Mei Wu Acoustics

Experts in acoustics, noise and vibration

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Date:	**March 15, 2018**	
Subject:	**Bloom Energy EQX005 – 444 Toyama Drive, Sunnyvale, CA - Acoustical Study Revision 5**	
	MWA Project – 17060.3	

Mei Wu Acoustics (MWA) has predicted the sound levels produced by the proposed fuel cells energy server system at 444 Toyama Drive in Sunnyvale, CA. In addition, MWA has conducted 48-hour sound level measurements at the site to establish the existing ambient environmental sound levels in order to compare predicted noise levels with existing conditions and demonstrate compliance with the Sunnyvale Municipal Code Requirements.

1. Project Overview

The proposed equipment will consist of four (4) "Yuma" ES-5 linear energy servers (2 back-to-back servers with 1100 kW total capacity) that will be located in the parking lot of the property, near Toyama Drive. The following figure provides the civil site plan layout with the fuel cells highlighted in blue and showing the distances to the property lines.

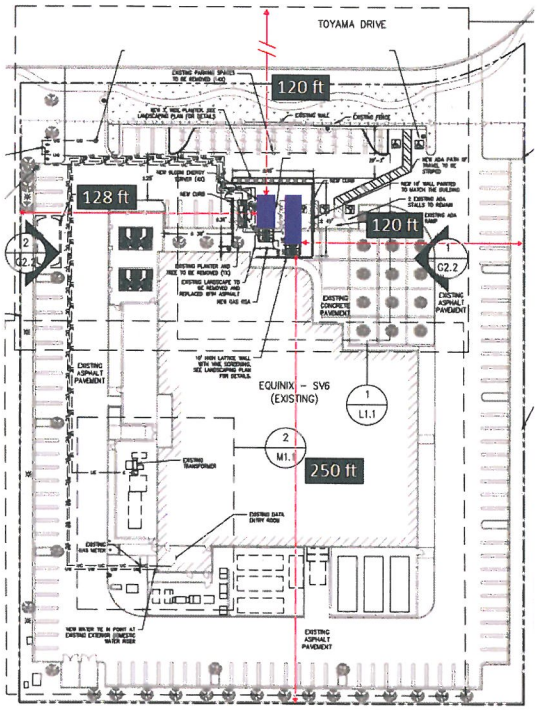


Figure 1: Site Plan showing layout of proposed ES-5 linear energy servers and distances to property lines.

The neighboring property to the south will be completely shielded by the existing Equinix building.

2. Noise Criteria

This section documents the environmental noise criteria and code requirements applicable the project site.

2.1. Sunnyvale Municipal Code

The following paragraphs from the City Municipal Code may be applicable to the project:

19.12.160. "O"

(6) "Operational noise" means continuous or frequent noise related to the basic use of a property. Operational noise includes, but is not limited to, noise produced by: air conditioners, equipment for swimming pools or spas, industrial machinery, air compressors, or fork lifts. Powered equipment or deliveries shall not be considered operational noise.

19.42.030. Noise or sound level.

(a) Operational noise shall not exceed seventy-five dBA at any point on the property line of the premises upon which the noise or sound is generated or produced; provided, however, that the noise or sound level shall not exceed fifty dBA during nighttime or sixty dBA during daytime hours at any point on adjacent residentially zoned property. If the noise occurs during nighttime hours and the enforcing officer has determined that the noise involves a steady, audible tone such as a whine, screech or hum, or is a staccato or intermittent noise (e.g., hammering) or includes music or speech, the allowable noise or sound level shall not exceed forty-five dBA.

(b) Powered equipment used on a temporary, occasional or infrequent basis which produces a noise greater than the applicable operational noise limit set forth in subsection (a) shall be used only during daytime hours when used adjacent to a property with a residential zoning district. Powered equipment used on other than a temporary, occasional or infrequent basis shall comply with the operational noise requirements. For the purpose of this section, powered equipment does not include leaf blowers. Construction activity regulated by Title 16 of this code shall not be governed by this section.

9.72.020. Definitions.

(3) "Nighttime hours" shall mean the hours between 10:00 p.m. and 8:00 a.m. the following day.

2.2. Sunnyvale General Plan – Chapter 6

Chapter 6 from the General Plan of the City of Sunnyvale states that operational noise is addressed in the Municipal Code. It also shows a land use compatibility guidelines. Residential areas are considered "normally acceptable" if the Ldn is below 60 dBA, while between 60 and 75 dBA is considered "conditionally acceptable", and above 75 dBA is "unacceptable".

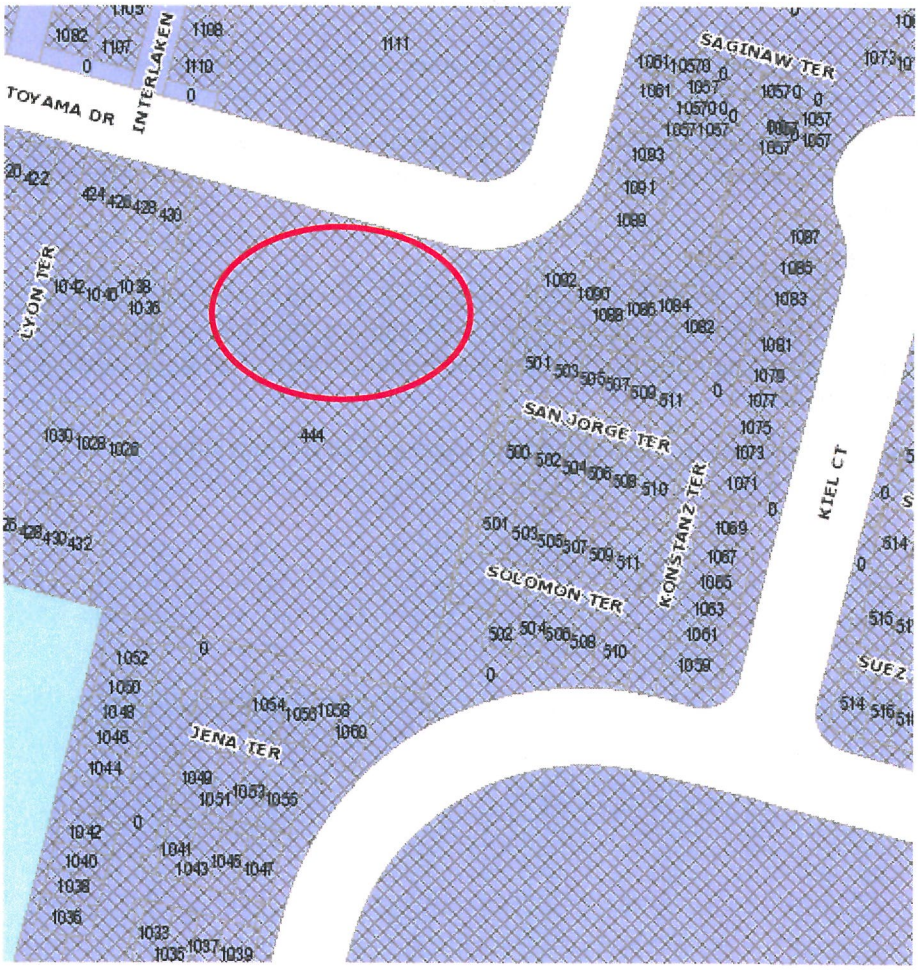
The General Plan also shows noise contours for the city. Figure 6-6 shows how noise increases are considered by the city.

