estimated worst-case noise levels (i.e., noise levels would lower when equipment moves away and return to ambient conditions when construction ceases for the day). Finally, the estimated construction noise level values presented in Table 3 are exterior noise levels, whereas receptors would be likely to be inside residential buildings. Interior noise levels associated with the Project's construction at nearby sensitive receptors would be approximately 12 dBA to 30 dBA lower depending on the presence of existing barriers, setback distances, façade construction type, and whether windows or doors were open or closed. Physiological effects occur when the human ear is subjected to either very high noise levels (e.g., 110 dB or more) for a short period or prolonged exposure to high noise environments. For example, to protect workers from noise-induced hearing loss, the U.S. Occupational Safety and Health Administration (OSHA) limits worker noise exposure to 90 dBA as averaged over an 8-hour time period (29 CFR 1910.95). Similarly, the National Institute for Occupational Safety and Health (NIOSH) recommends workers limit noise exposure to no more than 85 dBA over an 8-hour period to protect against noise-induced hearing loss (NIOSH, 1998). Although hourly construction noise levels may approach approximately 88 dBA L_{eq}, such noise levels would not be sustained over an 8-hour period (due to movement of equipment and changes in operations that occur during daily construction activities). Therefore, at worst-case, noise from construction activities may pose a temporary interference or annoyance effect on nearby sensitive receptors but would not result in adverse physiological effects on human receptors in the surrounding area.

To reduce the potential for the proposed Project's construction activities to result in a substantial temporary increase in ambient noise levels in the vicinity of the Project site that could annoy adjacent residential receptors and/or interfere with the normal use and enjoyment of residential properties, MIG recommends Mitigation Measure NOI-1 be incorporated into the Project:

Mitigation Measure NOI-1: Reduce Potential Project Construction Noise Levels

To reduce potential noise levels from Project construction activities, the Applicant shall:

1) *Notify Residential Land Uses of Planned Construction Activities.* This notice shall be provided at least two (2) weeks prior to the start of any construction activities, describe the noise control measures to be implemented by the Project, and include the name and phone number of the designated contact for the Applicant/Project representative and the City of Redlands responsible for handling construction-related noise complaints (per action #5 below). This notice shall be provided to the owner/occupants of residential dwelling units that border the Project site to the north and west and that are directly across Colton Avenue from the Project site.
2) *Restrict Work Hours:* All construction-related work activities, including material deliveries, shall be subject to the requirements of City Municipal Code Section 8.06.120(G). Construction activities, including deliveries, shall occur only during the hours of 7 AM to 6 PM Monday to Saturday and shall not occur any time on Sundays and holidays. The Applicant/Project representative and/or its contractor shall post a sign at all entrances to the construction site informing contractors, subcontractors, other workers, etc. of this requirement.
3) *Construction Equipment Selection, Use, and Noise Control Measures*: The following measures shall apply to construction equipment used at the Project site:
    a. Contractors shall use the smallest size equipment capable of safely completing work activities.
    b. Construction staging shall occur as far away from residential land uses as possible given site and active work constraints.
    c. Electric hook-ups shall be provided for stationary equipment (e.g., pumps, compressors, welding sets). This measure shall be subject to the approval of the

local electric utility. If electric service is denied, the Applicant shall ensure actions 3a, 3b, and 3d are implemented.

d. All stationary noise generating equipment shall be shielded and located as far as possible from residential land uses given site and active work constraints. Shielding may consist of a three-or four-sided enclosure provided the structure/enclosure breaks the line of sight between the equipment and the receptor and provides for proper ventilation and equipment operation.

e. Heavy equipment engines shall be equipped with standard noise suppression devices such as mufflers, engine covers, and engine/mechanical isolators, mounts, and be maintained in accordance with manufacturer's recommendations during active construction activities.

f. Pneumatic tools shall include a suppression device on the compressed air exhaust.

g. No radios or other amplified sound devices shall be audible beyond the property line of the construction site.

4) *Install Construction Noise Barrier:* The following measures shall apply to Project construction activities:

   a. Site Preparation, Grading, and Foundation Work: During all site preparation, grading, and structure foundation work activities, a physical noise barrier shall be installed and maintained around the north, south, and western site perimeter to the maximum extent feasible given site constraints and access requirements. The noise barrier shall extend to a height of six (6) feet above grade. Potential barrier options capable of reducing construction noise levels could include, but are not limited to:

      i. A plywood or other barrier installed at-grade (or mounted to structures located at-grade, such as a K-Rail), and consisting of a solid material (i.e., free of openings or gaps other than weep holes) that has a minimum rated transmission loss value of 20 dB.

      ii. Commercially available acoustic panels or other products such as acoustic barrier blankets that have a minimum sound transmission class (STC) or transmission loss value of 20 dB.

      iii. Any combination of noise barriers and commercial products capable of achieving required construction noise reductions during site preparation, grading, and structure foundation work activities.

      iv. The noise barrier may be removed following the completion of building foundation work (i.e., it is not necessary once framing and typical vertical building construction begins provided no other grading, foundation, etc. work is still occurring on-site).

   The noise barrier shall not be required if the perimeter concrete masonry unit wall included in the project's site plan is fully constructed prior to the start of substantial site preparation and grading activities at the site (i.e., only clearing and grubbing and grading necessary to access the site and install the perimeter wall may occur).

5) *Prepare a Construction Noise Complaint Plan:* The Applicant shall prepare a Construction Noise Complaint Plan that shall:

a. Identify the name and/or title and contact information (including phone number and email) for a designated Project and City representative responsible for addressing construction-related noise issues.

b. Includes procedures describing how the designated Project representative will receive, respond, and resolve construction noise complaints.

c. At a minimum, upon receipt of a noise complaint, the Project representative shall notify the City contact, identify the noise source generating the complaint, determine the cause of the complaint, and take steps to resolve the complaint.

The implementation of Mitigation Measure NOI-1 would reduce construction noise levels by 5 dBA to 10 dBA at individual receptor locations during the daytime. Based on the estimated worst-case scenario (88 dBA L_{eq}), exterior noise levels at individual receptors could reach 78 dBA L_{eq} to 83 dBA L_{eq} for limited periods of time with the incorporation of Mitigation Measure NOI-1. Such noise levels would be similar to the maximum measured daytime noise levels in the project vicinity, but noticeably louder (approximately 20 dBA to 30 dBA) than the typical measured daytime noise levels ((approximately 48 dBA L_{eq} to 65 dBA L_{eq}, see Table 2). Although worst-case noise levels could be noticeably louder than typical hourly daytime noise levels, Mitigation Measure NOI-1 would require the Applicant to provide advance warning of the proposed Project's potentially noisy construction activities, restrict work hours to periods when humans are less sensitive to elevated noise levels in accordance with Municipal Code requirements, implement equipment noise control measures, install a temporary noise barrier between work areas and affected receptors, and prepare and plan for potential unanticipated or unexpected construction noise issues. By providing advanced notice of loud construction activities and implementing equipment control measures and temporary noise barriers, the potential for sensitive residential receptors to be surprised or annoyed by loud exterior noises would be substantially reduced. In addition, daytime noise levels inside potential residential buildings would be approximately 12 dBA to 30 dBA lower, depending on whether windows and doors were open or closed. Thus, interior noise levels at individual receptors locations could potentially reach 58 dBA L_{eq} to 71 dBA L_{eq} during daytime hours, when humans are less sensitive to higher noise levels. At no time would the proposed Project's exterior or interior construction noise be loud enough to result in physical harm to adjacent residential receptors. Finally, although worst-case construction noise levels could be noticeably louder than typical conditions, this impact would occur intermittently (anticipated to be up to four (4) hours per day) for several days during the Project's anticipated 30-day site preparation and grading phases), which would not constitute sustained or prolonged exposure to substantially temporary noise increases. The implementation of Mitigation NOI-1 would lower overall Project construction noise levels, reduce the potential for Project construction noise levels to surprise or annoy residential receptors, and reduce the potential for Project construction noise levels to interfere with normal use of residential properties. The implementation of Mitigation Measure NOI-1 would, therefore, render the proposed Project's potential construction noise levels less than significant with mitigation.

<u>Project Operation (On-Site Noise Sources)</u>

The existing residential land uses near the Project site generate noise from vehicle parking activities, garbage collection activities, landscaping activities, stationary heating, ventilation, and air conditioning (HVAC) equipment, and other residential activities (e.g., building maintenance). The proposed Project would have a similar density as the existing land uses surrounding the Project site and involve similar noise generating sources and activities. Although the proposed Project could increase the amount of noise sources and noise-generating activities compared to existing conditions, the Project would have a limited potential to generate significant on-site noise levels or substantially change overall noise levels in the vicinity of the Project. In general, single-family residential land uses are not a substantial noise-generating land use type because they do not involve substantial noise-generating activities, buildings and equipment are usually setback from shared property lines, and properties are usually screened from public view by landscaping, fences, or walls and, therefore, shielded from adjacent property lines. For example, the short-term noise levels measured the interior of the site, away from Wabash Avenue and Colton Avenue, were less than 50 dBA L_{eq} (see Table 2), which is indicative of the fact that most residential land uses do not generate significant noise levels.

