WaveEngineering
Acoustics, Noise & Vibration

August 15, 2023

Mr. B. Steven King, AIA, LEED AP
Senior Associate
Perkins & Will
475 Lincoln Street, Suite 100
Denver, CO 80203

Re: CSM Energy & Minerals Research Facility
Wave #2945

Dear Steve,

We have completed our assessment of noise from the Energy & Minerals Research Facility (EMRF) at the Colorado School of Mines in Golden, Colorado. Our original noise assessment for the building was summarized in our report dated June 13, 2023. This report addresses potential ways to mitigate noise from the dust collection systems. Our noise study found that facility met the State of Colorado noise limits, but we were asked to evaluate ways to reduce dust collector noise radiated to the community.

The building is located at 1000 18th Street in Golden, CO.

The following equipment was included in the noise analysis.

- Lab exhaust fans
- General exhaust fans
- Emergency generators
- Dust collectors
- Air-handling units

Again, the intent of this follow up work is to address ways to reduce noise radiated outdoors from the dust collectors.

The analysis is based on the 100% Design Development documents. Sound data for the noise producing equipment was provided by Shaffer Baucom Engineering & Consulting (SBEC).

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Noise Level Prediction Method

Wave Engineering used Datakustik CadnaA noise prediction software to predict the equipment noise levels, with a focus on noise radiated to the residential area across 18th Street to the south. The CadnaA software takes into account sound that radiates from the equipment and the effect of the terrain, buildings, walls, ground conditions, and atmospheric conditions. For the preliminary study, the computer model assumes that all noise receivers are downwind from the equipment. The predictions are done according to the methodology of ISO Standard 9613-2: Acoustics – Attenuation of sound during propagation outdoors, Part 2: General method of calculation. It is an international standard for predicting noise transmission outdoors. The computer model assumes that noise receivers in all directions are downwind from the sources. This is not possible in reality but gives more of worst case prediction.

State of Colorado Noise Statute

We understand that the Colorado School of Mines has committed to meeting the noise limits in the Colorado Revised Statutes Title 25 Article 12 – NOISE ABATEMENT.

Section 25-12-103 sets maximum permissible noise levels. The following is a partial excerpt of the statute.

25-12-103. Maximum permissible noise levels.

(1) Every activity to which this article is applicable shall be conducted in a manner so that any noise produced is not objectionable due to intermittence, beat frequency, or shrillness. Sound levels of noise radiating from a property line at a distance of twenty-five feet or more therefrom in excess of the db(A) established for the following time periods and zones shall constitute prima facie evidence that such noise is a public nuisance:

Zone	***7:00 a.m. to next 7:00 p.m.***	***7:00 p.m. to next 7:00 a.m.***
Residential	*55 db(A)*	*50 db(A)*
Commercial	*60 db(A)*	*55 db(A)*
Light industrial	*70 db(A)*	*65 db(A)*
Industrial	*80 db(A)*	*75 db(A)*

(2) In the hours between 7:00 a.m. and the next 7:00 p.m., the noise levels permitted in subsection (1) of this section may be increased by ten db(A) for a period of not to exceed fifteen minutes in any one-hour period.
(3) Periodic, impulsive, or shrill noises shall be considered a public nuisance when such noises are at a sound level of five (dBA) less than those listed in subsection (1) of this section.

The Colorado School of Mines property is considered a Light Industrial zone for the purposes of the state statute. Since the EMRF equipment can operate 24/7, the nighttime limit of 65 dBA will be used for the purposes of this study.

The 65 dBA limit must be met at points 25′ or more from the campus boundary. The focus of this study is on the residential area south of 18th Street, a point that is 25′ from the CSM campus boundary falls on 18th Street. The campus boundary + 25′ line is shown as a bold Red line in Figure 1 and Figure 2 below.

Please note that if certain equipment produces strong tones at high frequencies, it could be considered "shrill." For shrill noises, the statute states that the limit is 5 dBA less, or 60 dBA. The "shrill" noise term is somewhat subjective and equipment manufacturer's sound data typically does not provide enough information to judge this. However, dust collection equipment can sometimes produce a high pitched "whine" which could be considered shrill. This is one of the reasons that additional mitigation is being evaluated. In the event that a piece of equipment produces shrill noise, it may have to meet a 60 dBA limit rather than the 65 dBA limit.

