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ACOUSTICS, NOISE & VIBRATION

CALIFORNIA
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WI #16-125

**MEMORANDUM**

3 January 2023

To: Andrew Crabtree, Reena Brilliot, Leah Ruch
Community Development Department, City of Santa Clara

Fr: Sarah Kaddatz, Derek Watry

Re: Levi's Stadium Noise Level Monitoring Project
2022 Concert Noise Levels

## Executive Summary


The community noise levels from three concerts are analyzed in this report: Coldplay, The Weeknd, and Elton John. In addition to using data from the unattended noise monitoring stations installed in the neighborhoods south and east of the Stadium, Wilson Ihrig conducted attended measurements for The Weeknd and Elton John Concerts on 8/27/22 and 10/9/22 respectively.

The noise levels are compared to the target maximum noise exposure level in the Stadium's Development Permit, the concert-noise level predicted for the environmental impact report (EIR), and typical noise levels on days when no events (NFL games, concerts) are held.

The closest noise monitoring station is at Cheeney and Lenox in the neighborhood south of the Stadium. The closest attended measurement location was at 2382 Avenida de Guadalupe (east of the Stadium). The concert noise levels can be summarized as follows:

- Noise levels from the Coldplay concert on 5/15/20 exceeded both the Development Permit target and the concert-noise level predicted for the EIR at the Cheeney and Lenox location.
- Noise levels from The Weeknd concert on 8/27/2022 exceeded the Development Permit target, but did not exceed the concert-noise level predicted for the EIR at the Cheeney and Lenox location. Noise levels also exceeded the Development Permit target at 2382 Avenida De Guadalupe (east of the Stadium).
- Noise levels from the Elton John concert on 10/9/2022 did not exceed either the Development Permit target or the concert-noise level predicted for the EIR at any location.

## Introduction

This memorandum presents concert noise levels, compares them to the community noise level target set in the Stadium's Development Permit, and puts them in the context of average non-game-day noise levels and noise level estimates taken from the Stadium's environmental impact report (EIR). Because jets are a major noise source in the area, noise from jets is explicitly noted. The community noise levels analyzed in this report are for three major concerts held in 2022 at Levi's Stadium: Coldplay, The Weeknd, and Elton John.[1]

Since 2017, noise level data has been collected continuously in the neighborhoods around the Stadium using Seti-Media unattended noise monitoring stations installed expressly for this purpose. Measurements are being made at four locations around the Stadium (see Figure 1), but this memo only reports data from the monitor at Cheeney and Lenox. The Cheeney and Lenox monitor characterizes noise in the neighborhood south of the Stadium which was the focus of the Stadium's EIR noise analysis; it is about the same distance from the Stadium as the Hughes Elementary School monitor; and it is lined up with the open, southern end of the Stadium. The Hughes location is shielded from Stadium noise to some extent by the bleacher seats on the eastern side, so stadium-generated noise levels are typically lower than those at Cheeney and Lenox. At the City's request, data from the Hughes and the other monitors could be analyzed and added to this report.

Additionally, attended measurements were conducted on 8/27/22 and 10/9/22 both to collect more data and to make site observations while two concerts were taking place (The Weeknd and Elton John, respectively). The attended measurement locations are shown in Figure *2*2.

**Concerts Analyzed** The 2022 data analyzed are for the following concerts:

| Event Date | Event | Start Time | End Time |
|---|---|---|---|
| 5/15/2022 | Coldplay | 7:00 p.m. | 11:00 p.m. |
| 8/27/2022 | The Weeknd | 6:30 p.m. | 11:00 p.m. |
| 10/9/2022 | Elton John | 8:00 p.m. | 10:40 p.m. |

**Explanation of Sound Level Metrics** Sound (noise) levels vary continuously, so acoustical engineers and scientists have developed a number of metrics to characterize them. This memo, following the EIR analysis, primarily uses the "$L_{eq}$":

> **Average or Equivalent Level ($L_{eq}$)** The *equivalent level*, abbreviated "$L_{eq}$" is the steady sound level that contains the same amount of acoustical energy during the measurement period as the actual, time-varying sound level did. For all intents and purposes, it is the average level and shall be referred to as such in this memo. While the measurement period may be of any duration, in this report the duration is 1 hour.

[1] Elton John also played a concert on10/8/2022.

This memo also reports some maximum noise levels ($L_{max}$):

> **Maximum Noise Levels ("Maximum")** The maximum noise level as discussed in this report refers to the loudest 1-second during documented events, e.g., the single loudest second when fireworks were used.

**<u>Unattended Noise Monitoring System Data Analysis and Assessment</u>**

- The unattended noise monitoring stations collect data on a second-by-second basis, but, for the most part, the $L_{eq}$, $L_{max}$, and other data are summarized on a 1-hour basis for consistency with the EIR noise analysis.
- The noise monitoring system can filter out most jet noise based on the typical characteristics of jet noise.[2] When it detects a jet, the system disregards the 30 seconds during which the jet flies over. Data with and without the inclusion of jet noise are presented in this report. The levels without jet noise include Stadium noise and all other non-jet sources.
- The Stadium's Development Permit includes the following condition regarding noise:

