APPENDIX 3.4-A: NOISE AND VIBRATION MITIGATION GUIDELINES

CALIFORNIA HIGH-SPEED RAIL AUTHORITY

PROGRAM DELIVERY OFFICE BULLETIN

BULL-ENV-02

Effective Date: December 14, 2018

Approved By:

Mark A. McLoughlin
Authority Director of
Environmental Services

December 14, 2018
Approval Date

N/A
Expiration Date

SUBJECT: Updated Noise Mitigation Guidance; Cost for Benefited Residence

References:

1. **Merced to Fresno Draft Environmental Impact Report/Environmental Impact Statement (August 2011)** http://www.hsr.ca.gov/docs/programs/merced-fresno-eir/drft_EIR_MerFres_Vol2_3_4a.pdf

2. **Fresno to Bakersfield Draft Environmental Impact Report/Environmental Impact Statement (August 2011)** http://www.hsr.ca.gov/docs/programs/fresno-baker-eir/drft_EIR_FresBaker_Vol2_3_4a.pdf

3. **California Department of Transportation (Caltrans) Environmental Noise and Vibration** http://www.dot.ca.gov/env/noise/

4. **Updated Noise Mitigation Guidance; Cost for Benefited Residence (April 2017)**

Background

Consistent with an approach used by the California Department of Transportation (Caltrans), the Authority in 2011 adopted criteria to determine the reasonableness of building noise barriers to mitigate severe noise impacts associated with operation of the train. In that guidance, the Authority specified it would build a barrier if the cost range was within $55,000 (2010$) per benefited residence. This amount was consistent with the 2010 Caltrans allowance.

Existing Practice:

To maintain consistency with Caltrans, the Authority's Noise Mitigation Guidelines was updated in April 2017, indicating it would build a barrier if the cost range was within $92,000 (2017$).

New Practice:

Based on the annual construction price index, Caltrans has updated its policy and increased the cost allowance to $95,000 (2018$). Thus, the Authority's guidelines have been amended to use this new cost allowance. They also require that the reasonable allowance be calculated using the Caltrans base cost allowance in effect at the time of implementation of the noise mitigation measure. The Authority's regional consultants are to also use the most recently published Caltrans price index when preparing their noise and vibration analyses. For future work, the regional consultants shall use the most recently published Caltrans price index when preparing their noise and vibration analyses.

Contact:

For general questions regarding this document, please contact Mark McLoughlin, Director of Environmental Services (Mark McLoughlin@hsr.ca.gov.)

Memorandum

DATE: December 14, 2018

TO: Regional Consultants (RCs) and Engineering and Environmental Consultants (EECs)

FROM: Bryan Porter and Rob Greene

CC: Scott Rothenberg and Vera Bezdicek

SUBJECT: Updated Noise and Vibration Mitigation Guidance; Cost for Benefited Residence

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Consistent with an approach used by the California Department of Transportation (Caltrans), the California High-Speed Rail Authority (Authority) in 2011 adopted criteria to determine the reasonableness of constructing noise barriers to mitigate severe noise impacts associated with operation of the train. In that guidance, the Authority specified it would build a noise barrier if it cost no more than $55,000 (2010$) per benefited residence. This amount was consistent with the 2010 Caltrans allowance. Based on the annual construction price index, Caltrans updated its policy (February 2018) and increased the cost allowance to $95,000 (2018$). For future work, the regional teams shall use the most recently published Caltrans price index when preparing their noise and vibration analyses.

For continued consistency with Caltrans, the Authority's updated its Noise Mitigation and Vibration Guidelines to state that the "reasonable allowance for the noise barriers will be calculated using the Caltrans base cost allowance in effect at the time of implementation of the noise mitigation measure." This version supersedes earlier guidance first issued in 2011 and revised in April 2017.

Should you have any questions, please contact Bryan Porter at Bryan.Porter@hsr.ca.gov or Rob Greene at Rob.Greene@wsp.com.

Attachment:
Authority Noise and Vibration Mitigation Guidelines (Rev. 12/2018)

Attachment

Noise and Vibration Mitigation Guidelines (Rev. 12/2018)

In general, noise mitigation must be considered when impacts are identified. Mitigation guidelines for the three impact categories identified by the Federal Railroad Administration (FRA) are as follows:

- No Impact: No mitigation required.
- Moderate Impact: Mitigation may be considered at the discretion of the California High-Speed Rail Authority (Authority), and implementation will be subject to reasonable project-specific factors related to effectiveness, cost, density, and proximity of sensitive receivers.
- Severe Impact: Consideration of mitigation is required if impacts cannot be avoided. The Authority will take steps to reduce noise substantially through mitigation measures that are reasonable, physically feasible, practicable, and cost-effective.