Noise Prediction Results – Unmitigated

The results of our analysis are shown in Figure 1 and Figure 2. The results may differ slightly from those shown in our Preliminary Assessment Report dated June 13, 2023 due to changes made based on our understanding of the equipment and layouts based on our meeting with the design team on June 15, 2023. The predicted sound levels shown in this report are the same or lower than in the June 13 2023 report. Note that in this current assessment we have assumed the inlets will be ducted on all outdoor dust collectors and the exhausts will be ducted on DC-101A/B, DC-103, and DC-105.

There is an emergency generator near the southwest corner of the USGS building to the west of the EMRF building. Our calculations assumed an 8′ concrete barrier to the south and east of the generator.

Figure 1 shows the results without the emergency generator running.
Figure 2 shows the result with the emergency generator running.

The hatched areas in Figures 1 and 2 represent areas of different noise levels, in 5 dBA increments. For example, the Blue hatched area shows where the sound level is 61-65 dBA. The sound level generally drops as you move away from the EMRF building (and emergency generator). In addition to the hatched areas, Figures 1 and 2 call out the sound levels at two discrete receiver locations. The predicted sound levels do not include ambient noise from traffic or other noise sources in the area. They only show the noise levels from the EMRF facility equipment.

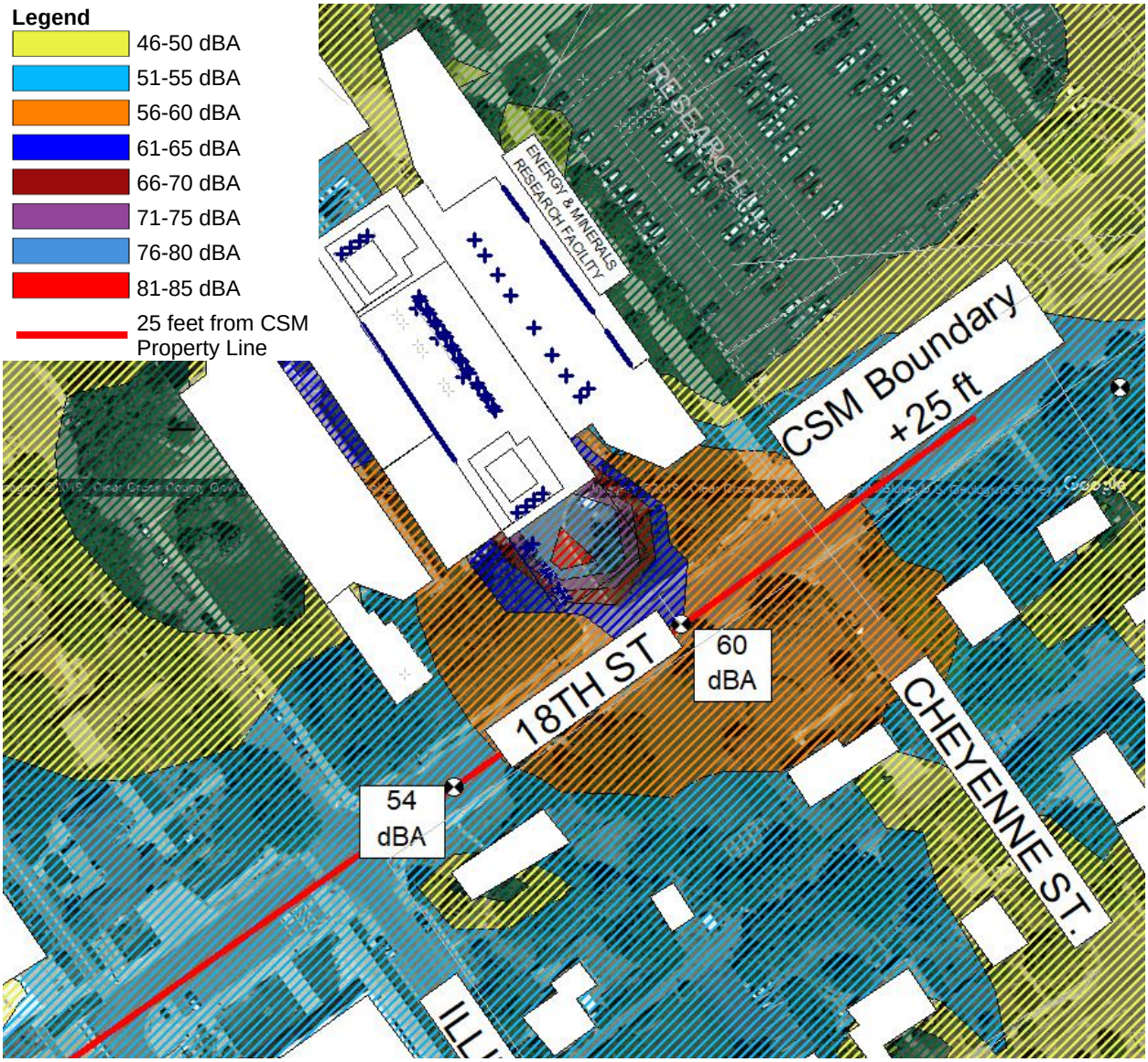

Figure 1: Predicted Noise Levels without Emergency Generator

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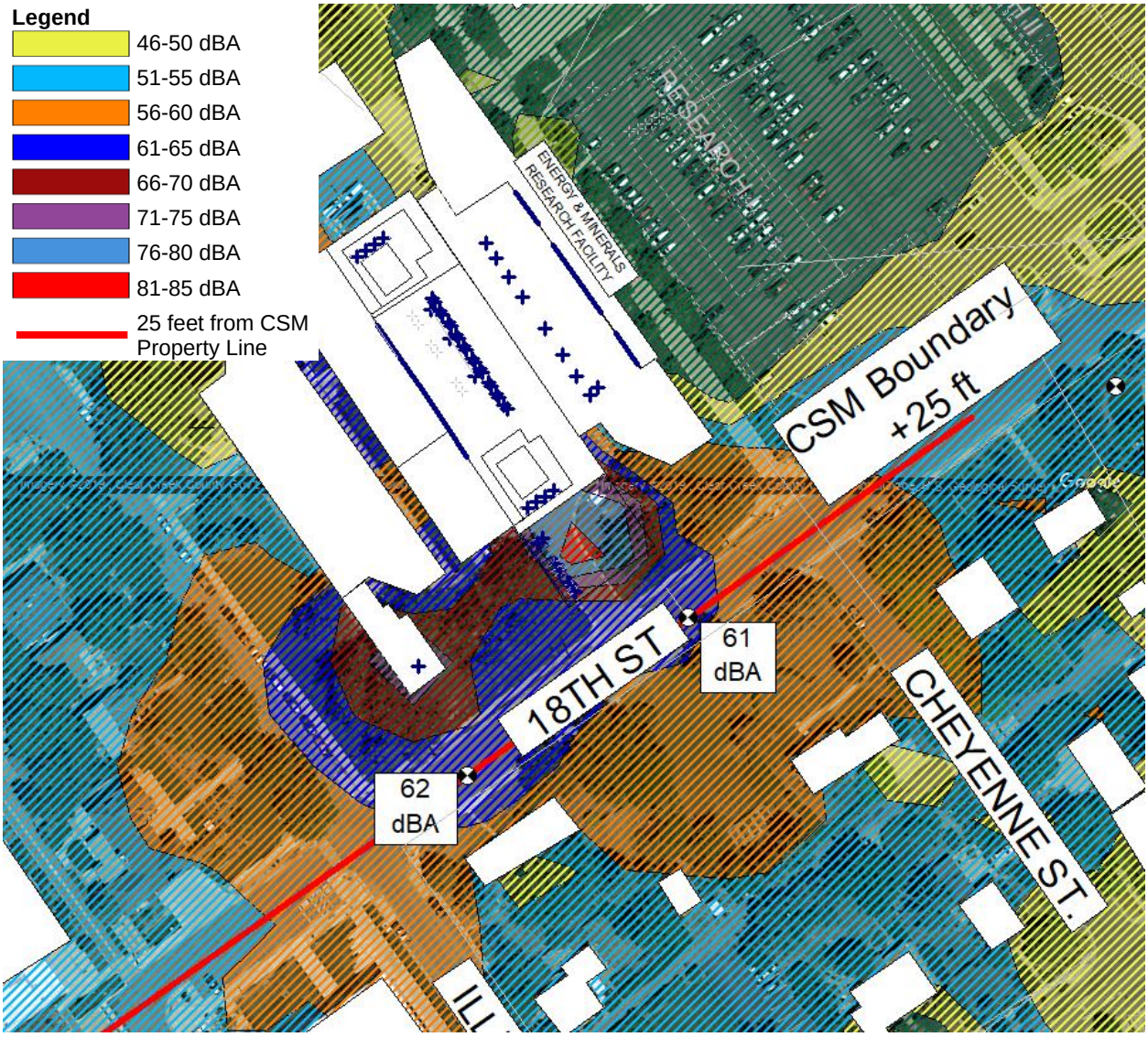

Figure 2: Predicted Noise Levels with Emergency Generator

The noise prediction model shows that the EMRF noise levels are below 65 dBA at all points 25′ beyond the campus boundary to the south of the EMRF.