Figure 6-6: Significant Noise Impacts from New Development on Existing Land Use

Ldn Category of Existing Development Per Figure 6-4	Noise Increase Considered "Significant" over Existing Noise Levels
Normally Acceptable	An increase of more than 3 dBA and the total Ldn exceeds the "normally acceptable" category
Normally Acceptable	An increase of more than 5 dBA
Conditionally Acceptable	An increase of more than 3 dBA
Unacceptable	An increase of more than 3 dBA

2.3. Sunnyvale Zoning Map

The following figure provides a zoning map highlighting the project site.



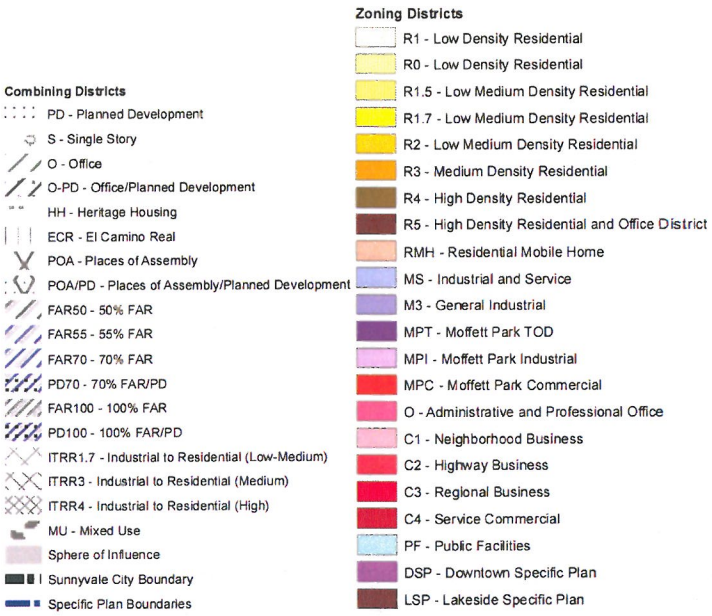


Figure 2: Sunnyvale Zoning Map with project site area highlighted.

As shown, all properties around the project site are labeled as Industrial to Residential zones. The properties to the east and west are three-story residential houses while the property to the north is an industrial use.

2.4. Summary of Noise Criteria

- Based on the code, residential exterior noise levels should not exceed 60 dBA daytime (8am-10pm); 50 dBA nighttime (10pm – 8am). Fuel cells are not tonal or impulsive; nevertheless, the city is requesting noise levels at the residential property lines to be below 45 dBA during nighttime hours.
- Industrial Exterior noise levels should not exceed 75 dBA at any time.

3. Environmental Ambient Sound Level Measurements

MWA visited the project site to conduct ambient environmental sound level measurements at the three nearest property lines: west, north, and south (shown in Figure 1 above).

3.1. Site visit details

MWA personnel:	Ping He
Date and time:	10/23/2017 12 PM – 10/25/2017 2 PM
Equipment used:	Four (4) Cesva SC160, Type II sound level meters

3.2. Measurement procedure

Three locations were measured during this study, as mentioned above. The following figure shows the location of the meters for each measured day.

Figure 3: Meter location to measure noise environment at the nearest property lines to the fuel cells.

Two meters were placed at each property line and during at least 24 hours they measured simultaneously to compare results between them and verify that the readings were correct. The meter locations were chosen based on the closest proximity of the fuel cells to the nearby properties. No sound meters were placed on the south property line given that the existing building (444 Toyama Drive) will completely shield noise from the fuel cells and no significant noise impact is expected at that location.

The data from the first day yielded similar results between nearby locations (W1 and W2 results are similar; E1 and E2 results are similar), and data from the second day yielded similar results between the two north location (N1 and N2). Therefore, this report will only analyze the noise

data recorded during the second day, simultaneously at the three property lines: locations W1, N1, and E1. The rest of the data analysis may be found in the appendices of this report.

Each sound level meter was installed on either a light pole or a bush near each of the three property lines, as shown in Figure 3. Ambient sounds comprised primarily traffic and existing equipment on site and on the neighboring properties.

The sound level meters recorded A-weighted noise levels every one (1) minute for the time period described above. The meters were equipped with windscreens. The following figure shows the location of the meters on site.