> In order to control noise, the stadium loudspeakers systems (permanent and temporary) shall be oriented in a manner consistent with Community Noise Analysis prepared by WJHW, dated May 27, 2010 for the proposed 49ers Stadium, in order to control noise impacts to adjacent residential neighborhoods. In accordance with Section 9.10.070(c) of the Santa Clara City Code, and the recommendations of this noise analysis, sound system levels shall be limited to 100 dBA for NFL games and other uses of the permanent speaker system, and not more than 105 dBA for temporary concert speaker systems as presented in the analysis. For sound system installations and modifications within the stadium site, the target for maximum sound level exposure in residential areas to the east and south shall be 60 dBA, in order to minimize noise impacts to sensitive receptors.[3]

The concert noise levels are compared to the "60 dBA target". As established in the WJHW report, this decibel level target is intended for the 1-hour $L_{eq}$ ("average") level at the residences closest to the Stadium – about 1,200 feet from the center of the stadium. The Cheeney & Lenox sound monitoring station is more deeply embedded in the community, about 50% farther away. To account for the extra attenuation with distance, 4 dB have been subtracted from the 60 dBA $L_{eq}$ target[4], meaning that the target at the Cheeney and Lenox

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[2] If the jet is not particularly loud or there is another, constant noise source such as a lawnmower at the time, the filter may not identify the jet. The filter excludes the noise from about 85% of all jets.

[3] Development Permit PLN2008-06947, 11/30/2010, Condition P23

[4] Technical note: Noise attenuates with distance for the same reason that the height of circular waves resulting from a rock thrown in a still lake get smaller as they travel away from the source location: the energy in the wavefront is spread over a larger and larger area which reduces the wave's amplitude. This is called "attenuation due to geometric spreading". Noise that is fairly far from the source – even a large source such as Levi's Stadium – spreads at a rate of 6 dB per doubling of distance. The distance from the center of the stadium (which is the effective location of the noise source) to the homes where the EIR predicted noise levels is about 1,200 feet, whereas the distance from the center of the stadium to the Cheeney and Lenox monitor is about 1,800 feet, a 50%

monitoring location is 56 dBA Leq. The 2340 Esperanca location is about 2,200 feet from the center of the stadium, so the target there is effectively 55 dBA Leq. Noise levels at 2382 Avenida De Guadalupe are assessed using the 60 dBA Leq target as this location is representative of the residences closest to the stadium to the east. Measurements made at 4305 Watson will not be assessed relative to the Development Permit target as this location is too far away to adjust the target in a meaningful manner.

- For context, data from 46 Sundays in 2021 when there were no NFL games ("non-game days") were arithmetically averaged to ascertain representative ambient levels on an hourly basis for non-game/non-event days.
- Also for context, the concert-noise level estimated for the Stadium project EIR is presented. From the Environmental Noise Assessment done for the project:

> A concert at the proposed stadium would also be expected to generate noise levels audible in the surrounding residential neighborhoods. Concert noise levels would vary depending on the type of music performed. On average, concerts typically generate an average noise level of approximately 95 dBA Leq measured 100 feet from the stage and speakers. Concert generated noise levels are likely to be similar or slightly less than the maximum crowd noise (i.e., cheering) at an NFL event. <u>Concert noise levels would be approximately 66 dBA Leq or less at the nearest residences south of the stadium site</u>. Hourly average noise levels would exceed the ambient hourly average noise levels by 4 dBA Leq and would exceed background noise levels by 19 to 24 dBA. Because concerts would occur during evening hours, the increase in ambient average noise levels over an approximately two to three hour period would be more obvious to nearby residents.[5]

The EIR predictions are for the residences closest to the Stadium whereas the Cheeney & Lenox sound monitoring station is more deeply embedded in the community, about 50% farther away. To account for the extra attenuation with distance, 4 dB have been subtracted from the levels predicted in the EIR[6], meaning that concert noise levels were nominally predicted to be 62 dBA Leq at the Cheeney and Lenox monitoring location. Similarly, predicted concert noise levels at the 2340 Esperanca location (about 2,200 feet from the center of the stadium) were nominally 61 dBA Leq. The 60 dBA Leq target directly applicable to 2382

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increase. Given the logarithmic mathematics of decibels, one may calculate that the expected attenuation for a 50% increase in distance is about 4 dB using the equation 20 $\log_{10}$ ($distance_1/distance_2$).

[5] Illingworth & Rodkin, *49ers Stadium Project Environmental Noise Assessment*, Santa Clara, California, I&R Job No. 08-046, 24 February 2009, p 14. Underlined emphasis added.

[6] Technical note: Noise attenuates with distance for the same reason that the height of circular waves resulting from a rock thrown in a still lake get smaller as they travel away from the source location: the energy in the wavefront is spread over a larger and larger area which reduces the wave's amplitude. This is called "attenuation due to geometric spreading". Noise that is fairly far from the source – even a large source such as Levi's Stadium – spreads at a rate of 6 dB per doubling of distance. The distance from the center of the stadium (which is the effective location of the noise source) to the homes where the EIR predicted noise levels is about 1,200 feet, whereas the distance from the center of the stadium to the Cheeney and Lenox monitor is about 1,800 feet, a 50% increase. Given the logarithmic mathematics of decibels, one may calculate that the expected attenuation for a 50% increase in distance is about 4 dB using the equation 20 $\log_{10}$ ($distance_1/distance_2$).

Avenida de Guadalupe as it is as close as any other residence to the east of the stadium. The EIR did not predict concert noise levels at distances as far as 4305 Watson Circle.