The EMRF noise levels are 54 to 60 dBA along the property line (+25′) without the emergency generator running, and 61 to 62 dBA with the generator running. This assumes all dust collector inlets are ducted and the exhausts of DC-101A/B, DC-103, and DC-105 are ducted.

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Noise Prediction Results – Dust Collectors Mitigated (optional)

The sound level at all points 25′ beyond the campus boundary to the south of the EMRF is at or below the State nighttime limit of 65 dBA. However, we understand that CSM would like to pursue mitigation measures for the dust collectors. We have worked with the design team to develop mitigation measures to reduce noise from the EMRF dust collectors. They are listed below.

- Ducted inlets on all outdoor dust collectors
- Ducted exhausts on the DC-101A/B, DC-103, and DC-105 dust collectors
- Lagging material on the outdoor dust-collector inlet and exhaust ducts
- Silencers on the DC-104 and DC-106 dust collector exhaust fan discharges

Ducted Dust-Collector Inlets and Exhausts

The duct diameter, length, gauge, and construction (spiral wound versus lock seam duct) affect how loud the duct-breakout noise will be. We made assumptions of these factors. The ducts should be of spiral wound construction. The heavier the gauge, the less the breakout noise will be. Our calculations assumed they will be no lighter than 22 gauge material.

Dust-Collector Inlet and Exhaust Duct Lagging

We used a 1 psf lagging material with a quilted or insulated interior in our calculations. The lagging material should be designed for outdoor applications with performance equivalent to the following:

- Acoustic Blankets by Shannon Global Energy Solutions
- Kinetics KNM-AL lagging (over 1″ thick fiberglass or rockwool insulation)

DC-104 and DC-106 Exhaust Silencers

We used the HP Silencers in our analysis which list a sound pressure level of 74 dBA on the cut sheet provided by SBEC. We are aware a “70 dBA” option exists as well. However, the 74 dBA silencers should be sufficient. See the following section for more comments.

Table and Contours of Results

Table 1 shows the dust collector inlet and exhaust noise levels with and without mitigation.

Figure 3 shows the results without the emergency generator running with mitigation measures in place.

Figure 4 shows the result with the emergency generator running and with all mitigation measures in place.

Table 1: Dust Collector Inlet and Exhaust Noise Levels with and without Mitigation

Source	Noise Level without Lagging or Exhaust Silencers	Noise Level with Lagging and Exhaust Silencers	Difference in Noise Level
DC-104 exhaust	45 dBA	39 dBA	-6 dBA
DC-106 exhaust	38 dBA	41 dBA	+3 dBA*
DC-101B ducted exhaust	47 dBA	29 dBA	-18 dBA
DC-103 ducted exhaust	46 dBA	28 dBA	-18 dBA
DC-101A ducted exhaust	45 dBA	27 dBA	-18 dBA
DC-101B ducted inlet	41 dBA	23 dBA	-18 dBA
DC-105 ducted exhaust	40 dBA	22 dBA	-18 dBA
DC-101A ducted inlet	39 dBA	22 dBA	-18 dBA
DC-103 ducted inlet	37 dBA	20 dBA	-18 dBA
DC-105 ducted inlet	31 dBA	14 dBA	-18 dBA
DC-104 ducted inlet	26 dBA	9 dBA	-18 dBA
DC-106 ducted inlet	22 dBA	4 dBA	-18 dBA

*This increase in noise level is most likely due to the height of the silenced exhaust relative to the barrier height and distance from the barrier.