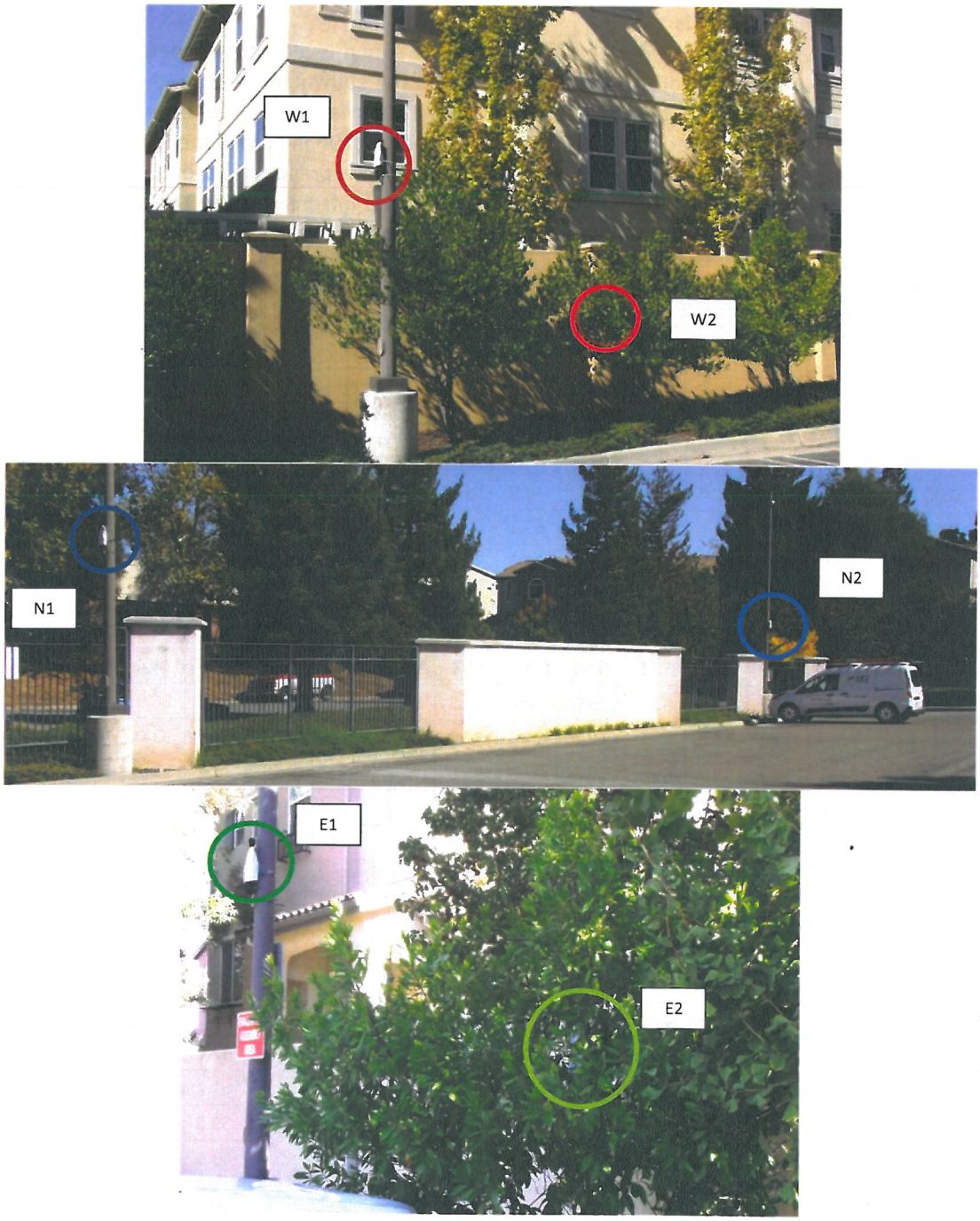


Figure 4: Meter locations on site.

3.3. Measurement Results

The following table provides the hourly average sound level measurements. All measurements indicated are given in dBA (A-weighted). LAeq is the equivalent measured level for the entire 1-hour measurement period. L1/10/L90/L99 are statistical averages – for example, L10 indicates the level that was exceeded for 10% of the time, whereas L90 indicates the level present for 90% of the measurement period. L99 & L90 are considered representative of the steady background sound levels, whereas L1 & L10 may suggest more infrequent and transient activities in the environment (door slams, car alarms, dog barking, etc.).

Hour	W1					N1					E1				
	L1	L10	L90	L99	LAeq	L1	L10	L90	L99	LAeq	L1	L10	L90	L99	LAeq
2:00 PM	54.9	50.6	47.0	46.6	48.8	57.9	51.9	48.0	47.6	50.1	53.2	50.1	46.3	45.8	48.0
3:00 PM	58.8	50.4	46.9	46.5	49.3	60.9	51.5	47.8	47.3	50.7	68.9	56.2	46.7	46.0	55.5
4:00 PM	55.9	50.5	48.1	47.7	49.4	55.9	51.7	49.3	48.9	50.5	53.7	50.6	47.8	47.3	49.2
5:00 PM	55.2	51.6	48.8	48.4	50.1	57.5	54.1	50.5	50.1	52.3	57.3	53.9	48.5	48.0	51.4
6:00 PM	56.6	53.8	51.4	51.0	52.6	60.9	56.3	53.2	52.8	54.9	55.9	53.7	51.5	51.1	52.6
7:00 PM	55.2	53.9	52.4	52.0	53.1	57.1	55.1	53.5	53.1	54.2	54.8	53.8	52.2	51.8	53.0
8:00 PM	56.5	54.4	52.8	52.4	53.6	57.2	55.2	53.6	53.2	54.3	55.4	53.9	52.1	51.7	53.0
9:00 PM	66.6	63.1	54.2	53.7	58.5	66.3	62.5	55.2	54.8	58.6	67.1	59.5	53.6	53.1	57.6
10:00 PM	55.4	54.0	52.5	52.1	53.3	57.5	55.0	53.4	53.0	54.2	56.6	54.4	52.6	52.2	53.6
11:00 PM	57.0	55.7	53.0	52.3	54.5	56.3	55.2	53.3	52.9	54.3	55.8	54.4	52.3	51.7	53.4
12:00 AM	60.8	58.7	54.1	53.3	56.6	60.0	58.3	54.5	53.9	56.4	58.7	56.9	53.2	52.6	55.2
1:00 AM	58.5	56.4	51.3	50.6	54.1	57.8	56.0	52.5	52.0	54.3	54.6	53.2	50.6	50.0	51.9
2:00 AM	56.5	54.2	51.7	51.2	53.0	57.0	55.5	53.7	53.3	54.6	54.7	53.2	51.2	50.8	52.2
3:00 AM	58.1	55.5	51.1	50.5	53.3	57.7	55.6	52.7	52.3	54.1	54.8	53.2	50.6	50.0	51.9
4:00 AM	58.3	56.2	53.6	53.0	54.9	58.5	56.9	54.9	54.5	55.9	56.4	55.1	53.3	52.9	54.2
5:00 AM	62.4	59.9	56.2	55.5	58.1	61.8	59.7	57.0	56.4	58.3	65.3	57.6	55.3	54.8	57.0
6:00 AM	61.4	59.7	56.9	56.3	58.4	61.1	59.7	57.4	56.8	58.6	60.5	58.0	56.1	55.6	57.1
7:00 AM	62.1	59.0	56.1	55.7	57.5	62.1	58.7	56.8	56.4	57.8	62.6	58.5	55.6	55.2	57.2
8:00 AM	59.0	56.3	53.9	53.4	55.1	60.3	57.3	55.2	54.7	56.2	58.7	56.3	53.8	53.2	55.0
9:00 AM	55.3	52.2	48.6	48.2	50.4	56.5	53.8	50.7	50.4	52.1	56.9	53.2	49.0	48.3	51.2
10:00 AM	57.2	53.4	48.9	48.4	51.1	62.5	57.6	51.2	50.7	54.6	62.6	58.0	49.2	48.5	54.5
11:00 AM	62.5	55.1	49.4	49.0	53.0	65.3	59.3	52.7	52.3	56.4	61.2	56.7	50.9	50.1	54.2
12:00 PM	57.8	53.1	49.1	48.7	51.1	62.9	56.8	52.5	52.0	54.9	59.8	54.1	48.5	47.8	52.1
1:00 PM	55.0	51.2	48.4	48.0	49.8	57.6	54.2	50.7	50.4	52.2	63.1	51.7	47.6	47.1	51.4
LDN	61.8					62.2					60.8				