- The 2022 concert hourly average levels ($L_{eq}$) as measured by the Cheeney & Lenox unattended noise monitoring station are plotted along with the 56 dBA $L_{eq}$ target from the Development Permit and the contextual backdrop of average non-game Sunday noise levels and the concert-noise level predicted for the EIR in Figure 3 to Figure 5. The approximate timeframe of the concert is indicated on each data plot along with commentary on the noise levels vis-à-vis the relevant assessment metrics.

**Manual Analysis of Coldplay Concert Noise Monitoring System Data**

At the request of the City of Santa Clara, additional manual analysis was conducted on data collected by the unattended noise monitoring station at Cheeney & Lenox during the Coldplay concert on 5/15/22. Our understanding is that this request stems from a written petition (Council Policy 030) which complained about noise from the Coldplay concert. Specifically, complaints were made about late-night fireworks which occurred after 10:00 pm.

Manual review of the data and audio recordings enabled us to identify events above 60 dBA $L_{eq}$ (mostly jets and fireworks) that occurred between 9:00 and 11:00 pm, the period of concern. The concert noise level including fireworks noise during the 10:00 to 11:00 pm hour was 65 dBA $L_{eq}$ (excludes jet noise). This exceeds the 62 dBA $L_{eq}$ concert-noise level predicted for the EIR. The concert noise level during that same hour excluding both fireworks and jets was 61 dBA $L_{eq}$. This is below the predicted noise level of concerts presented in the EIR, but still above the 56 dBA $L_{eq}$ target in the Development Permit. A plot of the results of this additional analysis is presented in Figure 6.

As discussed previously, the EIR analysis and, therefore, the Development Permit noise target uses the one-hour average ($L_{eq}$) metric, which are the standards established for the Stadium, but this is not what people typically respond to in situations like late-night concert fireworks. Rather, they respond to the maximum noise levels. For completeness, the maximum noise levels due solely to fireworks during the Coldplay concert were 77 to 87 dBA $L_{max}$ at Cheeney and Lenox. For context, the maximum noise levels due solely to jet aircraft were 64 to 83 dBA $L_{max}$ (jets flew until midnight on the night of the Coldplay concert). These maximum noise levels were analyzed during periods when jet aircraft and fireworks did not occur simultaneously.

**Attended Noise Measurement Data Analysis & Presentation**

Wilson Ihrig conducted attended measurements during the concerts on 8/27/22 (The Weeknd) and 10/9/2022 (Elton John) to document noise levels near residences who filed official complaints regarding the Coldplay concert on 5/15/2022, as well as to gather additional information about the concert noise, such as how much traffic influenced the noise measurements. For control, attended measurements were made near the Cheeney and Lenox unattended noise monitoring station. In addition, measurements were made at 2340 Esperanca, 2382 Avenida de Guadalupe, and 4305 Watson Circle.

Two Wilson Ihrig staff members made measurements during both concerts between 9:00 and 11:00 pm, one stationed near the Cheeney and Lenox unattended noise monitoring station for the entire duration and one making shorter measurements at multiple locations throughout the area over the

two hours. Attended noise measurements were made at a 5 ft height at all locations shown in Figure *2*. The continuous measurement at Cheeney and Lenox was done to ensure that if fireworks or other unusually loud concert-related event occurred, the events would be captured in real-time on an attended recording, however, no fireworks were utilized during either concert nor were there any unusually loud noises.

*8/27/22 Concert (The Weeknd)*

Over the 2-hour period centered on The Weeknd concert time (9:00 to 11:00 pm), noise levels measured by the unattended noise monitoring station at Cheeney and Lenox – with jet noise filtered out using the automated filter – did exceed 56 dBA $L_{eq}$ (the adjusted target at this location), but were below the 62 dBA $L_{eq}$ level predicted for concerts in the EIR.

As seen in Figure 2, one of the attended measurement locations was right below the Cheeney and Lenox monitoring station. The attended measurements were later post-processed to eliminate all major noise sources not related to the concert (e.g., cars, pedestrians, jet planes, etc.). This manual analysis resulted in noise levels approximately 2 to 3 dBA lower than those measured by the unattended noise monitoring stations even with jet noise filtered out using the automated filter (reflecting the fact that the jet filter does not eliminate car or pedestrian noise, nor even all jets). Results from this spot check establish that concert-noise levels at Cheeney and Lenox did exceed 56 dBA $L_{eq}$ but were below the concert-noise level predicted for the EIR throughout the entire concert.

Additional spot-check measurements were made near 4305 Watson Circle, 2340 Esperanca Ave, and 2382 Avenida de Guadalupe. Again, data from these attended measurements were later post-processed to eliminate sources not due to concert-related activity. Results from these spot checks indicate that noise levels at 2340 Esperanca Avenue did not exceed 55 dBA $L_{eq}$ (the adjusted target) and were below the concert-noise level predicted for the EIR at the time of measurement. At 4305 Watson Circle, it was observed that concert activities were not audible unless noise levels from local traffic were 43 to 44 dBA $L_{eq}$ or less (which only occurred when there were no vehicles in the immediate vicinity). Concert-only noise levels near 2382 Avenida de Guadalupe indicate that noise levels did exceed the 60 dBA $L_{eq}$ Development Permit target between 10:00 to 10:30 pm by approximately 1 dBA, but were still below the concert-noise level predicted for the EIR.

It was observed during these measurements that the noise level of the crowd commonly exceeded that of the amplified music at the Cheeney and Lenox, 2340 Esperanca, and 2382 Avenide de Guadalupe locations. Crowd noise was not audible at the 4305 Watson Circle location.