Once constructed, the proposed Project's primary on-site noise generating activities would include traffic on the new interior circulation roads, human activity from use of the small community park, and mechanical equipment such as garage doors and HVAC equipment; however, the Project includes several design features that limit the potential for Project noise sources to impact adjacent residential receptors. First, the proposed Project design includes a six (6)-foot high, four (4)-inch thick concrete wall along its entire northern and western perimeter, which would provide shielding between rear yards and adjacent residential uses (Sitescapes 2022). Second, the proposed Project layout generally places the housing units around the perimeter of the site, which would further shield potential noise originating from the interior of the Project from adjacent residences. Finally, the Project would be subject to Municipal Code provisions that generally govern the use of noise-generating equipment on residential properties, such as Municipal Code Section 8.06.090, which prohibits the use of domestic power tools and machinery (e.g., powered saws, lawn and garden tools) during nighttime hours if they create a noise disturbance.

The only stationary noise generating equipment at the Project site would be the proposed HVAC units, which would be located at ground-level, in the backyard area of each residential building (KTGY Architecture and Planning, 2022). Although the exact make and model of the HVAC units are unknown at this time, the type of HVAC unit anticipated to be installed is a small fan-type residential unit capable of generating noise levels between 70 and 76 dBA at a distance of three (3) feet, depending on the type of model installed (Carrier, 2021).

The site plan indicates that the Project's residential buildings would be set back a minimum of 25 feet from existing residences to the north and west (CA Engineering Inc., 2023). With distance, the typical residential HVAC unit would generate a noise level between 51.6 dBA L_{eq} and 57.6 dBA L_{eq} at adjoining property lines, which is above the City's 50 dBA L_{eq} nighttime noise standard for residential land uses. The proposed Project design also includes a six (6)-foot tall concrete masonry unit perimeter wall that would provide between approximately five (5) and 10 dB of attenuation in the rear yards of adjacent property lines. The difference in barrier attenuation is due to differences in receiver, source (i.e., HVAC), and top of barrier elevations along the site's northern and western property lines. In general, receptors adjacent to the western property line are situated below the project grade and the differences in elevations between the receptor, HVAC unit, and top of barrier height are greater. In contrast, receptors adjacent to the northern property line are situated closer to (on the west) or above (on the east) the project grade, and the differences in elevations between the receptor, HVAC unit, and top of barrier height are less pronounced. The proposed Project's estimated HVAC unit noise levels with distance and barrier attenuation are provided in Table 4. Refer to Appendix 04 for the detailed HVAC noise and barrier attenuation estimates.

Table 4: Potential HVAC System Noise Levels		
HVAC System Variable	**Property Line Receptor[A]**	
	West	**North**
HVAC Unit Noise Level	71 to 76 dBA	71 to 76
Distance to Receptor	25 feet	25 feet
Noise Level at 25 Feet	51.6 dBA L_{eq} to 57.6 dBA L_{eq}	51.6 dBA L_{eq} to 57.6 dBA L_{eq}
Perimeter Barrier Attenuation	-9.0 dBA to -10.4 dBA	-5.2 dBA to -7.5 dBA
Resulting HVAC Noise Level	41.2 dBA L_{eq} to 48.6 dBA L_{eq}	44.1 dBA L_{eq} to 52.4 dBA L_{eq}
City Municipal Code Standard	60 dBA L_{eq} (7 AM – 10 PM) 50 dBA L_{eq} (10 PM – 7 AM)	60 dBA L_{eq} (7 AM – 10 PM) 50 dBA L_{eq} (10 PM – 7 AM)
Additional Attenuation Needed	0 dBA	Up to 2.4 dBA (10 PM – 7 AM)

Source: MIG (see Attachment 04)

(A) The data presented are the worst-case prediction along the property line. Refer to Appendix XYZ for detailed information on HVAC noise level estimates.

As shown in Table 4, HVAC units that generate higher noise levels (74.6 dBA or higher) would require additional attenuation to ensure potential HVAC units do not exceed the City's nighttime noise standard of 50 dBA L_{eq}.

To reduce the potential for the proposed Project's operational HVAC noise levels to generate noise levels above the City's exterior standards for residential properties, MIG recommends Mitigation Measure NOI-2 be incorporated into the Project:

Mitigation Measure NOI-2: Reduce Potential Project HVAC Noise Levels

To reduce potential noise levels from Project heating, ventilation, and air conditioning (HVAC) equipment, the City shall prohibit the installation of HVAC systems that generate a noise level greater than 76 dBA at three (3) feet. In addition, for HVAC systems located in the rear or side yards of residential units along the Project's northern property line, the Applicant shall, prior to the release of the grading or building permit that authorizes the construction of any such unit, submit evidence of one the following:

1) The HVAC units to be installed shall be located at least 25 feet from the northern property line (as measured from the edge of the HVAC compressor/condenser equipment) and shall not generate a noise level in excess of 74.6 dBA at three (3) feet from the unit. The City may accept a manufacturer's specifications or other information, such as actual empirical noise measurements, as evidence of the noise levels that may be generated by the final proposed HVAC system(s).
2) If the HVAC units to be installed generate a noise level between 74.6 dBA and 76 dBA at three (3) feet they shall be located a minimum of 34 feet from the northern property line (as measured from the edge of the HVAC compressor/condenser equipment).
3) If the HVAC units to be installed generate a noise level between 74.6 dBA and 76 dBA at three (3) feet) and they are located closer than 34 feet from the northern property line (as measured from the edge of the HVAC compressor/condenser equipment), then the height of the planned northern perimeter concrete masonry unit wall shall be increased from six (6) feet to eight (8) feet in height above the planned finished surface elevation.

The implementation of Mitigation Measure NOI-2 would provide a minimum of 2.5 dBA of additional HVAC noise attenuation at existing residential receptors along the shared northern property line and ensure that HVAC noise levels would not exceed the City's 50 dBA L_{eq} exterior nighttime noise standard, nor any other exterior noise standard (e.g., the City's 60 dBA L_{eq} daytime standard for residential properties).

The Project also would not have the potential to result in noise levels that exceed the City's maximum permissible interior noise limit of 45 dBA L_{eq} for residential properties. Noise levels inside existing residential buildings would be approximately 12 dBA to 30 dBA lower than estimated exterior noise levels, depending on whether windows and doors were open or closed. Thus, potential HVAC-related interior noise levels at existing residential receptors adjacent to the Project would be less than 40 dBA L_{eq} even with windows open, which is less than the City's 45 dBA L_{eq} interior noise standard.

Finally, it is noted that HVAC equipment does not operate continuously and would not affect ambient noise levels when the equipment is not in use. For these reasons, potential HVAC equipment would not generate noise levels that have the potential to exceed the 45 dBA CNEL interior noise standard established by General Plan Policy 9.0s. Furthermore, with Mitigation Measure NOI-2, potential HVAC noise is estimated to be less than 50.0 dBA L_{eq} when in operation, which would be approximately 2.4 dBA above measured ambient noise levels on the interior of the site (47.6 dBA L_{eq} at ST-4, see Table 2). Since HVAC equipment would not operate continuously, the net change in 24-hour noise exposure levels at adjacent residential properties would be less than 2.4 dBA. The proposed Project, therefore, does not have the potential to result in incompatible noise levels at adjacent residences or otherwise result in a substantial permanent increase in ambient noise levels in the vicinity of the Project (considered by General Plan Policy 9.0v to be 4 dBA if a land use compatibility threshold is exceeded or 6 dBA in any situation).

As described above, the proposed Project would not result in a substantial permanent increase in ambient noise levels in the vicinity of the project in excess of City standards with the incorporation of Mitigation Measure NOI-2. This impact would be less than significant with mitigation.

Project Operation (Off-Site Vehicle Trip Noise)

The Transportation Study Screening Analysis prepared for the proposed Project indicates the Project would result in a net increase of 918 daily vehicle trips (Ganddini Group, 2023). Currently, there are approximately 7,400 vehicles per day on Wabash Avenue north of Colton Avenue, 5,800 vehicles per day on Wabash Avenue south of Colton Avenue, 4,100 vehicles per day on Colton Avenue east of Wabash Avenue, and 5,400 vehicles per day on Colton Avenue between Wabash Avenue and Dearborn Street (Ganddini Group, 2023). In general, it takes a doubling of traffic to increase traffic noise volumes by 3 dBA, which is considered an audible increase for exterior noise environments by the City's General Plan (Caltrans, 2013 and City of Redlands, 2017). The addition of 918 passenger cars to the roadway system would not result in a doubling of traffic on any roadway segment at or in the vicinity of the Project site and, therefore, would result in a less than 3 dBA increase in noise levels on local roads used to access the Project site. The proposed Project would not result in a substantial, permanent increase in noise levels along the roadways used to access the proposed Project as compared to existing or future conditions. This impact would be less than significant.