Table 1: Hourly environmental sound level measurements – 10/24-25/2017 in dBA (Second Day).

The following figure shows the hourly LAeq, L90 and L99 recorded at the three property lines (W1, N1, and E1) during the second day.

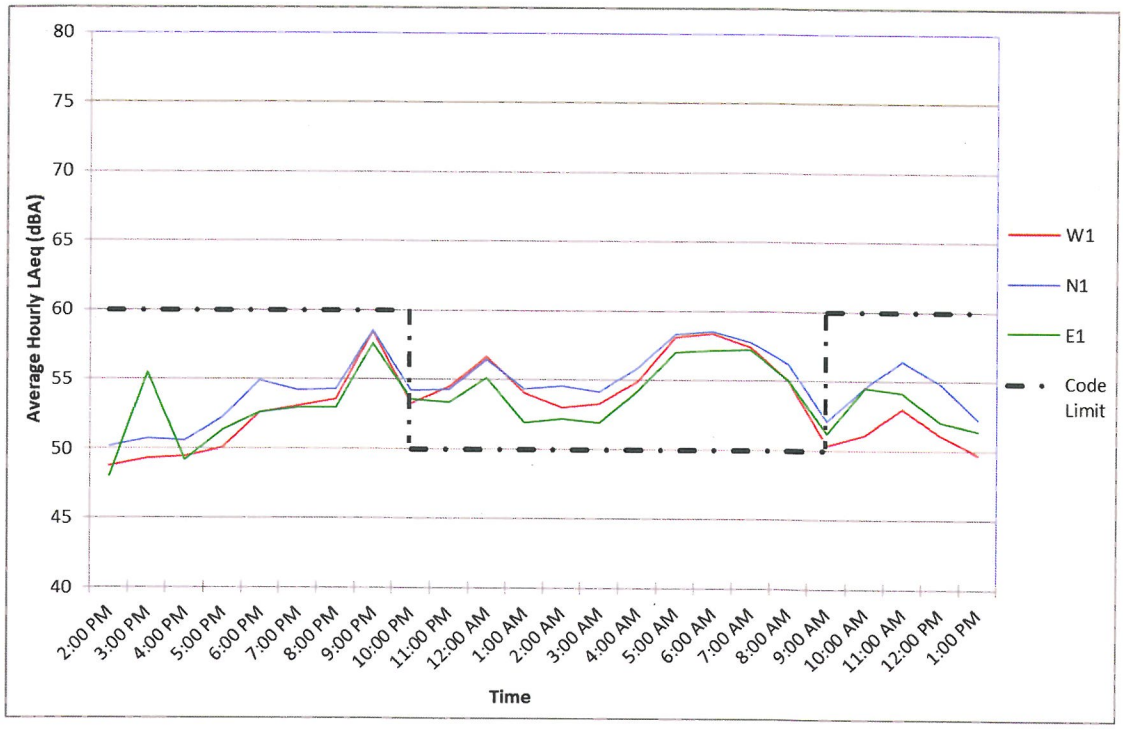


Figure 5-1: Hourly LAeq at three locations from 10/24 to 10/25/2017 (Second day).