Mitigation of Severe Noise Impacts

The Authority will examine alternatives to avoid, minimize, or mitigate severe noise impacts. If severe noise impacts cannot be avoided, then the Authority will take steps to reduce severe noise substantially through mitigation measures that are reasonable, physically feasible, practicable, and cost-effective. The following criteria will be used for evaluating the reasonableness of noise barriers as mitigation for severe noise impacts:

- The calculations and computations for barrier geometry as stated in Table 5-3 of *FRA's High- Speed Noise and Vibration Assessment* will be used.
- The amount of increase over existing noise levels will be considered.
- Number of noise-sensitive sites affected will be considered.
- The minimum number of affected sites should be 10, and the length of a noise barrier should be at least 800 feet unless there are special circumstances that will be studied on a case-by-case basis.
- Barrier heights up to a maximum of 14 feet will be considered. Mitigation options for areas that require barriers over 14 feet will be studied on a case-by-case basis.
- The "reasonable allowance" for the noise barriers is calculated using the Caltrans base cost allowance for the current year, which is published at http://www.dot.ca.gov/hq/env/noise/.
- The community should approve implementation of the recommended noise barriers (75% of all affected parties).

Section 4(f) and Section 106 properties with severe or moderate noise impacts, for which quiet is an expected condition or is a character-defining feature of the property, may require mitigation. These properties will not be subject to these guidelines, and will be evaluated on a case-by-case basis.

Substantial Noise Reduction

A minimum outdoor noise reduction of 5 decibels (dBA) using the applicable criterion for the property is considered substantial.

Reasonable

Reasonableness implies that good judgment and common sense have been applied during the decision-making process. Reasonableness is determined based on several factors listed below regarding the individual circumstances and the specific needs of affected receivers.

Physically Feasible

Noise mitigation measure must be designed, constructed, installed, or implemented in compliance with structural requirements related to ground conditions, wind loading, seismic risk, safety considerations, accessibility, material maintainability and longevity, and applicable engineering design practices and technology. Noise mitigation measures must not result in an adverse environmental impact, such as significant visual intrusions, blocked views, or adverse effects to a historical site.

Noise barriers are the most common noise mitigation measure. The maximum noise barrier height is 14-feet above top-of-rail for at-grade sections; however, all noise barriers should be designed to be as low as practicable while still achieving the optimum noise reduction. Berm and berm/barrier combinations are the preferred types of noise barriers where space and other environmental constraints permit.

On aerial structures, the maximum noise barrier height is also 14 feet above top-of-rail. However, the barrier material would be limited by engineering restrictions for any barriers built on the structure. Noise barriers on the aerial structure should still be designed to be as low as practicable to achieve the optimum noise level reduction.

In certain configurations, noise reflecting off reflective noise barriers (i.e., noise barriers constructed of noise-reflective materials) or structures can degrade the noise barriers' performance or cause noise increases in areas not protected by the barriers. To avoid this effect, the Authority's policy is that where appropriate barriers be provided which have an acoustically absorptive surface (typically with a noise reduction coefficient of 0.80 or greater) under either of the following conditions:

- The ratio of the spacing between new parallel barriers or retaining walls and the average height of the barriers or walls is 15:1 or less.
- Receptors on one side of the tracks have a direct line of sight from an area of frequent human use that would benefit from a lowered noise level to a new barrier or new retaining wall on the opposite side of the tracks. For comparison with the reasonable allowance for barrier construction, the cost of implementing an absorptive surface that is triggered by either of the conditions described above shall not be included in the cost of the abatement.

Visual Effects

Noise mitigation measures must be designed, constructed, installed, and implemented to avoid adverse impacts to the visual resources in the area. Noise barriers will consist of a solid barrier no more than 6-feet tall. Above 6 feet, the noise barrier will be made of transparent materials. For example, a 13-foot-high noise barrier would consist of 6 feet of solid material on the bottom topped by 7 feet of transparent material.

For Section 106 properties, the design of the barrier will be determined in consultation with the SHPO and consulting parties that have a demonstrated interest in the historic property.

