



Doosan Fuel Cell America, Inc.
195 Governor's Highway
South Windsor, CT 06074
T - 860 727 2200

February 24, 2017

RE: Responses to Interrogatories – Set Three for PETITION NO. 1270 - Doosan Fuel Cell America, Inc. petition for a declaratory ruling that no Certificate of Environmental Compatibility and Public Need is required to replace an existing customer-side 200-kilowatt fuel cell facility with a 460-kilowatt customer-side combined heat and power fuel cell facility to be located at the Fairfield Wastewater Treatment Facility, 183 Richard White Way, Fairfield, Connecticut.

Dear Siting Council,

Please find attached the responses to Council Interrogatories - (along with corresponding exhibits), requisitioned on 12/27/2016 for PE 1270-Set Three by the CT Siting Council.

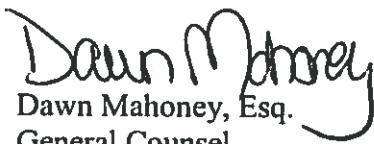
Please address additional questions to:

Tania Russell
195 Governor's Highway
South Windsor, CT 06074
(860) 727-2073
Tania.Russell@doosan.com

Thank you for your time and consideration.

Sincerely,

Doosan Fuel Cell America, Inc.


Dawn Mahoney, Esq.
General Counsel
Doosan Fuel Cell America, Inc.

VIA ELECTRONIC MAIL

December 27, 2016

Dawn Mahoney, Esq.
General Counsel
Doosan Fuel Cell America Inc.
195 Governor's Highway
South Windsor, CT 06074

RE: **PETITION NO. 1270** - Doosan Fuel Cell America, Inc. petition for a declaratory ruling that no Certificate of Environmental Compatibility and Public Need is required to replace an existing customer-side 200-kilowatt fuel cell facility with a 460-kilowatt customer-side combined heat and power fuel cell facility to be located at the Fairfield Wastewater Treatment Facility, 183 Richard White Way, Fairfield, Connecticut.

Dear Attorney Mahoney:

The Connecticut Siting Council (Council) requests your responses to the enclosed questions no later than December 14, 2016. To help expedite the Council's review, please file individual responses as soon as they are available.

Please forward an original and 15 copies to this office, as well as send a copy via electronic mail. In accordance with the State Solid Waste Management Plan and in accordance with Section 16-50j-12 of the Regulations of Connecticut State Agencies the Council is requesting that all filings be submitted on recyclable paper, primarily regular weight white office paper. Please avoid using heavy stock paper, colored paper, and metal or plastic binders and separators. Fewer copies of bulk material may be provided as appropriate.

Yours very truly,

Melanie Bachman
Acting Executive Director

MB/MP

c: Council Members
Tania Russell, Doosan Fuel Cell America, Inc.

Petition No. 1270
Doosan Fuel Cell America, Inc.
183 Richard White Way
Fairfield, CT
Interrogatories – Set Three

41. In Doosan's response to Council interrogatory number 34, an aerial photograph with a. depiction of the fuel cell and cooling module and electrical trench is provided. Provide a detailed site plan drawing with a scale that includes but is not limited to location and dimensions of the fuel cell, cooling module, concrete pads, fence design and bollards (if applicable), and utility connections including natural gas. (The site plan drawing provided in Petition No. 1262, interrogatory response 31 is an example.)

R41. Please see attached Fairfield -1 Detailed Site Plan Drawing.

44 Referencing Doosan's response to question 38, Doosan included a sound study based on testing a fuel cell facility. Please provide a site specific (i.e. consistent with the site plan) noise analysis report indicating the methodology used to compute the noise levels and identify the Connecticut Department of Energy and Environmental Protection (DEEP) Land Use Zones (A, B, or C) of the noise emitter and the noise receptors and indicate if the project is in compliance with the DEEP noise standards for the applicable emitter to receptors at the host property boundaries.

R44. Please see attached Fairfield – 2 Site Specific Noise Analysis Report.