*10/9 Concert (Elton John)*

Over the 2-hour period centered on the Elton John concert time (9:00 and11:00 pm), noise levels measured by the unattended noise monitoring station at the Cheeney and Lenox location – with jet noise filtered out using the automated filter – did not exceed 56 dBA $L_{eq}$ and were below the concert-noise level predicted for the EIR.

Attended noise measurements were made at three locations shown in Figure 2, locations #1, #3, and #4.[7] One of the attended monitoring locations was next to the Cheeney and Lenox monitoring

[7] Analysis of the 8/27 Concert (TheWeeknd) indicated the noise levels measured at Cheeney and Lenox were within 1 dBA of those measured at 2340 Esperanca. Therefore, measurement efforts during the Elton John concert were focused on the other locations.

station. The short-term measurements were later post-processed to eliminate all major noise sources not associated with the concert. This manual analysis resulted in noise levels approximately 2 dBA lower than those measured using the unattended noise monitoring station (with jet noise filtered out using the automated filter). Results from this spot check indicate that noise levels at Cheeney and Lenox did not exceed the 56 dBA Leq target and were below the concert-noise level predicted for the EIR throughout the entire concert.

Additional attended measurements were made near 4305 Watson Circle and 2382 Avenida de Guadalupe. All attended measurement data were later post-processed to eliminate all major noise sources not associated with the concert. Results from these spot checks indicate that noise levels at 2382 Avenida de Guadalupe did not exceed 60 dBA Leq target and were below the concert-noise level predicted for the EIR throughout the entire concert. It was observed that concert activities were not audible at the 4305 Watson Circle location (while clearly audible at the closer Cheeney and Lenox location at the same time).

It was observed during these measurements that the noise level of the crowd commonly exceeded that of the amplified music at the Cheeney and Lenox and 2382 Avenide de Guadalupe locations. Crowd noise was not audible at the 4305 Watson Circle location.

**Data Analysis and Assessment Conclusions**

The analysis of data from the unattended noise monitoring station at Cheeney and Lenox for all three concerts and of data from the short-term attended monitoring locations for the 8/27/22 concert (The Weeknd) and 10/9/22 concert (Elton John) is summarized in Table 1 below. The Coldplay concert on 5/15/20 exceeded the 56 dBA Leq Development Permit target and the concert-noise level predicted for the EIR at the Cheeney and Lenox location. The Weeknd concert of 8/27/2022 exceeded the 56 dBA Leq Development Permit target, but did not exceed the concert-noise level predicted for the EIR at the Cheeney and Lenox location. The Weeknd concert-noise levels also exceeded the 60 dBA Leq Development Permit target at 2382 Avenida De Guadalupe. Noise levels from the Elton John concert of 10/9/2022 did not exceed the Development Permit target and also did not exceed the concert-noise level predicted for the EIR at any location.

## *Table 1A: Noise Standards*

| Location | Development Permit Target (Adjusted) | Concert Level Predicted in EIR (Adjusted) |
|---|---|---|
| **Cheeney & Lenox** | 56 dBA Leq | 62 dBA Leq |
| **2340 Esperanca** | 55 dBA Leq | 61 dBA Leq |
| **2382 Ave. de Guadalupe** | 60 dBA Leq | 66 dBA Leq |
| **4305 Watson Circle** | N/A | N/A |

### *Table 1B: Noise Measurement Summary*

| **Measurement Location** | **Coldplay 5/15/2022** | **The Weeknd 8/27/2022** | **Elton John 10/9/2022** |
|---|---|---|---|
| **Cheeney and Lenox** (Unattended Noise Monitor) | **58-64** dBA Leq | 55-**59** dBA Leq | 55-56 dBA Leq |
| **Cheeney and Lenox Including Fireworks** (Manual Analysis of Unattended Data) | **58-65** dBA Leq | N/A | N/A |
| **Cheeney and Lenox Excluding Fireworks** (Manual Analysis of Unattended Data) | **58-62** dBA Leq | N/A | N/A |
| **Cheeney and Lenox** (Attended Monitor) | N/A | 56-**57** dBA Leq | 51-54 dBA Leq |
| **2340 Esperanca** (Attended Monitor) | N/A | 55 dBA Leq | N/A |
| **2382 Ave. De Guadalupe** (Attended Monitor) | N/A | **61** dBA Leq | 58 dBA Leq |
| **4305 Watson Circle** (Attended Monitor) | N/A | 47 dBA Leq | 42 dBA Leq |
| **Does Range Exceed Development Permit Target?** | Yes | Yes | No |
| **Does Range Exceed EIR-Predicted Levels?** | Yes* | No | No |
| *If assessed concert noise level includes fireworks noise. **Bold** values indicate exceedance of Development Permit target. | | | |