Groundborne Vibration

Construction vibration impacts generally occur when construction activities occur in close proximity to buildings and vibration-sensitive areas, during evening or nighttime hours, or when construction activities last extended periods of time. The potential for groundborne vibration is typically greatest when vibratory or large equipment such as rollers or bulldozers are in operation. For the proposed Project, these types of equipment would primarily operate during the site preparation, grading, and paving phases. Site preparation and grading would occur over a total of approximately 30 days at the beginning of construction and paving would occur over approximately 20 days near the end of construction. During site preparation and grading activities, large equipment could, at worst-case, operate adjacent to the site's property lines and within approximately 25 feet of the nearest residential buildings (to the north and west), although most operations would generally take place further from receptor locations. For example, equipment operating in the middle of the site could be 300 feet from receptors, and equipment operating along the southern and eastern perimeters could be approximately 600 feet from receptors. Paving operations would generally take place near the interior of the site, usually at least 50 feet from any adjacent residential building. The groundborne vibration levels generated by the type of equipment that would be used to construct the proposed Project are shown in Table 5. Refer to Attachment 05 for detailed vibration estimates.

Table 5: Potential Project Construction Vibration Levels

Equipment	Estimated Peak Particle Velocity at Distance (in/sec) (A),(B)							
	25 feet	50 feet	100 feet	200 feet	250 feet	300 feet	350 feet	400 feet
Small bulldozer	0.003	0.001	0.001	0.000	0.000	0.000	0.000	0.000
Jackhammer	*0.035*	*0.016*	0.008	0.006	0.005	0.004	0.003	0.002
Large bulldozer	*0.089*	*0.042*	*0.019*	*0.015*	*0.012*	0.009	0.007	0.006
Vibratory Roller	*0.210*	*0.098*	*0.046*	*0.034*	*0.029*	*0.021*	*0.017*	*0.010*

Sources: MIG (see Attachment 05)' Caltrans, 2020; and FTA, 2018.

(A) Estimated PPV calculated as: PPV(D)=PPV(ref)*(25/D)^1.1 where PPV(D)= Estimated PPV at distance; PPVref= Reference PPV at 25 ft; D= Distance from equipment to receiver; and n= ground attenuation rate (1.1 for dense, compacted hard soils). All distances are lateral distances and do not consider changes in topography.

(B) *Italicized* values indicate the estimated vibration level exceeds the vibration perception threshold of 0.01 in/sec established by City Municipal Code Section 8.06.090(G).

As shown in Table 5, specific vibration levels associated with typical construction equipment are highly dependent on the type of equipment used. The use of typical equipment during construction activities (e.g., bulldozer, jack hammer) is estimated to produce vibration levels above the City's vibration perception threshold of 0.01 in/sec PPV when operated within 250 feet of a residential building façade. For specific vibration-inducing equipment, such as a vibratory roller, it is estimated vibration levels may be above the City's vibration perception threshold when operated within 400 feet of a residential building façade. It is noted the vibration estimates shown in Table 5 do not take into account differences in grade or other subsurface conditions that may limit vibration transmission. In addition, the vibration estimated shown in Table 5 do not consider any loss of vibratory energy associated with the transfer of vibrations across different medium (e.g., from the soil to a concrete foundation to a floor or wall assembly). The vibration estimates shown in Table 5, therefore, are likely to overestimate potential vibration levels associated with construction equipment.

As shown in Table 5, the proposed Project's potential construction activities would have the potential to exceed the City's vibration perception threshold of 0.01 in/sec PPV; however, the vibration levels that could be generated by potential construction activities would not be considered excessive for several reasons. First, potential worst-case construction vibrations would be intermittent, lasting only a few hours each day at any individual receptor. Second, potential worst-case construction vibrations would occur only when equipment operates directly adjacent to a receptor, which is not anticipated to last more than several days in total. Third, all construction activity would occur during the daytime, when human beings are less sensitive to vibrations, and would not interfere with evening or knighting use of residences. Finally, potential construction vibrations would not result in physical damage to any building or structure because estimated worst-case vibration levels would be below Caltrans' guidelines for damage to sensitive residential structures (0.3 in/sec PPV; Caltrans, 2013).

While potential construction vibrations would not be considered excessive, the potential exists for construction equipment to generate vibration levels above the City's vibration perception threshold of 0.01 in/sec PPV. To reduce the proposed Project's potential to temporarily exceed the City's vibration standard, MIG recommends Mitigation Measure NOI-3 be incorporated into the Project.

> **Mitigation Measure NOI-3: Prohibit Vibratory Construction Equipment.** To reduce potential vibration levels associated with construction of the proposed Project, the Applicant and/or its designated contractor, contractor's representatives, or other appropriate personnel shall use tamper and drum/wheel style rollers during Project construction. The use of large vibratory rollers or other vibratory equipment shall be prohibited during construction unless geotechnical evaluations indicate the use of this equipment is specifically required to address compaction or other building requirements, in which case the use of vibratory rollers and equipment shall be limited to the area/conditions specified in the geotechnical report.

The implementation of Mitigation Measure NOI-3 would prohibit or limit the use of construction equipment with the greatest potential to exceed the City's vibration perception threshold. In addition, Mitigation Measure NOI-1 would require the Applicant to provide advance warning to adjacent residents of the proposed Project's construction activities, restrict work hours to daytime periods, and use the smallest equipment capable of safely completing work activities. By prohibiting and limiting the use of vibration inducing equipment, providing advanced notice of construction activities, and implementing equipment control measures, the potential for sensitive residential receptors to be exposed to disturbing or excessive perceptible vibrations would be substantially reduced. Thus, with Mitigation Measure NOI-3, the proposed Project's potential construction vibration levels would be rendered a less than significant impact.

Once operational, the proposed Project would not have any large equipment that would generate vibration. This impact would be less than significant.

Airport-Related Noise

The proposed Project is located approximately 1.3 miles south of the Redlands Municipal Airport. Noise from overhead flights was observed during the ambient noise monitoring conducted for the Project; however, the predominant source of noise was traffic noise from Wabash Avenue and Colton Avenue. As noted in the City's General Plan, aircraft noise is a relatively minor contribution to the City's overall noise environment (City of Redlands 2017). The Project site is located outside of the 60 CNEL noise contour for the Redlands Municipal Airport and is not located within any other airport planning boundary (City of Redlands 2003). The proposed Project, therefore, would not expose people living at the site to excessive airport-related noise levels.

Other Planning Considerations (Noise / Land Use Compatibility)

The California Supreme Court in *California Building Industry Association v. Bay Area Air Quality Management District*, 62 Cal.4th 369 (2015) ruled that CEQA review is focused on a project's impact on the environment “and not the environment’s impact on the project.” Per this ruling, a Lead Agency is not required to analyze how existing conditions might impact a project’s existing or future population except where specifically required by CEQA; however, a Lead Agency may elect to disclose information relevant to a project even if it not is considered an impact under CEQA. Furthermore, the City’s General Plan sets noise standards for receiving land uses which require evaluation for consistency and compliance even if such evaluation is not required by CEQA to be identified as a physical impact of the project. Specifically, General Plan Policy 7-A.135 establishes that the clearly compatible and normally incompatible noise levels for residential land uses are 60 CNEL and 75 CNEL, respectively.

The General Plan Healthy Community Element contains noise level contours along Wabash Avenue and Colton Avenue. The traffic noise modeling conducted for the General Plan indicates traffic noise levels 50 feet from the outermost lane of Colton Avenue and Wabash Avenue are approximately 59.4 and 63.2 CNEL, respectively, and will increase to approximately 61.2 CNEL and 64.3 CNEL, respectively, by 2035. It is noted the existing traffic noise levels in the General Plan were generally confirmed by ambient noise monitoring conducted at the Project site (See Table 2).

Exterior Noise Levels in Rear Yards

The proposed Project’s rear yards would be located approximately 40 feet from the center of the outermost travel lane on Wabash Avenue and 48 feet from the center of the outermost travel lane on Colton Avenue. At this distance, under 2035 conditions, the estimated noise levels at the proposed Project’s eastern and southern rear yards are estimated to be 62.2 CNEL and 64.5 CNEL, respectively. The proposed six (6)-foot-tall perimeter concrete masonry unit wall would provide, at minimum, six (6) dB of traffic noise attenuation in the rear yards that abut Colton and Wabash Avenues (see Attachment 04). Thus, with the proposed perimeter wall, the proposed Project would not be subject to exterior noise levels that exceed the City’s clearly compatible noise level limit of 60 CNEL.