FAIRFIELD -1

DETAILED SITE PLAN

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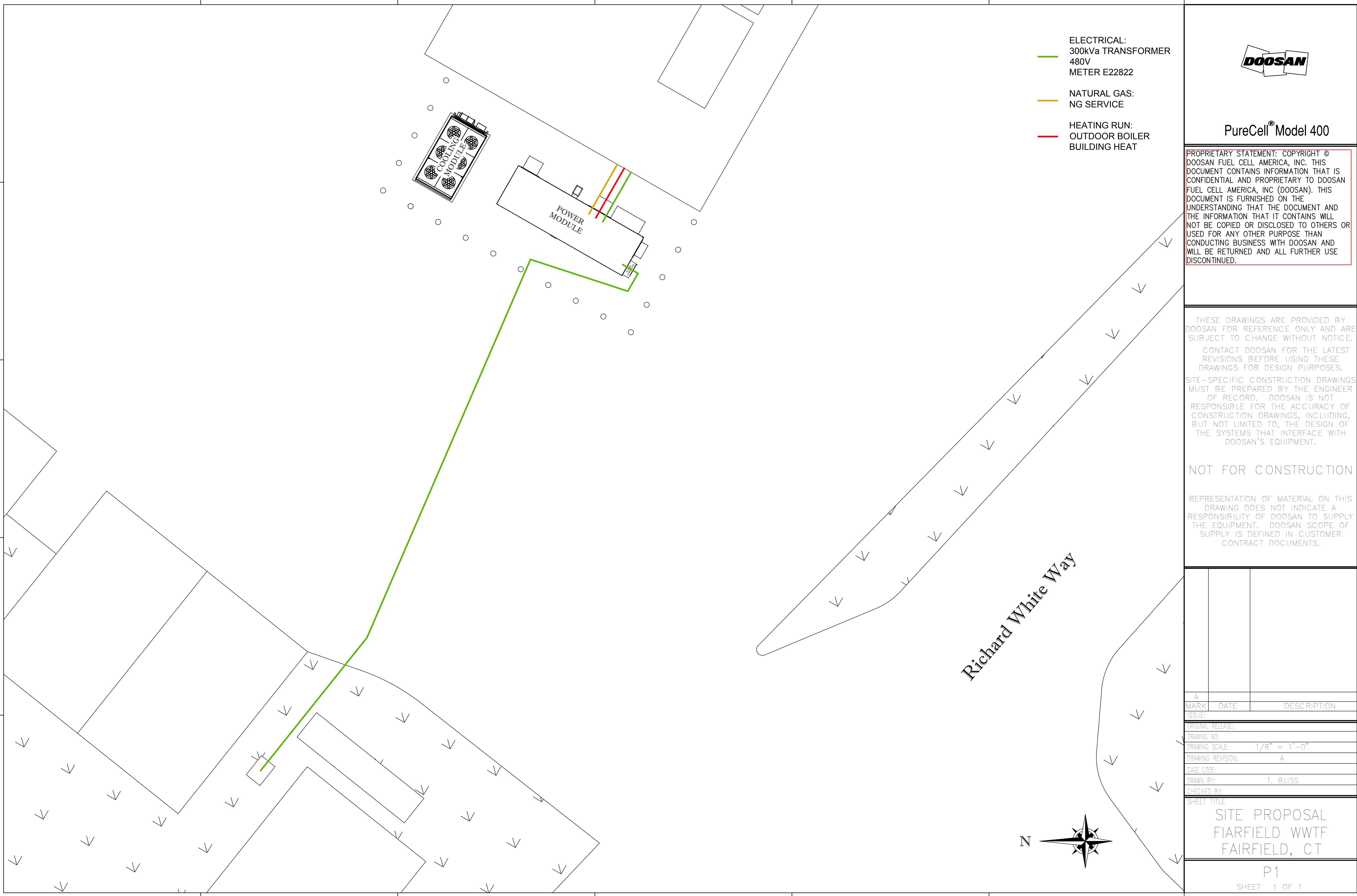
C

B

B

A

A



FAIRFIELD - 2

SITE SPECIFIC NOISE REPORT

Prepared For: Doosan Fuel Cell America Inc.