Cost Effectiveness

Two factors are required to determine cost effectiveness of noise barriers: the unit construction cost and the number of benefited receptors.[1] Currently, the cost for constructing a noise barrier along the at-grade portion of the alignment is estimated to be $70.00 per square foot, and the cost to construct a noise barrier along the elevated portion of the alignment is $65.00 per square foot. The total cost of mitigation cannot exceed $95,000[2] per benefitted receiver. This cost is determined by dividing the total cost of the noise barrier mitigation measure by the number of noise-sensitive dwellings that receive a substantial outdoor noise reduction. This calculation will generally limit the use of mitigation in rural areas that have few and/or isolated residential dwellings. If the density of residential dwellings is insufficient to make the mitigation measure cost-effective, then other noise abatement measures, such as noise insulation or less tall and less long "local" noise barriers, will be considered on a case-by-case basis. If noise insulation is identified as an alternative mitigation measure, the treatment must provide a substantial increase in noise reduction (i.e., 5 dBA or greater) between the outside and inside noise levels for interior habitable rooms. A "local" noise barrier shall provide substantial noise reduction and be cost-reasonable.

Mitigation Parameters

- Prior to operation of the high-speed rail, the Authority will install noise barriers where justified and they can achieve between 5 and 15 dBA of noise reduction, depending on their height and location relative to the tracks. The primary requirements for an effective noise barrier are that the barrier must (1) be high enough and long enough to break the line-of-sight between the noise source and the receiver, (2) be of a noise-impervious material with a minimum surface density of approximately 4 pounds per square foot, and (3) not have any gaps or holes between the panels or at the panel bottom. Because many materials meet these requirements, aesthetics, durability, cost, and maintenance considerations usually determine the selection of materials for noise barriers. Typically, local jurisdictions provide input during selection of noise barriers style to reduce the visual effect of barriers on adjacent lands uses, because noise barriers can be visually intrusive. For example, noise barriers maybe solid or transparent, and can be made using various colors, materials, and surface treatments.

- The Authority will work with communities to identify how the use and height of noise barriers would be determined using jointly developed performance criteria. Other solutions may result in more residual impacts than reported. Options may be to reduce the height of noise barriers and combine barriers with noise insulation or to accept higher noise thresholds than the FRA's current noise thresholds.

- If noise barriers are not proposed or do not reduce noise levels to below a severe impact level, then noise insulation can be installed in buildings. Noise insulation of residences and institutional buildings to improve the outdoor-to-indoor noise reduction is a mitigation measure that can be provided when the use of noise barriers is not feasible or would not provide a reasonable level (5 to 7 dB) of noise reduction. Although this approach has no effect on noise in exterior areas, it may be the best choice for sites where noise barriers are not feasible or desirable and for buildings where indoor sensitivity is

[1] The unit construction cost for high-speed rail noise barriers is based on an evaluation of the special design requirements established by the California High-Speed Rail Authority policy regarding noise barrier mitigation. The typical base cost for transportation noise abatement screen-wall type barriers is available from the Federal Highway Administration's national inventory of noise barriers, Caltrans, qualified barrier manufacturers, and construction cost historical databases. These sources in (2016/2017 dollars) were used to estimate probable costs per square foot for typical high-speed rail noise barriers that incorporate opaque and transparent materials. The estimate of probable costs for barriers that have special requirements (e.g., special foundations, highly curved sections, higher-than-standard height) should be evaluated individually.

[2] Using the Caltrans base cost allowance for the current year to calculate the "reasonable allowance" for noise barriers.

of greatest concern. Substantial improvements in building noise insulation (on the order of 5 to 10 dB) can often be achieved by adding an extra layer of glazing to windows, by sealing holes in exterior surfaces that act as noise leaks, and by providing forced ventilation and air conditioning so that windows do not need to be opened. Performance criteria would be established to balance existing noise events and ambient roadway noise conditions as factors for determining mitigation measures. For Section 106 properties, any noise insulation applied directly to the property will be designed in consultation with the SHPO and consulting parties, and will follow the Secretary of the Interior's Standards for the Treatment of Historic Properties.