Interior Noise Levels in Proposed Residential Units

The proposed Project’s exterior building façades would be located a minimum of 50 feet from the center of the outermost travel lane on Wabash Avenue and 58 feet from the center of the outermost travel lane on Colton Avenue. At this distance, under 2035 conditions, the estimated noise levels at the proposed Project’s eastern and southern rear yards are estimated to be 61.2 CNEL and 63.7 CNEL, respectively (see Attachment 04). As explained previously, standard construction techniques and materials for new residential buildings are commonly accepted to provide a minimum exterior to interior noise attenuation (i.e., reduction) of 12 to 30 dBA , depending on whether all windows and doors closed.[1] The proposed Project includes individual HVAC systems for each residential units, which would permit residents to occupy residential units with windows closed and result in interior noise levels in residential units fronting Wabash Avenue and Colton Avenue that would be, at minimum, less than 35 CNEL. Thus, with standard construction techniques, the proposed Project would satisfy the City’s 45 dBA CNEL interior

1 The U.S. Department of Housing and Urban Development (HUD) Noise Guidebook and supplement (2009a, 2009b) includes information on noise attenuation provided by building materials and different construction techniques. As a reference, a standard exterior wall consisting of 5/8-inch siding, wall sheathing, fiberglass insulation, two by four wall studs on 16-inch centers, and 1/2-inch gypsum wall board with single strength windows provides approximately 35 dBs of attenuation between exterior and interior noise levels. This reduction may be slightly lower (2-3 dBs) for traffic noise due to the specific frequencies associated with traffic noise but will still be sufficient to meet the 45 CNEL standard for dwelling units fronting Colton Avenue and Wabash Avenue. Increasing window space may also decrease attenuation, with a reduction of 10 dBs possible if windows occupy 30% of the exterior wall façade.

building code noise requirement established by General Plan Policy 9.0s and State building code requirements.

CONCLUSION

As described in this memo, the proposed Project, with mitigation incorporated, would not generate temporary or permanent noise levels that would exceed the City's standards or otherwise result in a substantial increase in ambient noise levels, would not generate excessive groundborne vibration or groundborne noise levels, and would not expose people residing or working in the Project area to excessive aircraft noise levels. The proposed Project, therefore, would not result in a substantial, adverse noise-related effect on the environment. In addition, the proposed Project would not be subjected to incompatible noise levels.

REFERENCES

The following references were used to prepare this memorandum:

CA Engineering Inc, 2023. "Sheet C1.2 Site Plan." March 10, 2023.

California Department of Transportation (Caltrans) 2013. Technical Noise Supplement to the Traffic Noise Analysis Protocol. Sacramento, California. September 2013.

_______2020. Transportation and Construction Vibration Guidance Manual. Sacramento, California. April 2020.

City of Redlands, 2003. Redlands Municipal Airport Land Use Compatibility Plan. May 6, 2003. https://raacp.org/wp-content/uploads/2016/07/Redlands-Airport-Land-Use-Compatibility-Plan.pdf

______2017. General Plan 2035. Adopted December 5, 2017. Available online at: https://www.cityofredlands.org/post/planning-division-general-plan

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KTGY Architecture and Planning. Madera at Citrus Trail Schematic Design. July 29, 2022.

Sitescapes Landscape Architecture and Planning. 2022. "Sheet L4.Overall Fence and Wall Plan. July 29, 2022.

U.S. Federal Highway Administration (FHWA) 2010. "Construction Noise Handbook, Chapter 9 Construction Equipment Noise Levels and Ranges: <https://www.fhwa.dot.gov/environment/noise/construction_noise/handbook/handbook00.cfm>

U.S. Federal Transit Administration (FTA) 2018. Transit Noise and Vibration Impact Assessment Manual. FTA Report No. 0123. Prepared by John A. Volpe National Transportation Systems Center. Washington, DC. September 2018.

U.S. HUD. 2009a.HUD Noise Guidebook. Prepared by the Environmental Planning Division, Office of Environment and Energy. March 2009.

_______2009b. HUD Noise Guidebook, Chapter 4 Supplement: Sound Transmission Class Guidance. Prepared by the Environmental Planning Division, Office of Environment and Energy. March 2009.

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Attachment 01

Project Site Plan

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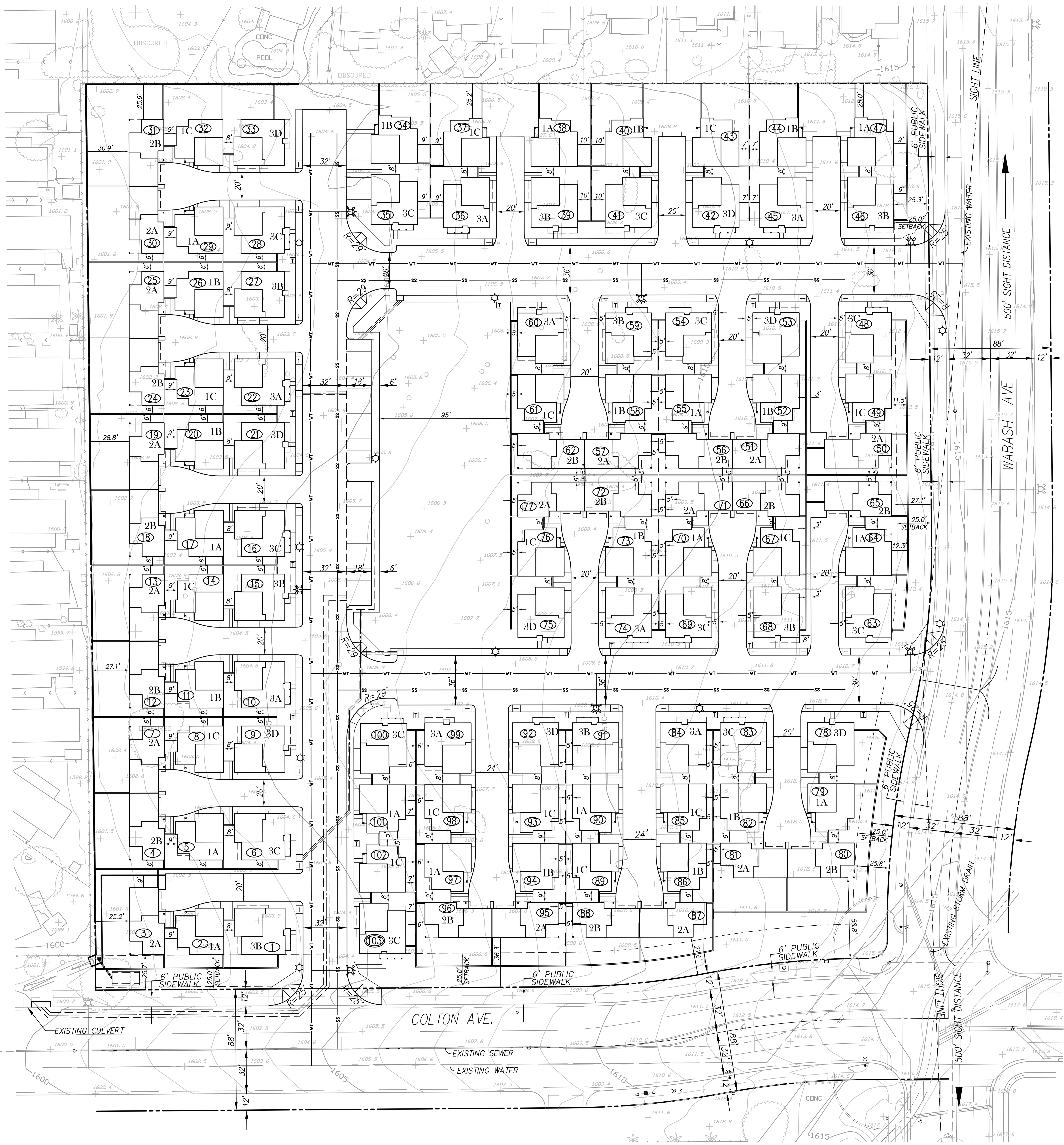
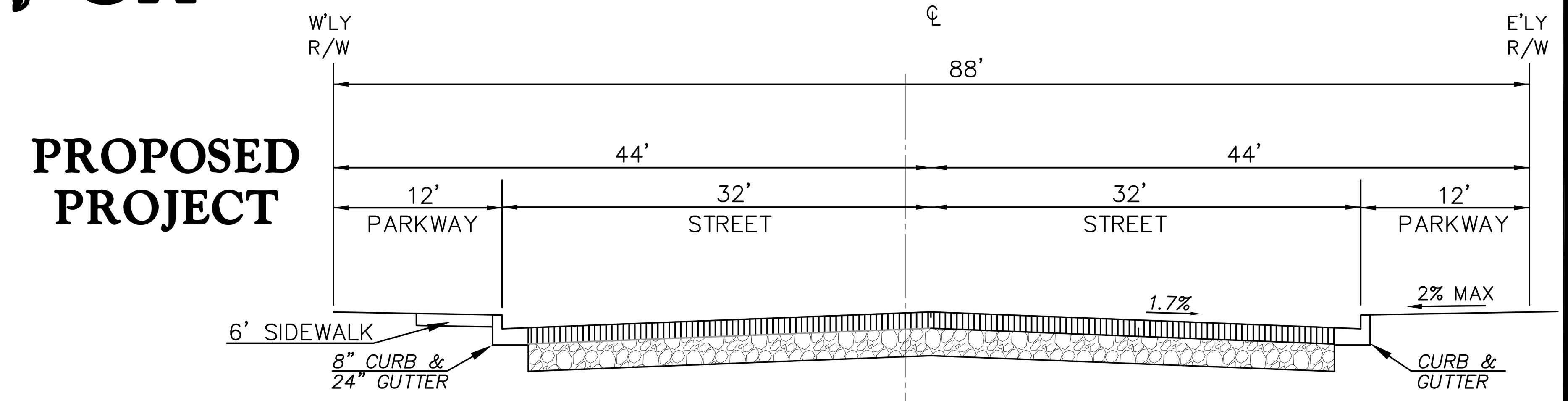
SITE PLAN