Point of Contact: Tania Russell

Prepared by: Acoustical Technologies Inc.
50 Myrock Avenue
Waterford, CT 06385-3008

Subject: Fairfield WWTF
Airborne Noise Assessment

Author: Carl Cascio

Date: February 3, 2017

Revision: 0

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Summary

This document makes a positive acoustic assessment that should assist in meeting any acoustic noise concerns during the operation of a Doosan 460 KW fuel cell at the Fairfield Waste Water Treatment Facility in Fairfield, CT. An acoustic assessment plan was developed and executed to acquire airborne acoustic information useful in explaining and mitigating the potential airborne noise issues associated with operation of the Doosan 460 KW fuel cell. It is important to show that the airborne noise generated by the fuel cell will not significantly impact the Waste Water Treatment Facility's neighbors.

The airborne noise levels expected to be generated by the Doosan fuel cell operating at the Waste Water Treatment Facility in Fairfield were simulated by exciting a set of four co-located speakers at the fuel cell power and cooling module positions. The cooling modules are the dominant noise source. The four speakers produced an overall airborne noise level that was 17 to 19 dB higher than the levels measured for a similar Doosan fuel cell installed at Mount Sinai Hospital in Hartford, CT. One-third octave band analysis showed the speakers to match or slightly exceed the fuel cell noise levels at frequencies below 250 Hertz where the A-weighted levels were low and to exceed the fuel cell signature by about 20 dB at higher frequencies where the fuel cell signature was higher.

Airborne noise levels were measured at distances from 5 to 300 meters from the fuel cell location. The speakers produced overall A-weighted sound pressure levels of 92 to 94 dBA at 5 meters and 86 to 89 dBA at 10 meters (reference 20 microPascals) at the proposed fuel cell locations. The airborne noise levels at nearby property lines varied from a low of 40 to a high of 73 dBA (reference 20 microPascals) with the speakers on. Analysis of the speaker data indicated propagation losses from 16 to 41 dB from the fuel cell location to the nearby property lines. Source levels at 10 meters from the operation of a Doosan fuel cell at Mount Sinai Hospital in Hartford, CT were used as a basis for the Fairfield noise estimates.

Operation of the fuel cell should produce noise levels below the day time Residential Zone noise limit of 55 dBA at all of the nearby property lines. The highest expected level of 49 dBA will be at the Harvest Supply property line 40 meters from the fuel cell. This location was the only one above the 45 dBA nighttime noise limit. Other Flood Zone property lines are much further away with expected levels of 25 to 38 dBA with the fuel cell on. Because the Harvest Supply business has operating hours from 7 am to 4 pm there are not expected to be any personnel or customers on sight during the nighttime hours to be affected by the 49 dBA level. In addition the background level at this location was 61 dBA due to the noise from the continuous operation of the Fairfield WWTF. The fuel cell component of 49 dBA should not be noticed at this location.

The nearest residential zone outside the Flood Zone is more than 330 meters from the fuel cell location and the airborne noise levels are expected to be well below the residential noise limits. There are no acoustic issues expected with operation of the fuel cell at the Fairfield WWTF site.

The Connecticut's Noise Code (Reference 1) also calls for review of acoustic issues associated with impulse noise, prominent discrete tones, infrasonic and ultrasonic noise. Operation of the fuel cell is expected to meet all of these requirements at all of the nearby property lines.

Introduction

Acoustical Technologies Inc. was tasked as part of a Doosan site permitting process with an assessment of potential acoustic issues associated with fuel cell airborne noise reaching the properties adjacent to the Fairfield Waste Water Treatment Facility (WWTF) in Fairfield, CT. Responding to a request from Tania Russell, a site visit was made on January 25, 2017. During the visit a survey of the airborne noise levels produced by a set of speakers simulating the airborne noise produced by a Doosan Fuel Cell was made in order to identify potential airborne noise issues. Airborne noise measurements were taken to quantify the propagation of the simulated fuel cell airborne noise to the adjacent properties. Background airborne noise levels were also made with the speakers off. This document provides an acoustic assessment to assist in meeting acoustic noise concerns during the permitting process for the siting of a Doosan fuel cell at 183 Richard White Way on the Fairfield WWTF property.