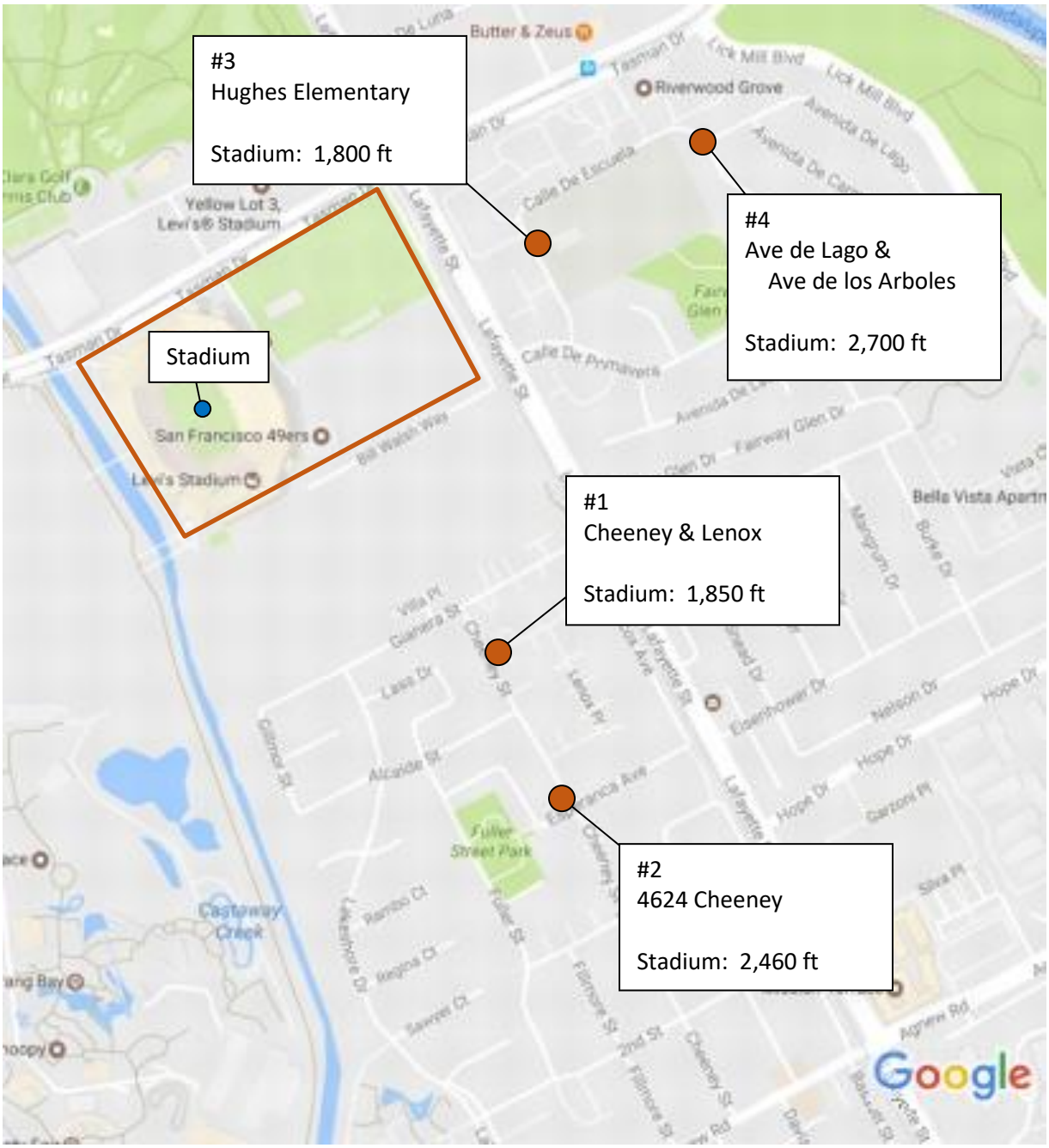


**Figure 1 Area Map with Unattended Noise Monitoring Station Locations (Distances are measured from the center of the Stadium)**