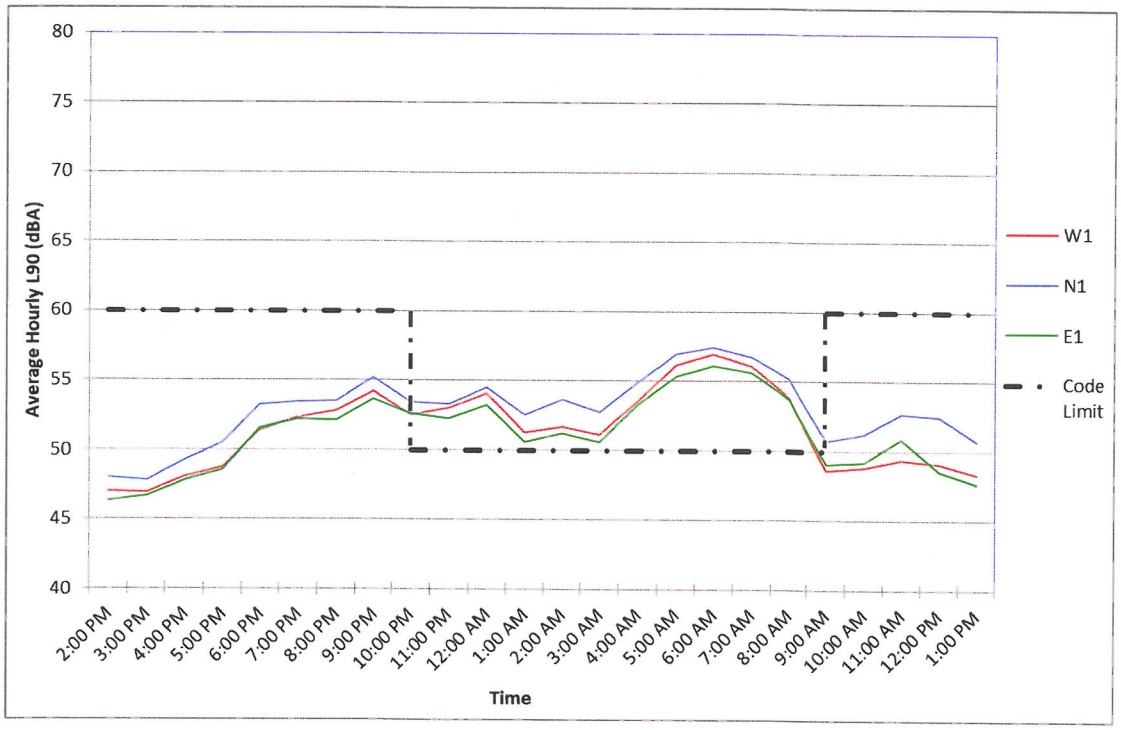


Figure 5-2: Average hourly L90 recorded at three locations from 10/24 to 10/25/2017 (Second day).

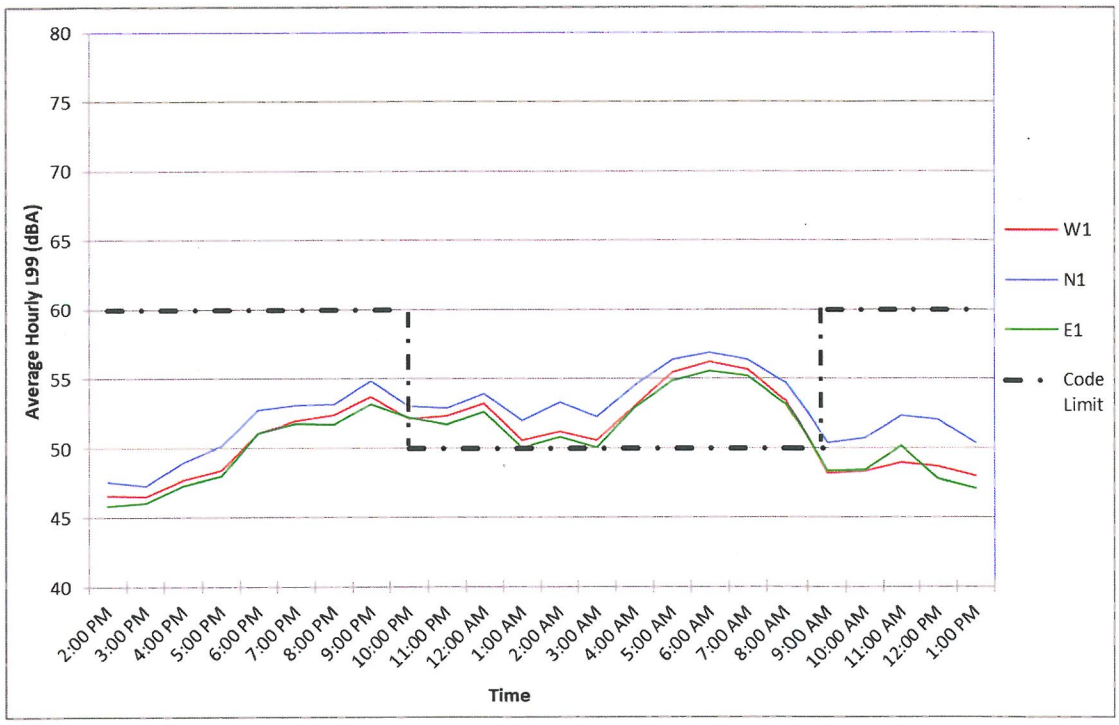


Figure 5-3: Average hourly L99 recorded at three locations from 10/24 to 10/25/2017 (Second day).

It can be seen that the noise levels at the three property lines are comparable to each other, with Ldn values between 61-62 dBA, and lowest ambient levels (L90) of 45-47 dBA.

4. Calculation and Prediction of Energy Server Noise Impacts to Adjacent Properties

Sound power levels for the energy server were used to calculate sound transmission to adjacent properties. As we understand it, four (4) ES-5 Yuma systems will be installed. Sound power levels for the ES-5 were provided in a MWA report dated June 21, 2016 (please notify MWA if the servers to be used differ from the ones measured in the mentioned report). The following table provides the total sound power for the ES-5 fuel cell.

	63 Hz	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	LwA
ES-6XXXv1	77.9 dB	80.9 dB	84.1 dB	82.3dB	80.5 dB	76.9 dB	69.4 dB	84.9 dBA

Table 2: Sound power levels (dB re 10^{-12} W) for a single ES-5 fuel cell.

The following figure shows a satellite view of the future location of the fuel cells (highlighted in blue), the nearest neighboring properties (numbered), and the measurement locations (colored circles for W1, N1, and E1).

Figure 6: Satellite view of the project site identifying the proposed location of the fuel cells (blue), nearest neighbours (numbered), and measurement location (colored dots).

The nearest residential property lines to the fuel cells are described with numbers one through three (3) on the figure above. Our calculations considered distance from the fuel cells to the neighboring

property, reflections on the existing building, the sound power of each fuel cell, and the attenuation provided by a proposed barrier around the fuel cells. The following figure shows the proposed barrier.