Development of the Acoustic Assessment Plan

The purpose of this effort is to acquire acoustic information useful in explaining the potential airborne noise issues associated with the operation of a Doosan 460 KW fuel cell at the Fairfield WWTF in Fairfield, CT. The WWTP site at 183 Richard White Way is located in a Flood Plane District near Pine Creek. The closest residential area is more than 180 meters to the northeast. Areas to the west, south and southeast are primarily commercial. The Town of Fairfield lists the Flood Plain area among its residential zoning districts. It is important to determine whether the airborne noise generated by the Doosan fuel cell will impact these neighbors.

The acoustic impact is assessed in the following way. The fuel cell is yet to be installed so there is no way to measure fuel cell operating airborne noise levels at the new site. The fuel cell airborne noise has been measured at other sites and both overall and one-third octave band airborne noise data of a typical Doosan 400 KW fuel cell are available for reference. Using this data, a set of four speakers will be programmed through a set of two octave band filters to generate a noise spectrum similar to that of the fuel cell. This spectrum will then be played through an audio amplifier to create the electrical voltage necessary to drive the four symmetrical speakers. In order to overcome the high background noise at the site the speaker output will be increased to a level about 18 dB higher than the overall dBA level measured on a fuel cell at a distance of 10 meters. With the speakers on, this approach then follows the traditional "What is the airborne noise level at the neighbor's property line?,,. The four speakers were run and airborne measurements made near the proposed fuel cell location and at several of the neighbor's property lines. This measured site data can also be used to estimate noise levels at other neighbor's property lines. The Town of Fairfield Noise Ordinance and the State of Connecticut Noise Code have been consulted to assess the impact of the measured and estimated acoustic levels. Noise mitigation may be recommended if the airborne noise estimated for the fuel cell exceeds the city and state noise requirements at the neighbor's property lines.

Acoustic Measurement Program

The acoustic data necessary to assess the impact of the 460 KW Doosan Fuel Cell are described below: Airborne sound pressure measurements and audio tape recordings were conducted at the Fairfield WWTF property on and near 183 Richard White Way during the morning hours of January 25, 2017. This testing established both background airborne noise levels and simulated airborne noise levels with the speakers operating. The overall A-weighted airborne noise measurements were made with an ExTech model 407750 Digital Sound Level Meter (s/n 3072577) that had been calibrated just prior to and after the test with a Quest model QC-10 Calibrator (s/n Q19080194). Measurements were taken with A-weighting (frequency filtering that corresponds to human hearing) and with the sound level meter in a Slow response mode. For reference, a noise level increase of 1 dB is equal to an airborne sound pressure increase of 12.2 per cent. The audio tape recordings were conducted with a Sony Digital Audio Tape Recorder (model TCD-D8 s/n 579588 on channels 1 and 2). Two PCB microphones (model 130C10 s/n 11283 and 130C10 s/n 10641) were powered by two Wilcoxon P702B power supply/amplifiers (s/n 1992 and 1995 respectively). The PCB microphones were also calibrated just prior to and after the test with a Quest model QC-10 Calibrator (s/n Q19080194). All measurements were made with the microphones at a height between four and five feet. A Hewlett Packard model HP3561A Dynamic Signal Analyzer, s/n 2338A00659, was used to perform A-weighted spectral analysis on the tape-recorded data. The tape-recorded data was also used to verify the ExTech sound level meter overall dBA readings.

At the Fairfield WWTF site “source on,, and background airborne noise measurements were taken at the following six nearby property lines all in the Flood Zone District:

- P1 - 295 Richard White Way, Harvest Supply Company
- P2 - 211 Richard White Way, Fairfield Animal Control
- P3 - 205 Richard White Way, Fairfield Regional Fire School
- P4 - One Rod Highway, Fairfield School Bus Parking Lot
- P5 - 248 Longdean Avenue, Nearest residential home
- P6 - 1 Ocean Reef Drive, Nearest residential condominium

See the Google satellite map in Figure 1 for the approximate measurement locations. (Figure 5 below shows individual Google Map pictures at each property line.) Measurements near the proposed operating fuel cell site at positions R and S were simultaneously taken with the ExTech sound level meter and two microphones recording on the digital tape recorder. Figure 2 provides a Doosan sketch of the site location for the fuel cell. Figure 3 below shows a photograph of the speakers at source position S. The two source locations were chosen because R represents the center of the cooling module and S represents the side of the power module facing the neighbors on Richard White Way. At locations R and S, 31 and 24 minute records of the acoustic noise were stored for the speakers in the “on,, condition, respectively. Two to three minutes of background airborne noise data were also recorded at each location.