**Figure 2 8-27-2022 (The Weeknd) and 10-9-2022 (Elton John) – Attended Noise Measurement Locations**

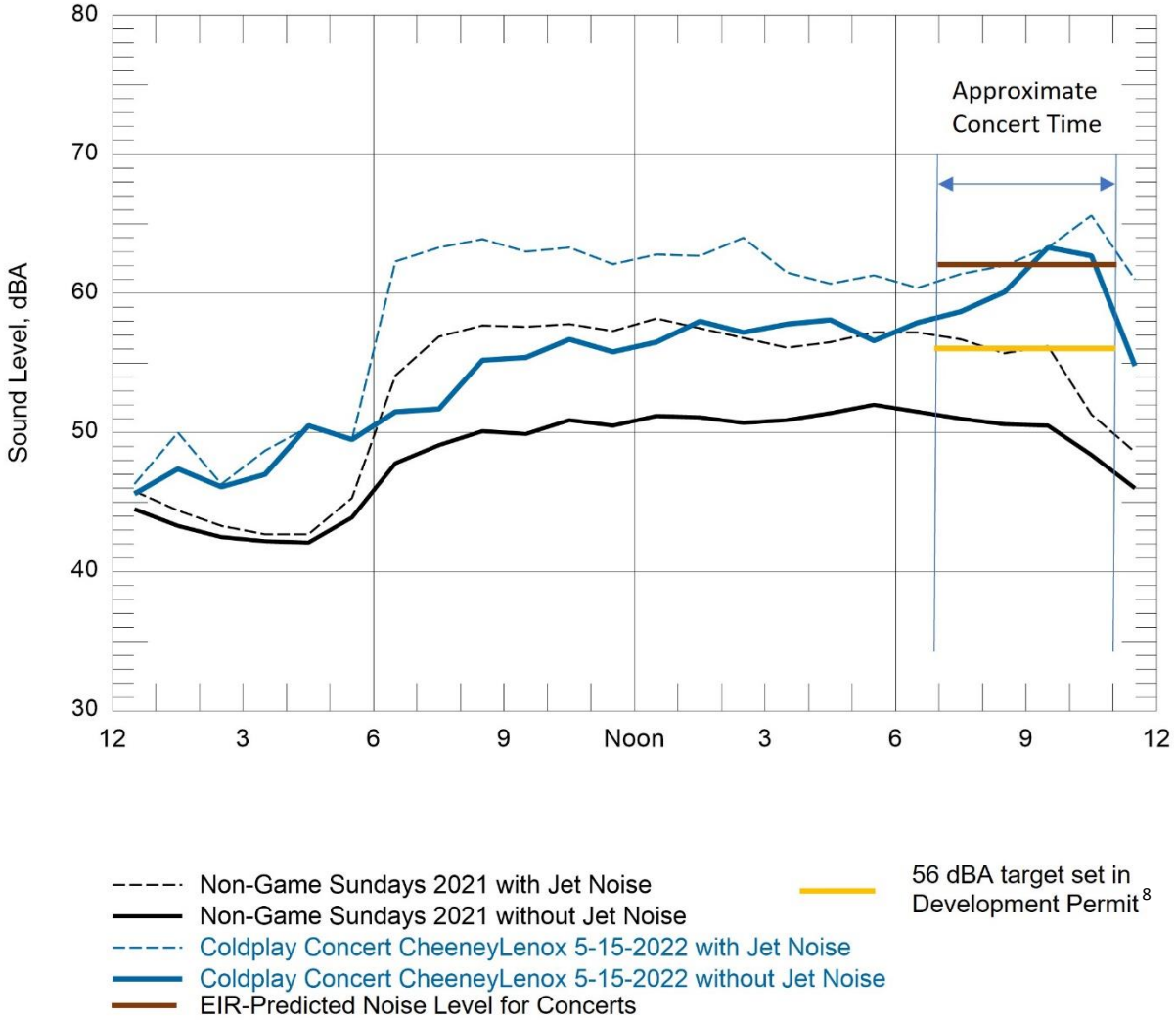


**Figure 3 5-15-2022 (Coldplay) – Hourly-Average Leq**

The following regards measured noise levels with jet noise and, inadvertently, fireworks noise filtered out by the Seti-Media system: Over the 4-hour period centered on the concert time, noise levels exceeded 56 dBA between 7:00 and 11:00 pm. They were 7 to 15 dB higher than average non-game-day levels. They were below the concert-noise level predicted for the EIR between 7:00 pm and 9:00 pm, but above the predicted level between 9:00 and 11:00 pm.

Because the jet noise filter inadvertently also filtered out fireworks noise, it was subsequently improved by adding information about jet flyover times to the automated filtering process. This new filter will be fully operational for future concerts after 10/21/2022. See discussion at Figure 5 for noise levels with jet noise removed and fireworks noise remaining.

[8] The Cheeney & Lenox sound monitoring station is more deeply embedded in the community than the residences closest to the Stadium, about 50% farther away. To account for the extra attenuation with distance, 4 dB have been subtracted from the 60 dBA Leq target, meaning that the target at the Cheeney and Lenox monitoring location is 56 dBA Leq.