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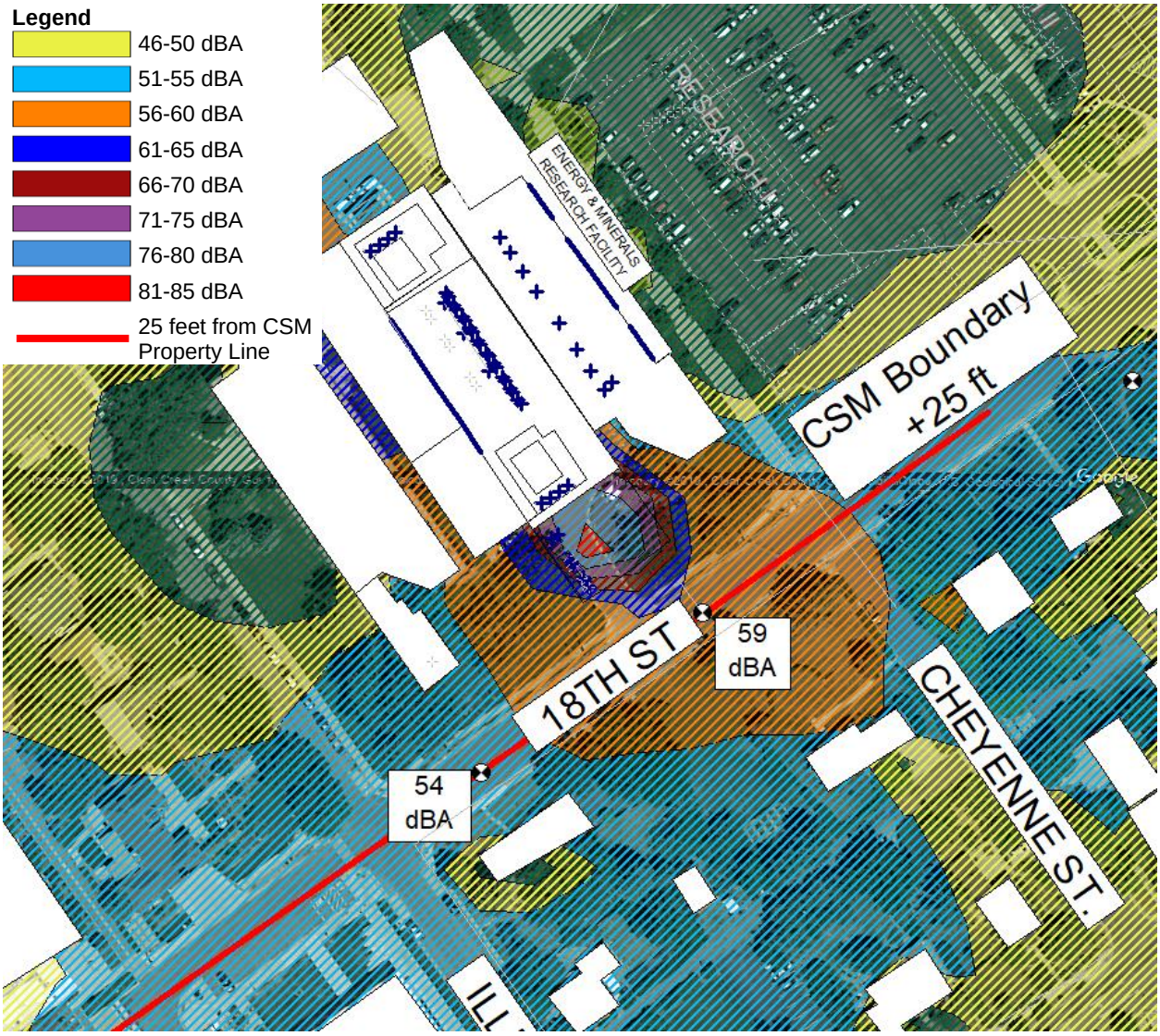

Figure 3: Predicted Noise Levels without Emergency Generator (Dust Collector Mitigation in Place)