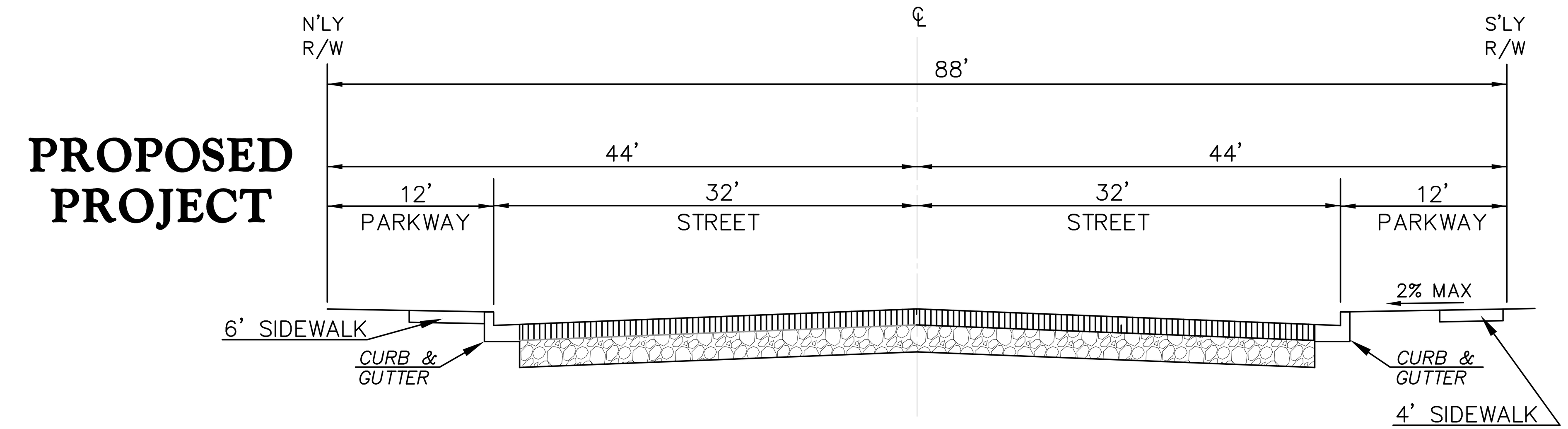
COLTON AVE & WABASH AVE, REDLANDS, CA

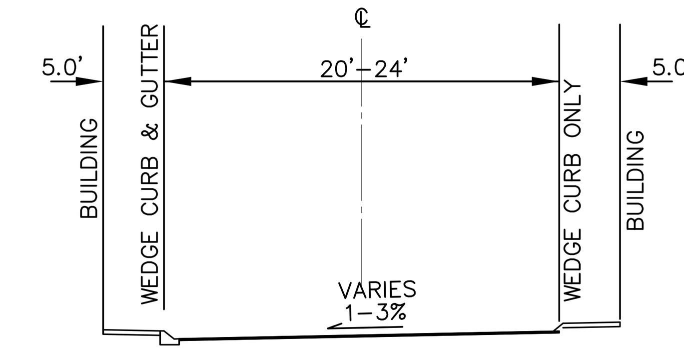


WABASH AVE.
TYPICAL SECTION
N.T.S.



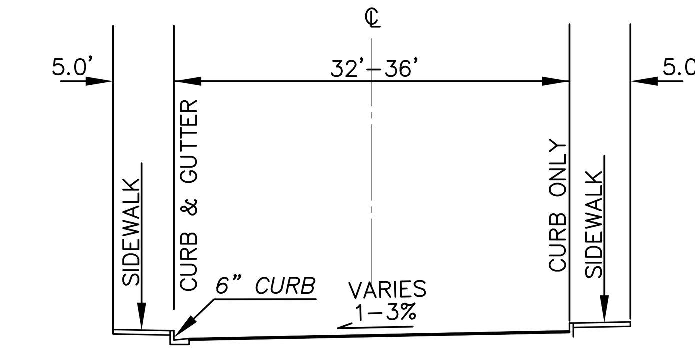
COLTON AVE.
TYPICAL SECTION
N.T.S.





PRIVATE ON-SITE ALLEY

STREET SECTION
NO SCALE



PRIVATE ON-SITE STREET

STREET SECTION
NO SCALE

LEGEND

- PROP. LOT LINE
- BOUNDARY LINE
- PROP. CURB
- EX. CURB
- PROPOSED SEWER
- EXISTING SEWER
- PROPOSED WATER
- EXISTING WATER
- PROPOSED STORM DRAIN
- EXISTING STORM DRAIN

PROJECT SUMMARY

9.01 ACRES (NET & GROSS)
11.43 DU/ACRE
103 TOTAL UNITS

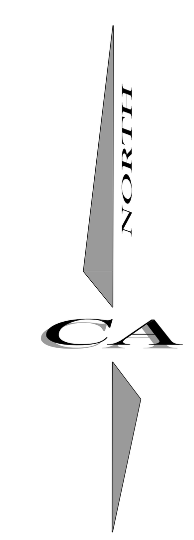
PRODUCT 1
40 UNITS
1,544 SF

PRODUCT 2
27 UNITS
1,700 SF

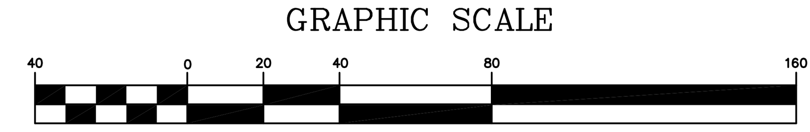
PROCUCT 3
36 UNITS
1,858 SF

PARKING SUMMARY
63 GUEST STALLS
206 GARAGE STALLS
269 TOTAL STALLS

MIX SUMMARY
PRODUCT 1 – 40 UNITS 38.8%
PRODUCT 2 – 27 UNITS 26.2%
PRODUCT 3 – 36 UNITS 35.0%



GRAPHIC SCALE



(IN FEET)
1 inch = 40 ft.

Soni 2012 Irrevocable Trusts 1423 Georgina Avenue Santa Monica Santa Monica, CA 90402 (949) 922-7075 Contact: Vanita Soni Puri	CA ENGINEERING, INC. Planning · Engineering · Surveying 13821 NEWPORT AVE, STE 110 TUSTIN, CA 92780 949-724-9480 949-724-9484 FAX	SHEET C1.2 Mar 10 2023 JOB NO. 816-1 SHEET NO. 1 OF 1 SHTS.

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Attachment 02

Environmental Noise Background

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ENVIRONMENTAL NOISE BACKGROUND

Noise may be defined as loud, unpleasant, or unwanted sound. The frequency (pitch), amplitude (intensity or loudness), and duration of noise all contribute to the effect on a listener, or receptor, and whether the receptor perceives the noise as objectionable, disturbing, or annoying.