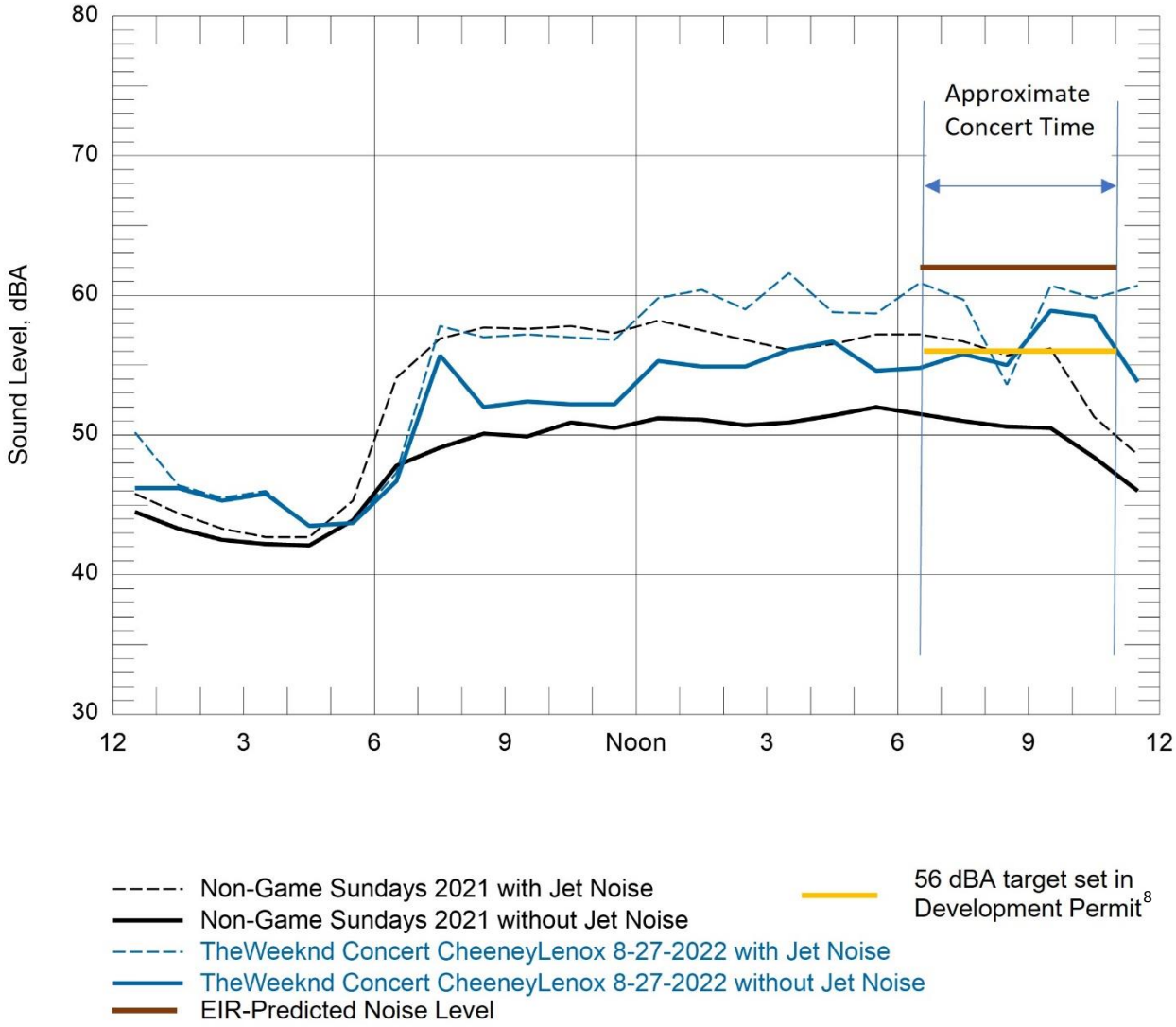


Figure 4 8-27-22 (The Weeknd) – Hourly-Average $L_{eq}$

The following regards measured noise levels with jet noise filtered out: Over the 4-hour period centered on the concert time, noise levels exceeded 56 dBA between 9:00 and 11:00 pm. They were 3 to 11 dB higher than average non-game-day levels, but were generally below the concert-noise level predicted for the EIR.

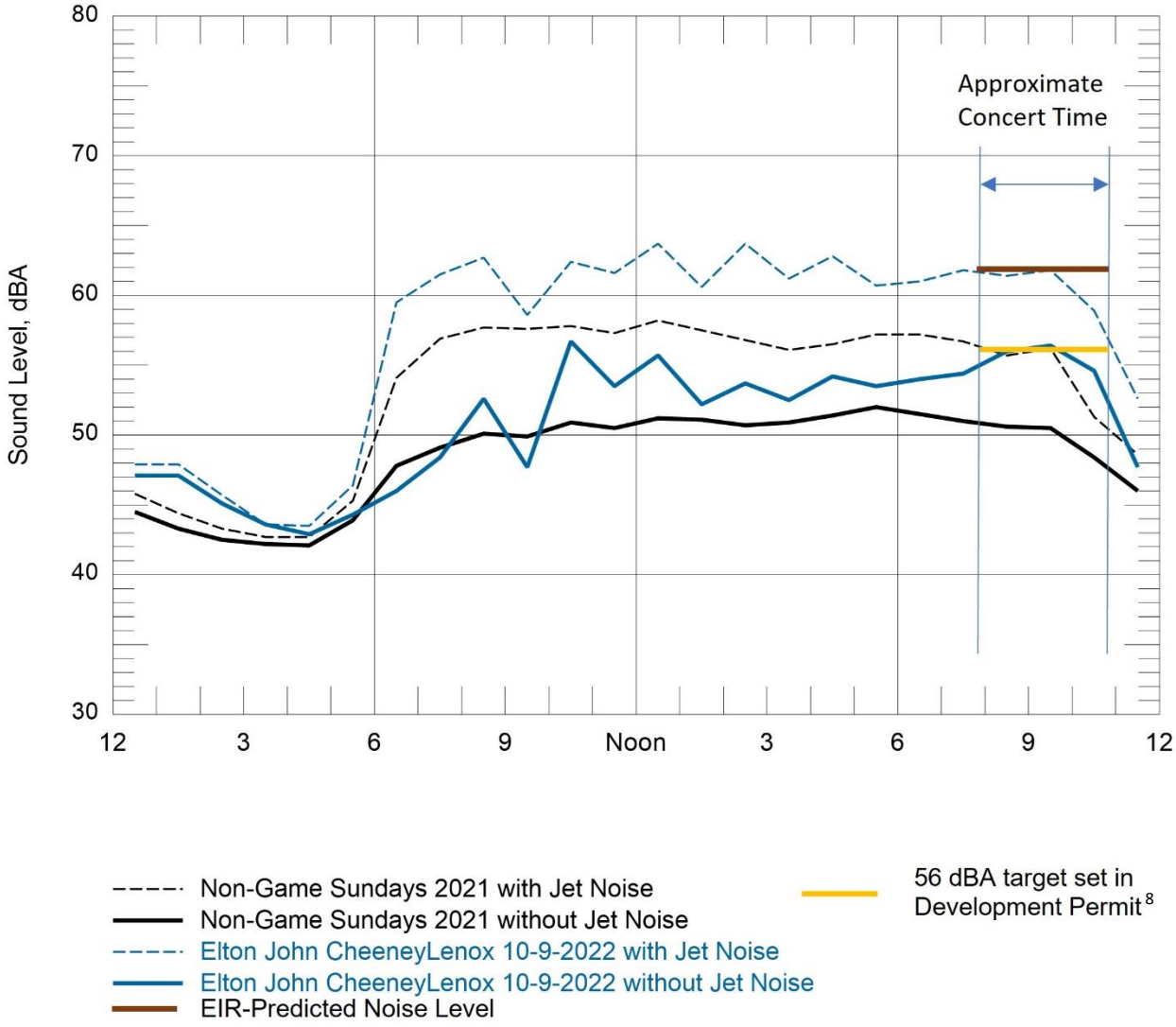


**Figure 5 10-9-22 (Elton John) – Hourly-Average $L_{eq}$**

The following regards measured noise levels with jet noise filtered out: Over the 3-hour period centered on the concert time, noise levels did reach but did not exceed 56 dBA. They were 5 to 7 dB higher than average non-game-day levels, but were below the concert-noise level predicted for the EIR.