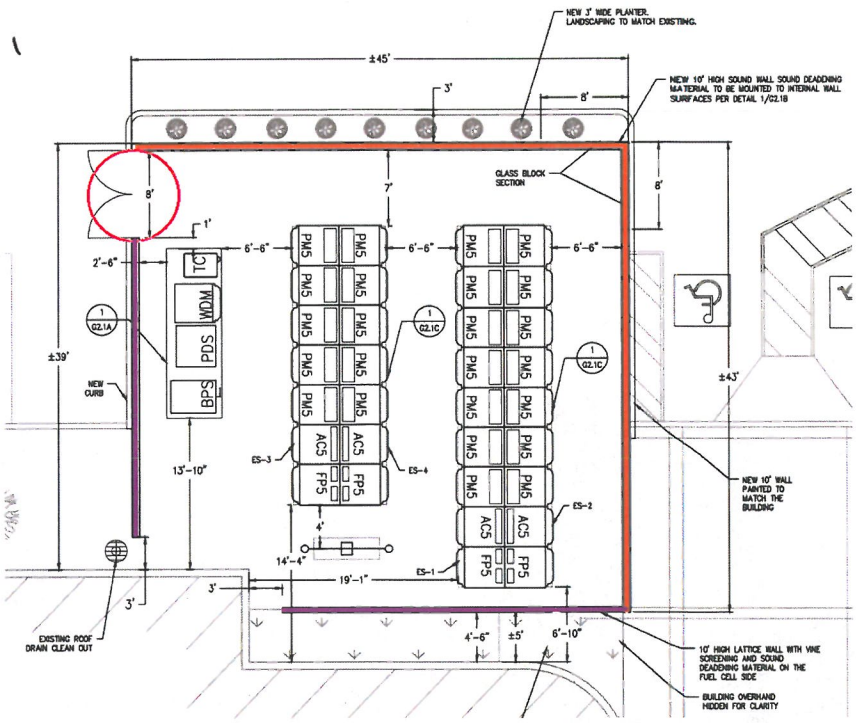


Figure 7: Sound barrier around the fuel cells.

The height of all walls must be at least 10 ft. The dimensions of the walls and the position of the fuel cells relative to the walls should be as shown in the figure above. The gap between the purple walls and the existing building should be less than 3 ft. There should be no air gap between the purple and orange wall. One double door is accounted on the north-west corner of the walls. **No other doors or additional gaps are accounted for.** The location of the fuel cell relative to the walls and existing building shown in the figure above should not change.

The door should be made of metal (at least 18 gauge), have weather stripping on all vertical and top sections of the door. It should have a closing mechanism that provides an airtight seal on all weather stripping. The door should be as high as the barrier walls. Astragal with seals must be used at the meeting of stiles of the double doors, or a single door should be used instead. The gap between the bottom of the door and the floor should not be more than 1 ½" tall (for drainage purposes). No other gaps for drainage purposes (in the wall or door) are accounted in the calculations.

The following table shows the predicted sound levels at the nearest property lines including the proposed sound wall.

Location		Horizontal Distance from Fuel Cells	Maximum Allowable Nighttime Exterior Sound Level	Predicted Sound Level from Fuel Cells @ nearest property line
1	Residential to the west	≈128 ft.	45 dBA	44.5 dBA
2	Residential to the north-west	≈195 ft.		43.9 dBA
3	Residential to the east	≈120 ft.		43.5 dBA
4	Industrial to the north	≈130 ft.	75 dBA	41.3 dBA

Table 3: Calculated noise impacts from the fuel cells to nearest noise sensitive receivers including mitigation.

Location 1 (Residential to the west shown in Figure 6) will have the highest noise impact from the fuel cells (44.5 dBA as shown in Table 3). As it can be seen in Figures 5-1 through 5-3, measured ambient noise levels range from 47 dBA to 60 dBA. The following table shows the calculated new ambient at Location 1 based on the existing ambient.

Condition	Noise Levels (dBA) at Property Line			
Existing Ambient	45	47	50	60
Fuel Cell	44.5			
New Ambient	47.8	48.9	51.1	60.1

Table 4: Calculated new ambient (existing ambient plus fuel cell) at Location 1 for different existing ambient levels.

As the ambient noise level gets louder, the impact from fuel cell noise becomes negligible. This does not mean that the fuel cells will not be audible. There might be some neighbors that will be able to hear the fuel cell, nevertheless, the fuel cells will be meeting the 50 dBA limit at the property line established on 19.42.030 of the Sunnyvale Municipal Code, and at the worst case will increase the existing ambient by less than 2 dB, which is not usually considered a significant increase.

The receivers on the residential property lines were calculated to be 25 ft above ground to account for the three story buildings present at the adjacent properties, at lower locations the sound pressure levels will be lower.

In addition to the barrier wall, MWA accounted for the interior sound absorptive material that is being installed inside the fuel cells. This material provides additional attenuation that is required for this site.

MWA understands that the client would like to use the All Weather Sound Panels by AcoustiBlok. The panels are rated as STC 29 (transmission loss) and have an NRC of 1.0 (sound absorption). These panels will meet MWA's requirements as long as they meet the dimensions and recommendations provided in this report. **No airgaps should be allowed between panels or below the panels.**

If another material will be used for the barrier, then any solid (gapless) material with a density no less than 2 lb. per square foot will suffice. Materials meeting this requirement include ½-inch thick wood, ½-inch outdoor plywood and 16 gauge steel sheet, masonry, or CMU blocks. Sound absorptive material rated as NRC 0.85 or more should be used in at least 80% (evenly distributed) of the interior area of all barriers to account for the absorption that is included in the AcoustiBlok All Weather Sound Panels.

5. Summary & Conclusion

The Energy Server / Fuel Cells enclosed in the acoustic barrier proposed is expected to produce operational noise of 44.5dBA at the property lines (east, west and north side) and complies with the Sunnyvale Municipal Code standards. This noise when added to the existing recorded ambient noise levels at the site is expected to have a minimal increase (0.1 to 2.8 dBA) to the noise levels at the east, west and north property lines. No significant noise impact will occur at the south property line given that the existing building will completely shield it from the new Fuel Cells.

* * *

This concludes our report. Please contact Mei Wu Acoustics if there are any questions or comments regarding this document.

Appendix – Additional noise measurements analysis

Section 3 of the report only analyzed the data gathered during the second day of measurement. This section shows the results of the other measured locations.

Figure 3 of the report shows the measurement location for both measurement days, that figure is copied below for reference.