The Decibel Scale (dB)

The decibel scale (dB) is a unit of measurement that indicates the relative amplitude of a sound. Sound levels in dB are calculated on a logarithmic basis. An increase of 10 dB represents a tenfold increase in acoustic energy, while 20 dBs is 100 times more intense, 30 dBs is 1,000 more intense, and so on. In general, there is a relationship between the subjective noisiness, or loudness of a sound, and its amplitude, or intensity, with each 10 dB increase in sound level perceived as approximately a doubling of loudness. Due to the logarithmic basis, decibels cannot be directly added or subtracted together using common arithmetic operations:

$$50\ decibels + 50\ decibels\ \neq 100\ decibels$$

Instead, the combined sound level from two or more sources must be combined logarithmically. For example, if one noise source produces a sound power level of 50 dBA, two of the same sources would combine to produce 53 dB as shown below.

$$10 *\ 10\, log\left(10^{\left(\frac{50}{10}\right)} +\ 10^{\left(\frac{50}{10}\right)}\right)\ = 53\ decibels$$

In general, when one source is 10 dB higher than another source, the quieter source does not add to the sound levels produced by the louder source because the louder source contains ten times more sound energy than the quieter source.

Sound Characterization

There are several methods of characterizing sound. The most common method is the “A-weighted sound level,” or dBA. This scale gives greater weight to the frequencies of sound to which the human ear is typically most sensitive. Thus, most environmental measurements are reported in dBA, meaning decibels on the A-scale.

Human hearing matches the logarithmic A-weighted scale, so that a sound of 60 dBA is perceived as twice as loud as a sound of 50 dBA. In a quiet environment, an increase of 3 dB is usually perceptible, however, in a complex noise environment such as along a busy street, a noise increase of less than 3 dB is usually not perceptible, and an increase of 5 dB is usually perceptible. Normal human speech is in the range from 50 to 65 dBA. Generally, as environmental noise exceeds 50 dBA, it becomes intrusive and above 65 dBA noise becomes excessive. Nighttime activities, including sleep, are more sensitive to noise and are considered affected over a range of 40 to 55 dBA.

Sound levels are typically not steady and can vary over a short time period. The equivalent noise level (L_{eq}) is used to represent the average character of the sound over a period of time. The L_{eq} represents the level of steady noise that would have the same acoustical energy as the sum of the time-varying noise measured over a given time period. L_{eq} is useful for evaluating shorter time periods over the course of a day. The most common L_{eq} averaging period is hourly, but L_{eq} can describe any series of noise events over a given time period.

Variable noise levels are values that are exceeded for a portion of the measured time period. Thus, L_{01} is the level exceeded one percent of the time and L90 is the level exceeded 90 percent of the time. The L_{90} value usually corresponds to the background sound level at the measurement location.

Noise exposure over the course of an entire day is described by the day/night average sound level, or DNL (also referred to as L_{dn}), and the community noise equivalent level, or CNEL. Both descriptors represent the 24-hour noise impact on a community. For DNL, the 24-hour day is divided into a 15-hour daytime period (7 AM to 10 PM) and a nine-hour nighttime period (10 PM to 7 AM) and a 10 dB "penalty" is added to measure nighttime noise levels when calculating the 24-hour average noise level. For example, a 45-dBA nighttime sound level would contribute as much to the overall day-night average as a 55-dBA daytime sound level. The CNEL descriptor is similar to DNL, except that it includes an additional 5 dBA penalty beyond the 10 dBA for sound events that occur during the evening time period (7 PM to 10 PM). The artificial penalties imposed during DNL and CNEL calculations are intended to account for a receptor's increased sensitivity to sound levels during quieter nighttime periods.

Sound Propagation

The energy contained in a sound pressure wave dissipates and is absorbed by the surrounding environment as the sound wave spreads out and travels away from the noise generating source. Theoretically, the sound level of a point source attenuates, or decreases, by 6 dB with each doubling of distance from a point source. Sound levels are also affected by certain environmental factors, such as ground cover (asphalt vs. grass or trees), atmospheric absorption, and attenuation by barriers. Outdoor noise is also attenuated by the building envelope so that sound levels inside a residence are from 10 to 20 dB less than outside, depending mainly on whether windows are open for ventilation or not.

For an ideal "point" source of sound, the energy contained in a sound pressure wave dissipates and is absorbed by the surrounding environment as the sound wave spreads out in a spherical pattern and travels away from the point source. Theoretically, the sound level attenuates, or decreases, by 6 dB with each doubling of distance from the point source. The change in noise levels between two distances can be calculated according to Equation 1 (California Department of Transportation (Caltrans), 2013) as follows:

Equation 1

$$dBA2 = dBA1 + 20\log(D1/D2)$$

Where:

dBA1 = Known noise level, such as a reference noise level
D1 = Distance associated with dBA1
dBA2 = Noise level at distance 2
D2 = Distance associated with dBA2

For an ideal line source of sound, the energy contained in a sound pressure wave dissipates and is absorbed by the surrounding environment as the sound wave spreads out in a cylindrical pattern from the source. Theoretically, the sound level attenuates, or decreases, by 3 dB with each doubling of distance from the line source. The change in noise levels between two distances can be calculated according to Equation 2 as follows:

Equation 2

dBA2 = dBA1 + 10log (D1/D2)

Where:

dBA1	= Known noise level, such as a reference noise level
D1	= Distance associated with dBA1
dBA2	= Noise level at distance 2
D2	= Distance associated with dBA2

Noise Effects on Humans

Noise effects on human beings are generally categorized as:

- Subjective effects of annoyance, nuisance, and/or dissatisfaction
- Interference with activities such as speech, sleep, learning, or relaxing
- Physiological effects such as startling and hearing loss

Most environmental noise levels produce subjective or interference effects; physiological effects are usually limited to high noise environments such as industrial manufacturing facilities or airports.

Predicting the subjective and interference effects of noise is difficult due to the wide variation in individual thresholds of annoyance and past experiences with noise; however, an accepted method to determine a person's subjective reaction to a new noise source is to compare it the existing environment without the noise source, or the "ambient" noise environment. In general, the more a new noise source exceeds the ambient noise level, the more likely it is to be considered annoying and to disturb normal activities.

Under controlled conditions in an acoustical laboratory, the trained, healthy human ear is able to discern 1-dB changes in sound levels when exposed to steady, single-frequency ("pure-tone") signals in the mid-frequency (1,000–8,000 Hz) range. In typical noisy environments, changes in noise of 1 to 2 dB are generally not perceptible. However, it is widely accepted that people are able to begin to detect sound level increases of 3 dB in typical noisy environments. Further, a 5-dB increase is generally perceived as a distinctly noticeable increase, and a 10-dB increase is generally perceived as a doubling of loudness that would almost certainly cause an adverse response from community noise receptors.

When exposed to high noise levels, humans may suffer hearing damage. Sustained exposure to high noise levels (e.g., 90 dBs for hours at a time) can cause gradual hearing loss, which is usually temporary, whereas sudden exposure to a very high noise level (e.g., 130 to 140 dBs) can cause sudden and permanent hearing loss. In addition to hearing loss, noise can cause stress in humans and may contribute to stress-related diseases, such as hypertension, anxiety, and heart disease (Caltrans, 2013).

Vibration

Vibration is the movement of particles within a medium or object such as the ground or a building. As is the case with airborne sound, groundborne vibrations may be described by amplitude and frequency. Vibration amplitudes are usually expressed in peak particle velocity (PPV) or root mean squared, in inches per second (in/sec). PPV represents the maximum instantaneous positive or negative peak of a vibration signal and is most appropriate for evaluating the potential for building damage. Human response to groundborne vibration is subjective and varies from person to person

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Attachment 03

Ambient Noise Monitoring Data

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Madera at Citrus Trail Residential Development
Wabash Avenue and Colton Avenue, Redlands, CA

Attachment 03: On-site HVAC Noise and Barrier Attenuation Estimates
Prepared by: MIG, Inc.
July 2023

Contents:

Madera at Citrus Trail Residential Project
Wabash Avenue and Colton Avenue, Redlands, CA
Attachment 03: On-site HVAC Noise and Barrier Attenuation Estimates

Sheet 1: Project HVAC Noise Level Estimates (dBA Leq)

Table 1: Estimated Noise Levels at Adjacent Property Lines

On-Site Noise Source	Reference Noise Data		Property Line (No Barrier)		Property Line (With Barrier)	
	Distance	Hourly Leq dBA	Distance	Hourly Leq dBA	Distance	Hourly Leq dBA
HVAC (low range)	3	70.0	25	51.6	25	48.6
HVAC (high range)	3	76.0	25	57.6	25	52.4
HVAC (high range)	3	76.0	34	54.9	34	49.8

Madera at Citrus Trail Residential Project
Wabash Avenue and Colton Avenue, Redlands, CA
Attachment 03: On-site HVAC Noise and Barrier Attenuation Estimates

Sheet 2: Noise Barrier Attenuation Estimates (HVAC Low Range)

Table 1: Source/ Property Line Receiver Information									
Noise Source:	Residential Fan-type HVAC Unit (Low)								
Source Noise Level:	PL=	51.6							
Receptor Noise Level:	PL=	50.0							
Noise Reduction Level:	PL=	1.6							
Source Frequency:	125	Hertz							