Acoustical Technologies Inc.

Airborne noise measurements taken outside are corrupted by rain and wind so a day was selected when the weather was dry and the winds were 11 miles per hour or less. Table 1 provides the weather data in Fairfield for the measurements on January 25, 2017. Measurements were taken over the period from 9:30 am until 12:10 pm. The table below shows the temperature and wind speeds in hourly intervals. Wind conditions were excellent and the wind did not affect the operating and background airborne noise measurements. There was no rain. Motor traffic was moderate and it was possible to wait for periods of time when no traffic was seen or heard at the measurement locations. Continuous operation of the waste water treatment plant does cause high background noise levels in the vicinity of the plant. (Airborne noise levels near the location of the two source positions varied from 57 to 64 dBA.)

Table 1. Fairfield Weather on January 25, 2017 from www.LocalConditions.com

Time (EST)	Temp. (°f)	Humidity (%)	Dew Point (°f)	Barometer (in HG)	Wind Speed (mph)	Wind Direction
2:00 PM	46.4	56.99	32	29.61	-	-
1:30 PM	44.6	61.02	32	29.61	7	s
1:00 PM	46.4	52.98	30.2	29.6	8	w
12:30 PM	44.6	56.72	30.2	29.61	6	w
12:00 PM	42.8	60.77	30.2	29.61	7	wnw
11:30 AM	42.8	60.77	30.2	29.64	9	wnw
11:00 AM	42.8	56.46	28.4	29.63	11	wnw
10:30 AM	42.8	56.46	28.4	29.64	9	w
10:00 AM	42.8	56.46	28.4	29.63	10	wnw
9:30 AM	41	60.51	28.4	29.63	11	wnw
9:00 AM	39.2	64.9	28.4	29.61	4	wnw
8:30 AM	39.2	64.9	28.4	29.61	-	-
8:00 AM	37.4	64.66	26.6	29.6	5	nw
7:30 AM	37.4	64.66	26.6	29.58	7	nw
7:00 AM	37.4	64.66	26.6	29.57	7	wnw

Figure 1. Fairfield WWTF Site Map from Google Maps



Data Analysis

This section analyzes the airborne noise levels measured at the Fairfield site and then estimates the transmission loss to nearby property lines expected during fuel cell operation. These levels will be compared to the limits in the Connecticut and Town of Fairfield noise ordinances. Both background noise levels at the Fairfield WWTF site and estimated Doosan Fuel Cell equipment operating noise levels will be reported. Comparing these Fairfield WWTF measurements with the state and town noise requirements will identify which nearby locations are quiet and meet the requirements and which locations are not quiet enough. The complete set of overall A-weighted airborne noise levels that were measured are in Table 2 for the conditions with the speakers on and off. The CT and Town of Fairfield daytime noise requirement is 55 dBA and the nighttime requirement is 45 dBA for residential areas when the emitter is in a residential zone. The requirement in the Commercial Zone is 55 dBA and the Industrial Zone is 62 dBA when the emitter is in a residential zone. Figure 4 is a map showing the Fairfield zoning in the WWTP area. The position locations were calculated using the Pocket Ranger GPS App from the CT State Parks & Forests. The indicated GPS accuracy was about 10 meters. The GPS range results were calculated with an application found at <http://www.movable-type.co.uk/scripts/latlong.html> and then checked with Google Maps. Figure 5 provides the position vector at each location.

A comparison of the airborne noise produced at 10 meters by the Doosan fuel cell on the Mount Sinai Hospital site with the airborne noise produced by the speakers at the Fairfield WWTF site is shown in Figure 6. The speakers match the fuel cell airborne noise for frequencies below 250 Hertz and greatly exceed the fuel cell airborne noise at higher frequencies. The overall airborne noise levels are 17 and 19 dB higher for the speakers at positions R and S compared to what is expected from the Doosan 460 KW fuel cell.