- If noise barriers or noise insulation would not effectively mitigate severe noise impacts, the Authority can acquire easements on the affected properties. Another option for mitigating noise impacts is for the Authority to acquire easements on residences likely to be affected by high-speed rail operations in which the homeowners would accept the future noise conditions. This approach is usually taken only in isolated cases where other mitigation options are infeasible, impractical, or too costly.
- The decision to include mitigation assessments may depend on factors such as the number of noise-sensitive sites affected, the relative increase in noise levels, the sensitivity at affected land uses, the effectiveness of mitigation measures, community views, costs versus benefits, design limitations, whether noise-sensitive use is solely indoors, and safety. For example, where land-use activity is solely indoors, an interior Ldn (i.e., day-night average sound level) criterion of 45 dBA from project sources is recommended to determine whether building noise insulation improvements should be considered for mitigation.

Such mitigation measures should be included in the Authority's Division of Real Property appraisals as a cost to cure through physical modifications to the improvement or the purchase of noise easements, as appropriate.

Federal Transit Administration (FTA)/ Federal Railroad Administration (FRA) Construction Noise Mitigation

1. Design considerations and project layout:
    - Construct noise barriers, such as temporary barriers or piles of excavated material, between noisy activities and noise-sensitive receivers.
    - Route truck traffic away from residential streets, if possible. Select streets with the fewest homes, if no alternatives are available.
    - Locate equipment on the construction lot as far away from noise-sensitive sites as possible.
    - Construct walled enclosures around especially noisy activities or around clusters of noisy equipment. For example, shields can be used around pavement breakers and loaded vinyl curtains can be draped under elevated structures.
2. Sequence of operations:
    - Combine noisy construction operations so they occur in the same time period. The total noise level produced will not be significantly greater than the level produced if the operations were performed separately.
    - Avoid nighttime activities. Sensitivity to noise increases during the nighttime hours in residential neighborhoods.

3. Alternative construction methods:

   - Avoid impact pile driving where possible in noise-sensitive areas. Drilled piles or the use of a sonic or vibratory pile driver are quieter alternatives where the geological conditions permit their use.
   - Use specially quieted equipment, such as quieted and enclosed air compressors, and mufflers on all engines.
   - Select quieter demolition methods, where possible. For example, sawing bridge decks into sections that can be loaded onto trucks results in lower overall noise levels than impact demolition by pavement breakers.
   - The environmental assessment should include a description of one or more mitigation approach for each affected location.

FTA / FRA Construction Vibration Mitigation

1. Design considerations and project layout:

   - Route heavily loaded trucks away from residential streets, if possible. Select streets with fewest homes, if no alternatives are available.
   - Operate earthmoving equipment on the construction lot as far away from vibration-sensitive sites as possible.

2. Sequence of operations:

   - Phase demolition, earthmoving, and ground-impacting operations so as not to occur in the same time period. Unlike noise, the total vibration level produced could be significantly less when each vibration source operates separately.
   - Avoid nighttime activities. People are more aware of vibration in their homes during the nighttime hours.

3. Alternative construction methods:

   - Avoid impact pile driving where possible in vibration-sensitive areas. Drilled piles or the use of a sonic or vibratory pile driver causes lower vibration levels where the geological conditions permit their use.
   - Select demolition methods not involving impact, where possible. For example, sawing bridge decks into sections that can be loaded onto trucks results in lower vibration levels than impact demolition by pavement breakers, and milling generates lower vibration levels than excavation using clam shell or chisel drops.
   - Avoid vibratory rollers and packers near sensitive areas.

Construction Noise and Vibration Mitigation Guidelines

All construction activities in this report were analyzed in terms of their noise impacts based on FRA recommended guidelines. Many local jurisdictions provide construction noise exempt times where the FRA guidelines are followed. Most construction would be conducted during these construction noise exempt times. However, when construction is conducted outside of the construction noise exempt times, construction noise must abide by local noise standards or absent local standards, follow FRA/FTA

guidelines. Proper mitigation may be necessary to avoid noise impacts at nearby noise-sensitive receivers.

Pile driving activities conducted during the grade separation and elevated track structure construction phases would be the loudest noise-generating activity during construction. Residences within 410 feet of grade separation construction activities that include pile driving, or within 430 feet of elevated track structure construction activities that include pile driving, would be exposed to noise levels greater than the 80 dBA Leq (equivalent continuous noise level) threshold.

Piles that are required for structure along the high-speed train corridor that would be located within 500 feet of a noise-sensitive receiver should be installed using the drilling and casing method.