Note: "PL" = Property Line

Table 2: Source, Receptor, and Barrier Elevation Data						
Receptor	**Elevation Above Mean Sea Level**					
	Grade	**Receiver**	**Source**	**fective Source**	**Barrier**	**Top of Barrier**
PL - West (South)	1599.1	1604.1	1603.1	1606.1	1603.1	1609.1
PL - West (mid)	1600.6	1605.6	1603.3	1606.3	1603.3	1609.3
PL - North (west)	1604.0	1609.0	1605.5	1608.5	1605.5	1611.5
PL - North (center)	1610.6	1615.6	1609.8	1612.8	1609.8	1615.8

Table 3: Barrier Insertion Loss Summary			
Property Line	**Preliminary Barrier Insertion Loss Estimate**		
	Predicted Noise Level	**Barrier Attenuation**	**Noise Level with Barrier**
PL - West (South)	51.6	10.4	41.2
PL - West (mid)	51.6	9.0	42.6
PL - North (west)	51.6	7.5	44.1
PL - North (center)	51.6	5.2	46.4

Table 4: Barrier Attenuation 6-Foot High Wall (West -South)								
Receptor	**A**	**B**	**C**	**D**	**D1**	**D2**	**H1**	**H2**
Property Line	25.18	7.07	30.07	30	25	5	2.0	5.0

Table 5: Fresnel Number (N_0) and Barrier Insertion Loss Estimate (West-South)				
Receptor	**δ (Feet)**	**λ (Feet)**	**N_0**	**Insertion Loss (dB)**
Property Line	2.18	9.00	0.4853	10.4

Table 6: Barrier Attenuation 6-Foot High Wall (West-Mid)								
Receptor	**A**	**B**	**C**	**D**	**D1**	**D2**	**H1**	**H2**
Property Line	25.18	6.22	30.01	30	25	5	0.7	3.7

Table 7: Fresnel Number (N_0) and Barrier Insertion Loss Estimate (West-Mid)				
Receptor	**δ (Feet)**	**λ (Feet)**	**N_0**	**Insertion Loss (dB)**
Property Line	1.39	9.00	0.3092	9.0

Table 8: Barrier Attenuation 6-Foot High Wall (North-West)								
Receptor	**A**	**B**	**C**	**D**	**D1**	**D2**	**H1**	**H2**
Property Line	25.18	5.59	30.00	30	25	5	-0.5	2.5

Table 9: Fresnel Number (N_0) and Barrier Insertion Loss Estimate (North-West)				
Receptor	**δ (Feet)**	**λ (Feet)**	**N_0**	**Insertion Loss (dB)**
Property Line	0.77	9.00	0.1701	7.5

Table 10: Barrier Attenuation 6-Foot High Wall (North-Central)								
Receptor	**A**	**B**	**C**	**D**	**D1**	**D2**	**H1**	**H2**
Property Line	25.18	5.00	30.13	30	25	5	-2.8	0.2

Table 11: Fresnel Number (N_0) and Barrier Insertion Loss Estimate (North-Central)				
Receptor	**δ (Feet)**	**λ (Feet)**	**N_0**	**Insertion Loss (dB)**
Property Line	0.05	9.00	0.0118	5.2

Madera at Citrus Trail Residential Project
Wabash Avenue and Colton Avenue, Redlands, CA
Attachment 03: On-site HVAC Noise and Barrier Attenuation Estimates

Sheet 3: Noise Barrier Attenuation Estimates (HVAC High Range)

Table 1: Source/ Property Line Receiver Information									
Noise Source:	Residential Fan-type HVAC Unit (Low)								
Source Noise Level:	PL=	57.6		54.9	(34 ft setback)				
Receptor Noise Level:	PL=	50.0							
Noise Reduction Level:	PL=	7.6							
Source Frequency:	125	Hertz							

Note: "PL" = Property Line

Table 2: Source, Receptor, and Barrier Elevation Data						
Receptor	**Elevation Above Mean Sea Level**					
	Receiver Grade	**Receiver Height**	**Source Grade**	**Effective Source Height**	**Barrier Grade**	**Top of Barrier**
PL - West (South)	1599.1	1604.1	1603.1	1606.1	1603.1	1609.1
PL - West (mid)	1600.6	1605.6	1603.3	1606.3	1603.3	1609.3
PL - North (west)	1603.8	1608.8	1605.5	1608.5	1605.5	1611.5
PL - North (mid)	1610.6	1615.6	1609.8	1612.8	1609.8	1615.8
PL - North (mid, 8 ft)	1610.6	1615.6	1609.8	1612.8	1609.8	1617.8
PL - North (east)	1614.0	1619.0	1613.8	1616.8	1613.8	1619.8
PL - North (east, 8 ft)	1614.0	1619.0	1613.8	1616.8	1613.8	1621.8

Table 3: Barrier Insertion Loss Summary			
Property Line	**Preliminary Barrier Insertion Loss Estimate**		
	Predicted Noise Level	**Barrier Attenuation**	**Noise Level with Barrier**
PL - West (South)	57.6	10.4	47.2
PL - West (mid)	57.6	9.0	48.6
PL - North (west)	57.6	7.7	49.8
PL - North (mid)	57.6	5.2	52.4
PL - North (mid, 8 ft)	57.6	7.7	49.9
PL - North (mid, 34 ft)	54.9	5.1	49.8
PL - North (east)	57.6	5.6	52.0
PL - North (east, 8 ft)	57.6	8.4	49.2
PL - North (east, 34 ft)	54.9	5.5	49.4

Table 4: Barrier Attenuation 6-Foot High Wall (West -South)								
Receptor	**A**	**B**	**C**	**D**	**D1**	**D2**	**H1**	**H2**
Property Line	25.18	7.07	30.07	30	25	5	2.0	5.0

Table 5: Fresnel Number (N_0) and Barrier Insertion Loss Estimate (West - South)				
Receptor	**δ (Feet)**	**λ (Feet)**	**N_0**	**Insertion Loss (dB)**
Property Line	2.18	9.00	0.4853	10.4

Table 6: Barrier Attenuation 6-Foot High Wall (West - Mid)								
Receptor	**A**	**B**	**C**	**D**	**D1**	**D2**	**H1**	**H2**
Property Line	25.18	6.22	30.01	30	25	5	0.7	3.7

Table 7: Fresnel Number (N_0) and Barrier Insertion Loss Estimate (West - Mid)				
Receptor	**δ (Feet)**	**λ (Feet)**	**N_0**	**Insertion Loss (dB)**
Property Line	1.39	9.00	0.3092	9.0

Table 8: Barrier Attenuation 6-Foot High Wall (North - West)								
Receptor	**A**	**B**	**C**	**D**	**D1**	**D2**	**H1**	**H2**
Property Line	25.18	5.68	30.00	30	25	5	-0.3	2.7

Table 9: Fresnel Number (N_0) and Barrier Insertion Loss Estimate (North - West)				
Receptor	**δ (Feet)**	**λ (Feet)**	**N_0**	**Insertion Loss (dB)**
Property Line	0.86	9.00	0.1912	7.7

Table 10: Barrier Attenuation 6-Foot High Wall (North - Mid)								
Receptor	**A**	**B**	**C**	**D**	**D1**	**D2**	**H1**	**H2**
Property Line	25.18	5.00	30.13	30	25	5	-2.8	0.2

Table 11: Fresnel Number (N_0) and Barrier Insertion Loss Estimate (North - Mid)				
Receptor	**δ (Feet)**	**λ (Feet)**	**N_0**	**Insertion Loss (dB)**
Property Line	0.05	9.00	0.0118	5.2

Table 12: Barrier Attenuation 8-Foot High Wall (North - Mid)								
Receptor	**A**	**B**	**C**	**D**	**D1**	**D2**	**H1**	**H2**
Property Line	25.50	5.46	30.13	30	25	5	-2.8	2.2

Table 13: Fresnel Number (N_0) and Barrier Insertion Loss Estimate (North - Mid)				
Receptor	**δ (Feet)**	**λ (Feet)**	**N_0**	**Insertion Loss (dB)**
Property Line	0.83	9.00	0.1838	7.7

Table 14: Barrier Attenuation 6-Foot High Wall, 34-foot Setback (North - Mid)								
Receptor	**A**	**B**	**C**	**D**	**D1**	**D2**	**H1**	**H2**
Property Line	34.13	5.00	39.10	39	34	5	-2.8	0.2

Table 15: Fresnel Number (N_0) and Barrier Insertion Loss Estimate (North - Mid)				
Receptor	**δ (Feet)**	**λ (Feet)**	**N_0**	**Insertion Loss (dB)**
Property Line	0.04	9.00	0.0079	5.1

Table 16: Barrier Attenuation 6-Foot High Wall (North - East)								
Receptor	**A**	**B**	**C**	**D**	**D1**	**D2**	**H1**	**H2**
Property Line	25.18	5.06	30.08	30	25	5	-2.2	0.8