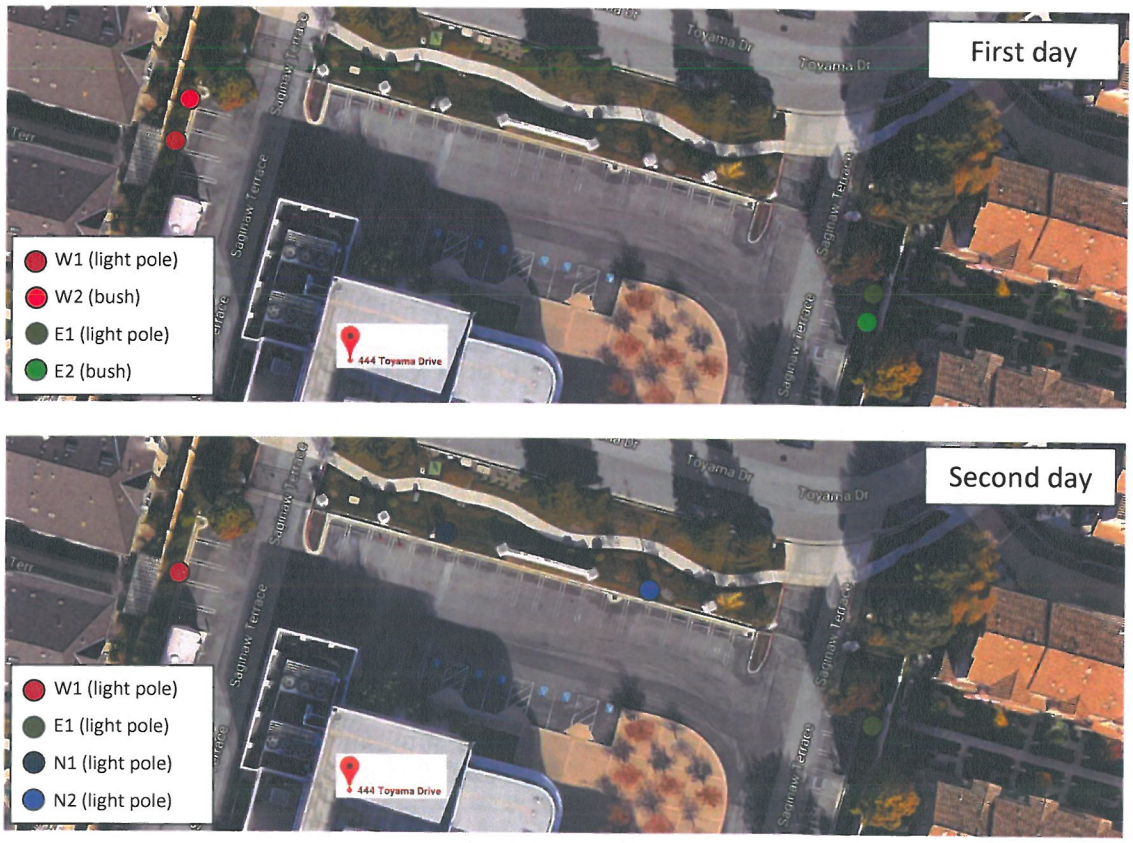


Figure A1: Meter location to measure noise environment at the nearest property lines to the fuel cells. (Figure 3 on report)

The following table shows the calculated Ldn for each measured location.

Location / Day	First	Second
W1 (lightpole)	61.0	61.8
W2 (bush)	59.3	NA
N1 (lightpole)	NA	62.2
N2 (lightpole)	NA	61.3
E1 (lightpole)	60.7	60.8
E2 (bush)	59.1	NA

Table A1: Ldn at each measurement location – 10/23-25/2017 (dBA).

The following graphs show the hourly LAeq measured in adjacent locations. **This comparison shows that meters near each other measured similar noise levels.**