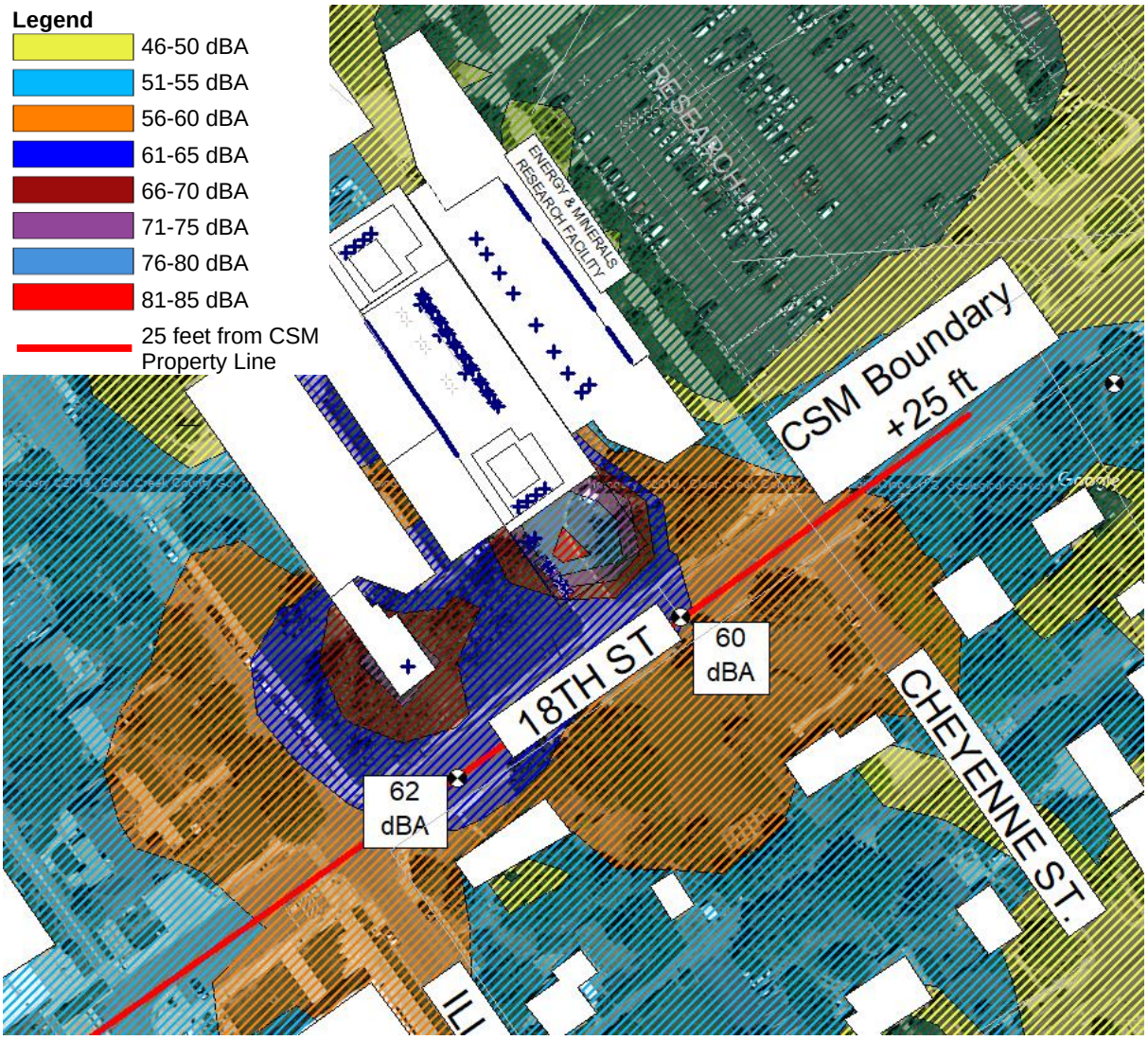

Figure 4: Predicted Noise Levels with Emergency Generator (Dust Collector Mitigation in Place)

The noise prediction model shows that the EMRF noise levels are 54 to 59 dBA along the property line (+25′) without the emergency generator running, and 60 to 62 dBA with the generator running with mitigation measures in place. The overall sound levels are reduced only slightly since other equipment serving the building has not been mitigated, but the dust collector noise reduction is more significant, as shown in Table 1. The results are slightly conservative since we do not have unducted noise levels for the dust collectors.

The noise from the DC-106 exhaust increased slightly with the silencer in place which is likely due to the increased height of the exhaust with the silencer and the dust-collector's proximity to

the barrier. We used a height of 15′ for the exhaust with the silencer per the call on June 15, 2023 which is equal to or taller than the barrier. If the exhaust height will be shorter than the barrier with the silencer in place, it is still advisable. Otherwise, the exhaust silencer on DC-106 is not necessary.

This assumes all equipment running with the exception of the generator.

After the generator and dust collectors, the most dominant noise sources are the EF-601A-D exhaust fans.

Please feel free to contact us if you have any questions or want to discuss this further.

Sincerely,

Iliana Schad
Digitally signed by Iliana Schad
DN: C=US, E=ilianaS@WaveEngineering.US, O=Wave Engineering, CN=Iliana Schad
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