Table 17: Fresnel Number (N_0) and Barrier Insertion Loss Estimate (North - East)

Receptor	δ (Feet)	λ (Feet)	N_0	Insertion Loss (dB)
Property Line	0.16	9.00	0.0361	5.6

Table 18: Barrier Attenuation 8-Foot High Wall (North - East)								
Receptor	**A**	**B**	**C**	**D**	**D1**	**D2**	**H1**	**H2**
Property Line	25.50	5.73	30.08	30	25	5	-2.2	2.8

Table 19: Fresnel Number (N_0) and Barrier Insertion Loss Estimate (North - East)				
Receptor	**δ (Feet)**	**λ (Feet)**	**N_0**	**Insertion Loss (dB)**
Property Line	1.15	9.00	0.2545	8.4

Table 20: Barrier Attenuation 6-Foot High Wall, 34-foot Setback (North - East)								
Receptor	**A**	**B**	**C**	**D**	**D1**	**D2**	**H1**	**H2**
Property Line	34.13	5.06	39.06	39	34	5	-2.2	0.8

Table 21: Fresnel Number (N_0) and Barrier Insertion Loss Estimate (North - East)				
Receptor	**δ (Feet)**	**λ (Feet)**	**N_0**	**Insertion Loss (dB)**
Property Line	0.13	9.00	0.0297	5.5

Madera at Citrus Trail Residential Project
Wabash Avenue and Colton Avenue, Redlands, CA
Attachment 03: On-site HVAC Noise and Barrier Attenuation Estimates

Sheet 4: Noise Compatibility Estimates

Table 1: Existing and Future Traffic Noise Levels

Road	General Plan Traffic Noise Level 50 Feet from Outermost Lane (CNEL)	Distance to Rear Yard or Building Façade	Estimated Traffic Noise Level at Rear Yard or Building Façade (CNEL)
Wabash Ave - Ex Yrd	59.4	40.0	60.4
Wabash Ave - Future Yrd	61.2	40.0	62.2
Wabash Ave - Future Bldg	61.2	50.0	61.2
Colton Ave - Ex Yrd	63.2	48.0	63.4
Colton Ave - Future Yrd	64.3	48.0	64.5
Colton Ave - Future Bldg	64.3	58.0	63.7

Table 2: Source/ Property Line Receiver Information					
Noise Source:	Traffic				
Source Noise Level:	PL=	62.2	Wabash	64.5	Colton
Receptor Noise Level:	PL=	60.0			
Noise Reduction Level:	PL=	2.2	Wabash	4.5	Colton
Source Frequency:	500	Hertz			

Note: "PL" = Property Line

Table 3: Source, Receptor, and Barrier Elevation Data

Receptor	Elevation Above Mean Sea Level					
	Receiver Grade	Receiver Height	Source Grade	Effective Source Height	Barrier Grade	Top of Barrier
Wabash Rear Yard 1	1615.0	1620.0	1614.5	1619.5	1615.0	1621.0
Wabash Rear Yard 2	1614.0	1619.0	1614.5	1619.5	1614.0	1620.0
Wabash Rear Yard 3	1613.0	1618.0	1614.5	1619.5	1613.0	1619.0
Colton Rear Yard 1	1612.0	1617.0	1612.0	1617.0	1612.0	1618.0
Colton Rear Yard 2	1609.0	1614.0	1609.0	1614.0	1609.0	1615.0
Colton Rear Yard 3	1606.0	1611.0	1606.0	1611.0	1606.0	1612.0

Table 4: Barrier Insertion Loss Summary

Property Line	Preliminary Barrier Insertion Loss Estimate		
	Predicted Noise Level	Barrier Attenuation	Noise Level with Barrier
Wabash Rear Yard 1	62.2	6.7	55.5
Wabash Rear Yard 2	62.2	6.4	55.8
Wabash Rear Yard 3	62.2	6.0	56.2
Colton Rear Yard 1	64.5	6.5	58.0
Colton Rear Yard 2	64.5	6.5	58.0
Colton Rear Yard 3	64.5	6.5	58.0

Table 5: Barrier Attenuation 6-Foot High Wall (Wabash Rear Yard 1)

Receptor	A	B	C	D	D1	D2	H1	H2
Property Line	40.03	5.10	45.00	45	40	5	-0.5	1.0

Table 6: Fresnel Number (N_0) and Barrier Insertion Loss Estimate (Wabash Rear Yard 1)

Receptor	δ (Feet)	λ (Feet)	N_0	Insertion Loss (dB)
Property Line	0.12	2.30	0.10814	6.7

Table 7: Barrier Attenuation 6-Foot High Wall (Wabash Rear Yard 2)								
Receptor	A	B	C	D	D1	D2	H1	H2
Property Line	25.00	5.10	30.00	30	25	5	0.5	1.0

Table 8: Fresnel Number (N_0) and Barrier Insertion Loss Estimate (Wabash Rear Yard 2)				
Receptor	δ (Feet)	λ (Feet)	N_0	Insertion Loss (dB)
Property Line	0.10	2.30	0.08683	6.4

Table 9: Barrier Attenuation 6-Foot High Wall (Wabash Rear Yard 3)								
Receptor	A	B	C	D	D1	D2	H1	H2
Property Line	25.00	5.10	30.04	30	25	5	1.5	1.0

Table 10: Fresnel Number (N_0) and Barrier Insertion Loss Estimate (Wabash Rear Yard 3)				
Receptor	δ (Feet)	λ (Feet)	N_0	Insertion Loss (dB)
Property Line	0.07	2.30	0.05786	6.0

Table 11: Barrier Attenuation 6-Foot High Wall (Colton Rear Yard 1)								
Receptor	A	B	C	D	D1	D2	H1	H2
Property Line	48.01	5.10	53.00	53	48	5	0.0	1.0

Table 12: Fresnel Number (N_0) and Barrier Insertion Loss Estimate (Colton Rear Yard 1)				
Receptor	δ (Feet)	λ (Feet)	N_0	Insertion Loss (dB)
Property Line	0.11	2.30	0.09516	6.5

Table 13: Barrier Attenuation 6-Foot High Wall (Colton Rear Yard 2)								
Receptor	A	B	C	D	D1	D2	H1	H2
Property Line	48.01	5.10	53.00	53	48	5	0.0	1.0

Table 14: Fresnel Number (N_0) and Barrier Insertion Loss Estimate (Colton Rear Yard 2)				
Receptor	δ (Feet)	λ (Feet)	N_0	Insertion Loss (dB)
Property Line	0.11	2.30	0.09516	6.5

Table 15: Barrier Attenuation 6-Foot High Wall (Colton Rear Yard 3)								
Receptor	A	B	C	D	D1	D2	H1	H2
Property Line	48.01	5.10	53.00	53	48	5	0.0	1.0

Table 16: Fresnel Number (N_0) and Barrier Insertion Loss Estimate (Colton Rear Yard 3)				
Receptor	δ (Feet)	λ (Feet)	N_0	Insertion Loss (dB)
Property Line	0.11	2.30	0.09516	6.5

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Attachment 04

Groundborne Vibration Estimates

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Madera at Citrus Trail Residential Development
Wabash Avenue and Colton Avenue, Redlands, CA

Attachment 03: On-site HVAC Noise and Barrier Attenuation Estimates
Prepared by: MIG, Inc.
July 2023

Contents:

Madera at Citrus Trail Residential Project
Wabash Avenue and Colton Avenue, Redlands, CA
Attachment 04: Construction Vibration Estimates

Sheet 1: Construction Vibration Estimates

Table 1: Typical Peak Particle Velocity (PPV) Estimates (in/sec) - Equipment at Top of Bluff

Equipment	Reference PPV at 25 ft (in/sec)	Soil Attenuation Rate (n)	Estimated PPV (in/sec) at Specified Distance from Source (in feet)								
			50	100	130	150	200	250	300	350	400
Small bulldozer	0.003	1.1	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Jackhammer	0.035	1.1	*0.016*	0.008	0.006	0.005	0.004	0.003	0.002	0.002	0.002
Large bulldozer	0.089	1.1	*0.042*	*0.019*	*0.015*	*0.012*	0.009	0.007	0.006	0.005	0.004
Vibratory roller	0.210	1.1	*0.098*	*0.046*	*0.034*	*0.029*	*0.021*	*0.017*	*0.014*	*0.012*	0.010

Notes:
Reference PPV from Caltrans Transportation and Construction Vibration Guidance Manual (2020), Table 18
Soil attenuation rate from Caltrans (2020, Table 17). Assumes Soil Class III - hard soils.
Italicized values indicate the estimated vibration level exceeds City of Redlands vibration perception threshold (0.01 PPV in/sec).