If the drilling and casing method is used, maximum noise levels associated with construction activities would drop by 11 dB, and the distances to the 80 dBA Leq contour would decrease from 410 feet to 180 feet for grade separation construction activities, and decrease from 430 feet to 220 feet for elevated track structure construction activities. Another method to mitigate noise related to pile driving is the use of an augur to install the piles instead of a pile driver which would reduce noise levels. If pile driving is necessary, the time of day during which the activity occurs will be limited.

The most effective way to minimize the impact of construction noise during the development of the project is to enforce the time restrictions for the hours of construction as listed in local noise ordinances. It is important for the design engineer to plan the order of operations during construction so that the noise levels resulting from construction operations will not exceed local noise ordinances or those recommended by the FRA. To avoid unnecessary annoyance from construction noise, the following best practices for construction noise control should also be considered for inclusion in construction contract documents:

- All noise-producing project equipment and vehicles using internal combustion engines shall be equipped with mufflers and air-inlet silencers, where appropriate, in good operating condition that meet or exceed original factory specifications. Mobile or fixed "package" equipment (e.g., arc-welders, air compressors) shall be equipped with shrouds and noise control features that are readily available for that type of equipment.
- All mobile or fixed noise-producing equipment that is regulated for noise output by a local, state, or federal agency, shall comply with such regulation during project activity.
- Material stockpiles and mobile equipment staging, parking, and maintenance areas shall be located as far as practicable from noise-sensitive receivers.
- Material stockpiles should be used to block line of site to nearby noise-sensitive receivers when possible.
- Locate fixed noise-generating equipment as far from noise-sensitive land uses as is practical.
- Limit the loudest construction activities, such as concrete breaking and jack hammering, to the middle of the day when the sensitivity to such noises will be minimal. Noise-producing signals, including horns, whistles, alarms, and bells shall be used for safety warning purposes only.
- No project-related public address or music system shall be audible at any adjacent receiver.
- The contractor shall create and initiate a construction noise monitoring plan to ensure the construction noise levels at the nearest noise-sensitive land uses are within the limits of the noise regulations.
- Avoid nighttime construction in residential neighborhoods.

- During nighttime work, use smart back-up alarms, which automatically adjust the alarm level based on the background noise level, or broadband sound back-up alarms, or switch off back-up alarms and replace with spotters.
- Re-route construction-related truck traffic along roadways that will cause the least disturbance to residents.
- Implement noise-reducing measures, such as resilient liners for truck loading and operations.
- Minimize the use of generators to power equipment and use commercial power where possible.
- Grade surface irregularities on construction sites.
- Consider using temporary noise barriers where project activities and equipment are unavoidably close to noise-sensitive receivers.
- Use on-site trailers and containers as temporary barriers between any fixed construction noise source and nearby noise-sensitive receivers.
- All workers involved with the construction of this project must be protected from excessive noise exposure as mandated by the California Occupational Safety and Health Administration (Cal/OSHA), which has regulated worker noise exposure to a time-weighted-average of 90 dBA over an 8-hour work shift. Areas where levels exceed 85 dBA must be designated and labeled as high-noise-level areas where hearing protection is required.

Construction Vibration Mitigation

After locating construction activities that would have potential vibration impacts as described above, mitigation may still be necessary to ensure that there will be no vibration impacts at sensitive receivers. Changes in the design and project layout, changes in the sequence of operations, and using alternative construction methods are all available vibration mitigation options.

When the engineers design the project and the layout of the project, heavily loaded trucks can be re-routed away from residential streets and onto streets with fewer homes. Earthmoving equipment on the construction lot should also be operated as far as possible from sensitive receivers. Changes in the sequence of operations can also mitigate vibration impacts at sensitive receivers. Construction activities that cause high levels of vibration should be staggered so that multiple sources of vibration are not occurring at once. Nighttime construction activities should also be avoided. Alternative construction methods are also an acceptable vibration mitigation option. If pile driving does occur, impact pile driving should be avoided near vibration-sensitive areas. A sonic or vibratory pile driver will generate lower vibration levels at sensitive receivers. Demolition methods not involving impacts should be used when possible. The utilization of vibratory rollers and packers should be avoided near vibration-sensitive receivers.

Historic properties adjacent to construction activities may have pre-construction conditions assessments that find that a building may be susceptible to damage from construction-related activities. Protection measures recommended in the assessment may include structural stabilization, not-to-exceed maximum vibration levels, and vibration monitoring to ensure that construction-related damage is avoided.