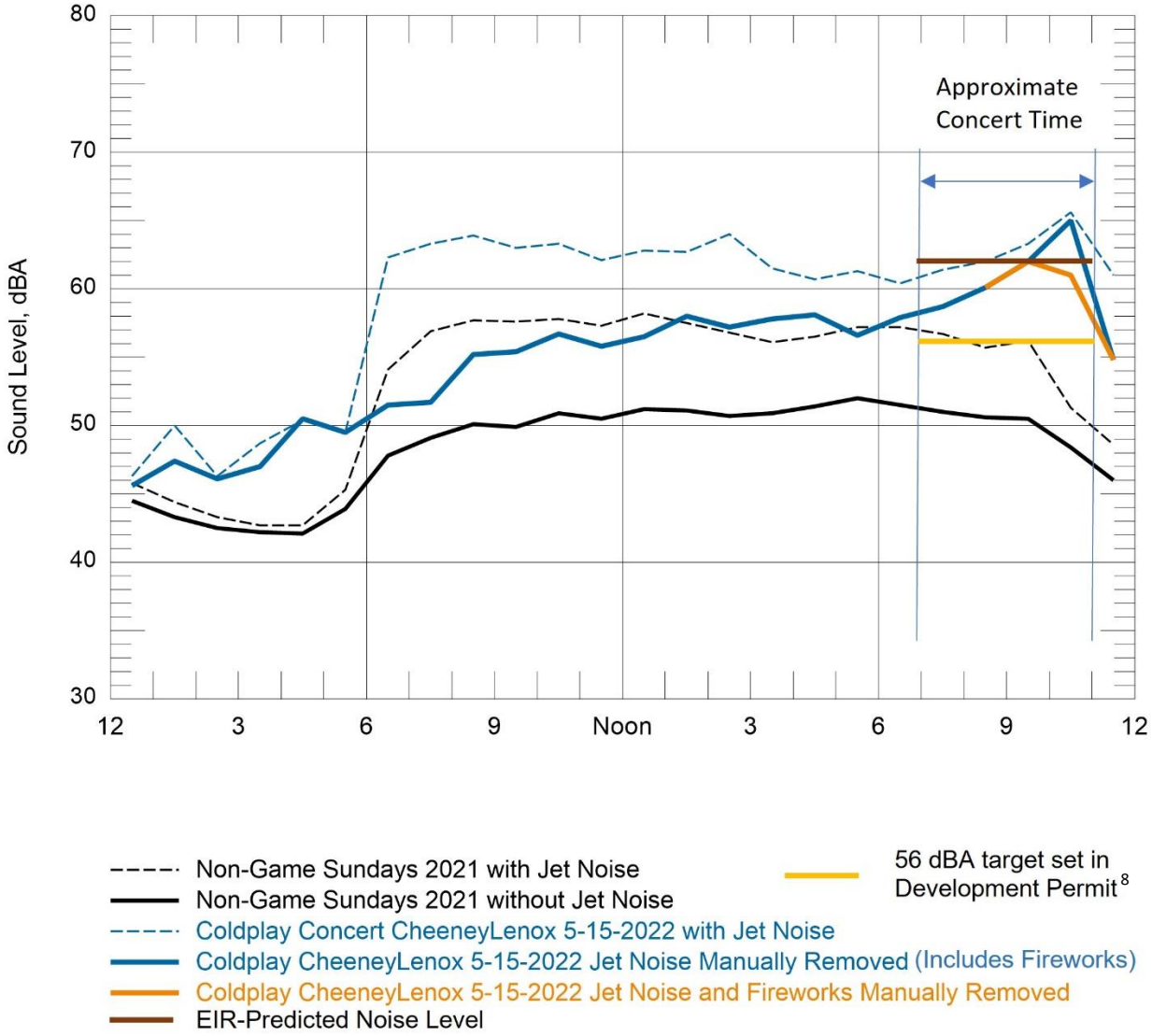


**Figure 6 5-15-2022 (Coldplay) – Hourly-Average $L_{eq}$, Including Additional Analysis**

The following regards measured noise levels with jet noise filtered out manually: Between the hours of 7:00 and 9:00 p.m., the concert-only noise remained below the 62 dBA predicted noise level, but was still 3 to 4 dB above the Development Permit target level. During the 9:00 to 10:00 p.m. hour, the concert noise equalled the 62 dBA predicted level, 6 dBA above the target. During the 10:00 to 11:00 p.m. hour, the concert noise level – including fireworks – was 65 dBA $L_{eq}$. This is 3 dB above the concert-noise level predicted for the EIR, 9 dB above the Development Permit target level, and about 15 dB above the non-game (non-event) level for that hour. Without the fireworks (yellow line), the concert noise level was 61 dBA $L_{eq}$, below the concert-noise level predicted for the EIR, but still 5 dB above the adjusted target and 11 dB above the level for that hour when there is no stadium event.