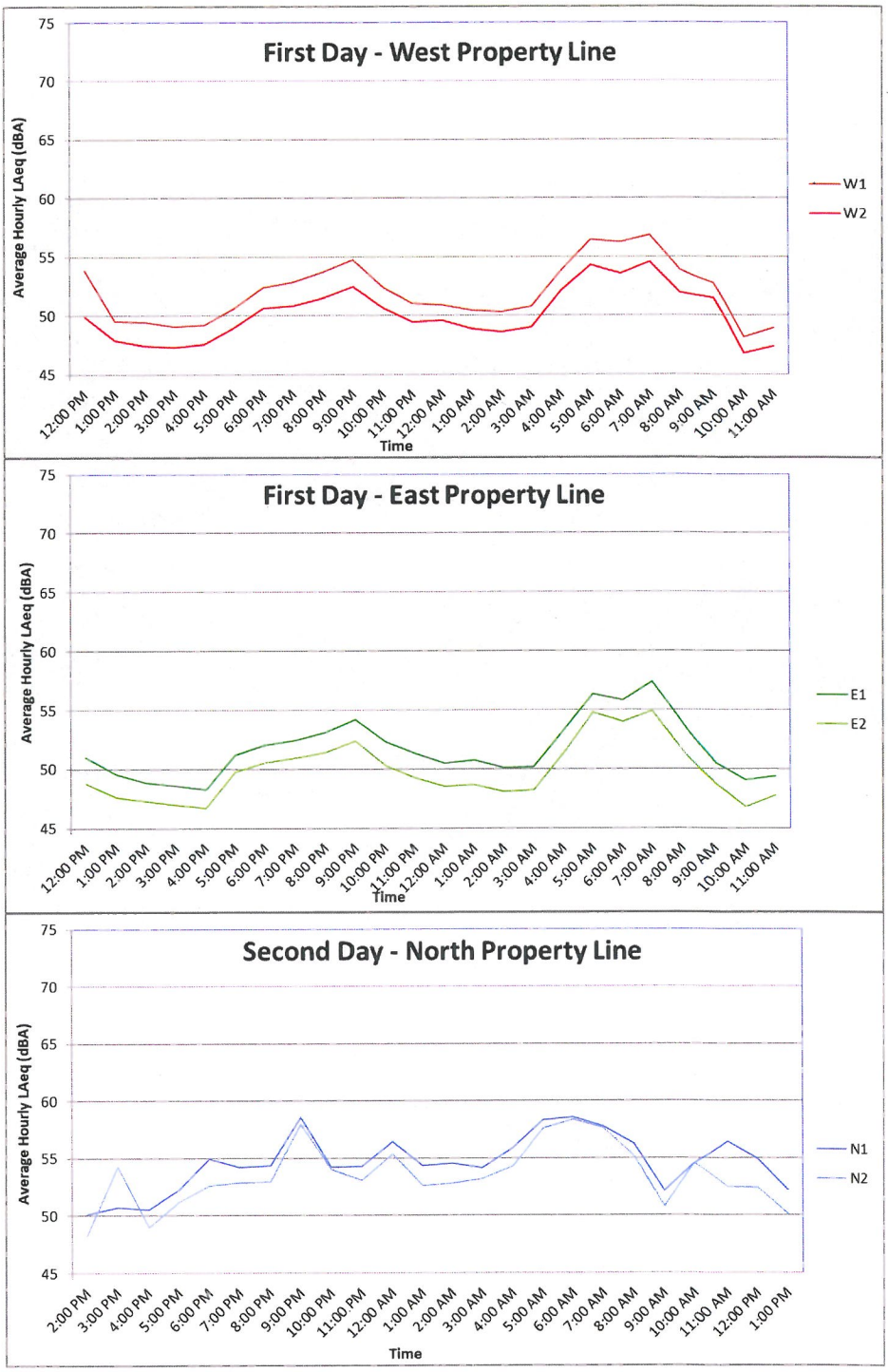
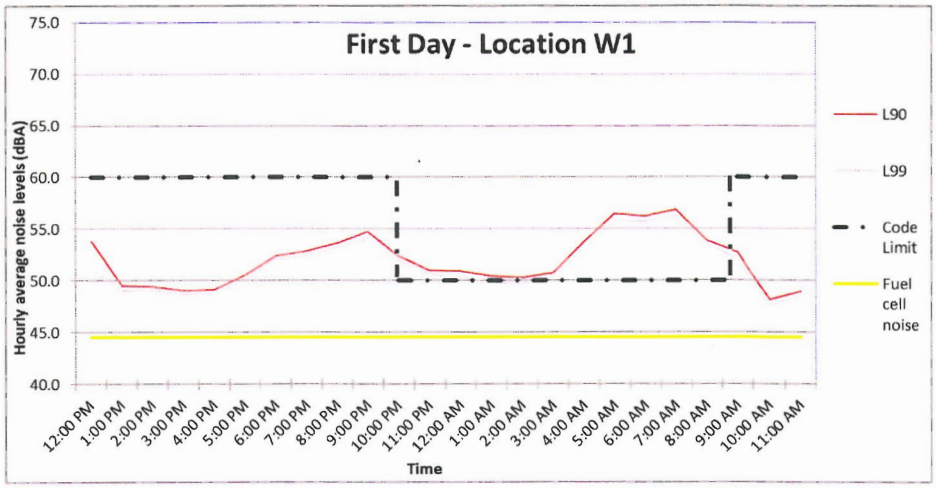
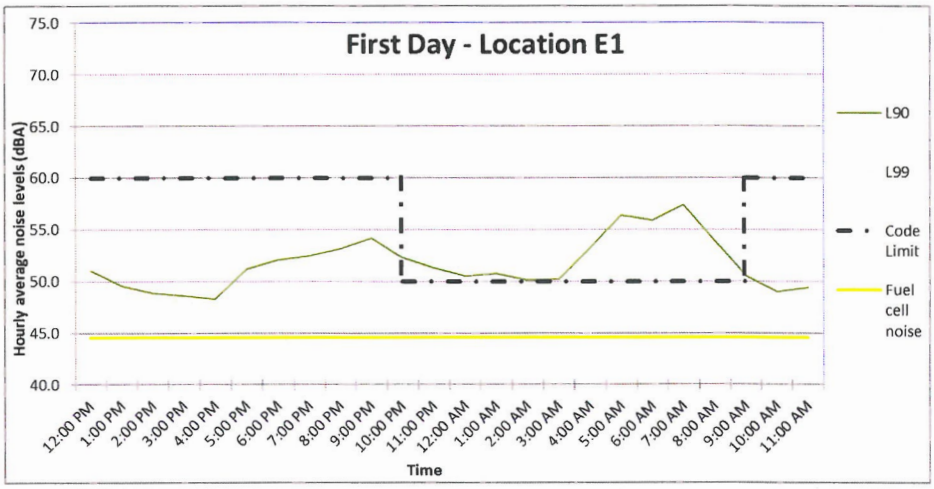


Figure A2: Hourly LAeq recorded at adjacent locations.

The following graphs show the hourly L90 and L99 measured at locations N1, E1, and W1, compared to the Sunnyvale noise limit and the expected noise levels to be generated by the fuel cells.





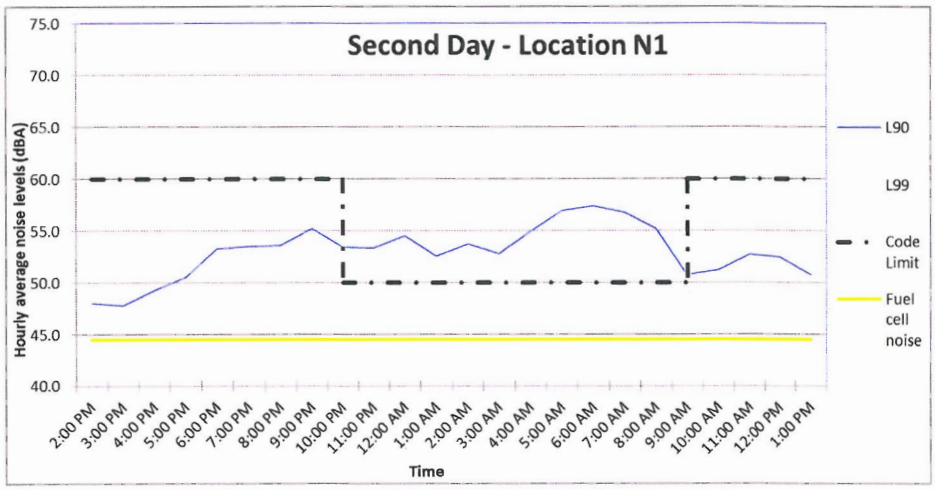


Figure A3: Hourly average L90 and L99 at three locations compared to Sunnyvale noise limit and the expected noise from fuel cells.