Figure 2. Doosan Fuel Cell Installation Sketch for the Fairfield WWTF



Figure 3. Speaker Source at Position S where the Fuel Cell Power Module Will Be Located



Figure 4. Fairfield Zoning Map Showing Speaker Location at Position R

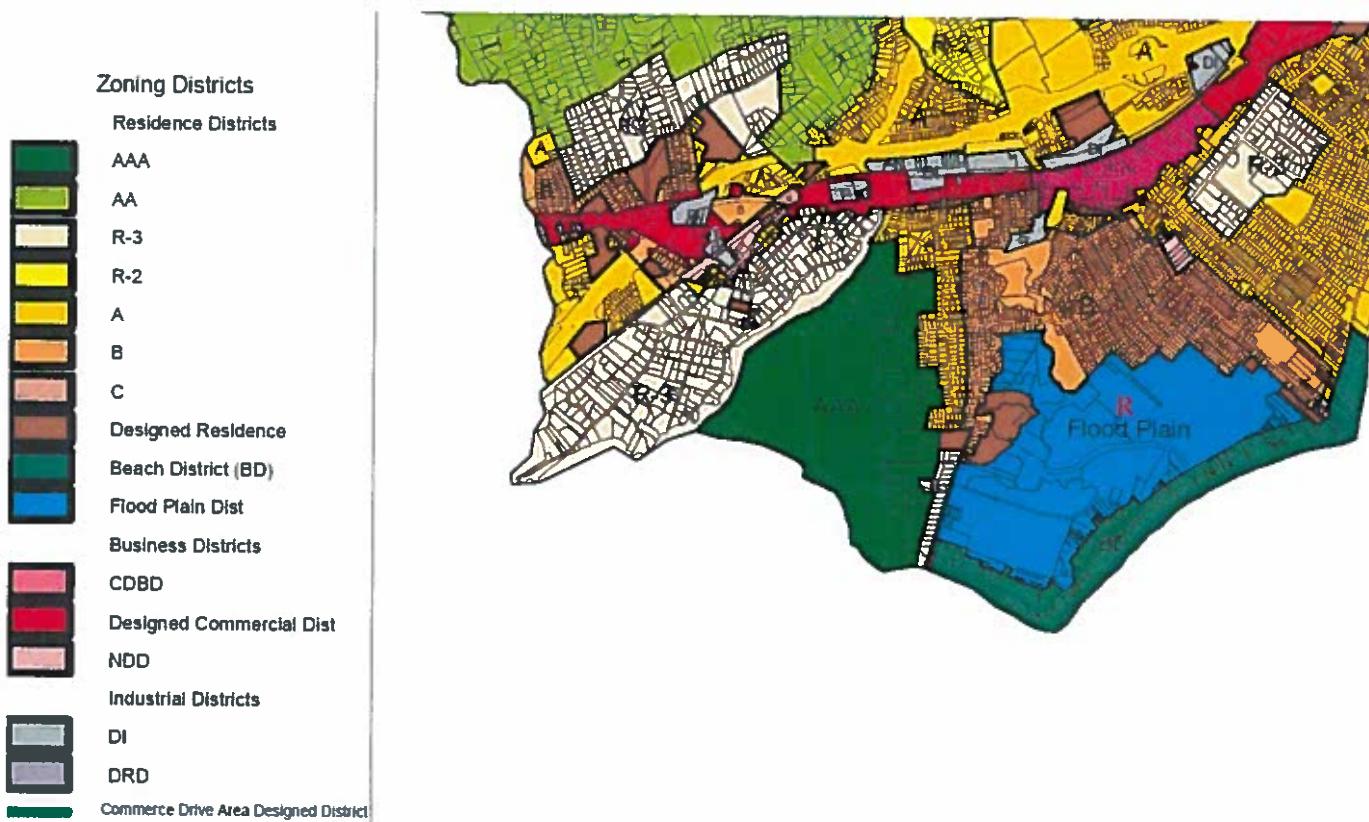


Figure 5. Measurement Locations Showing Range Vectors to the Source at Position S

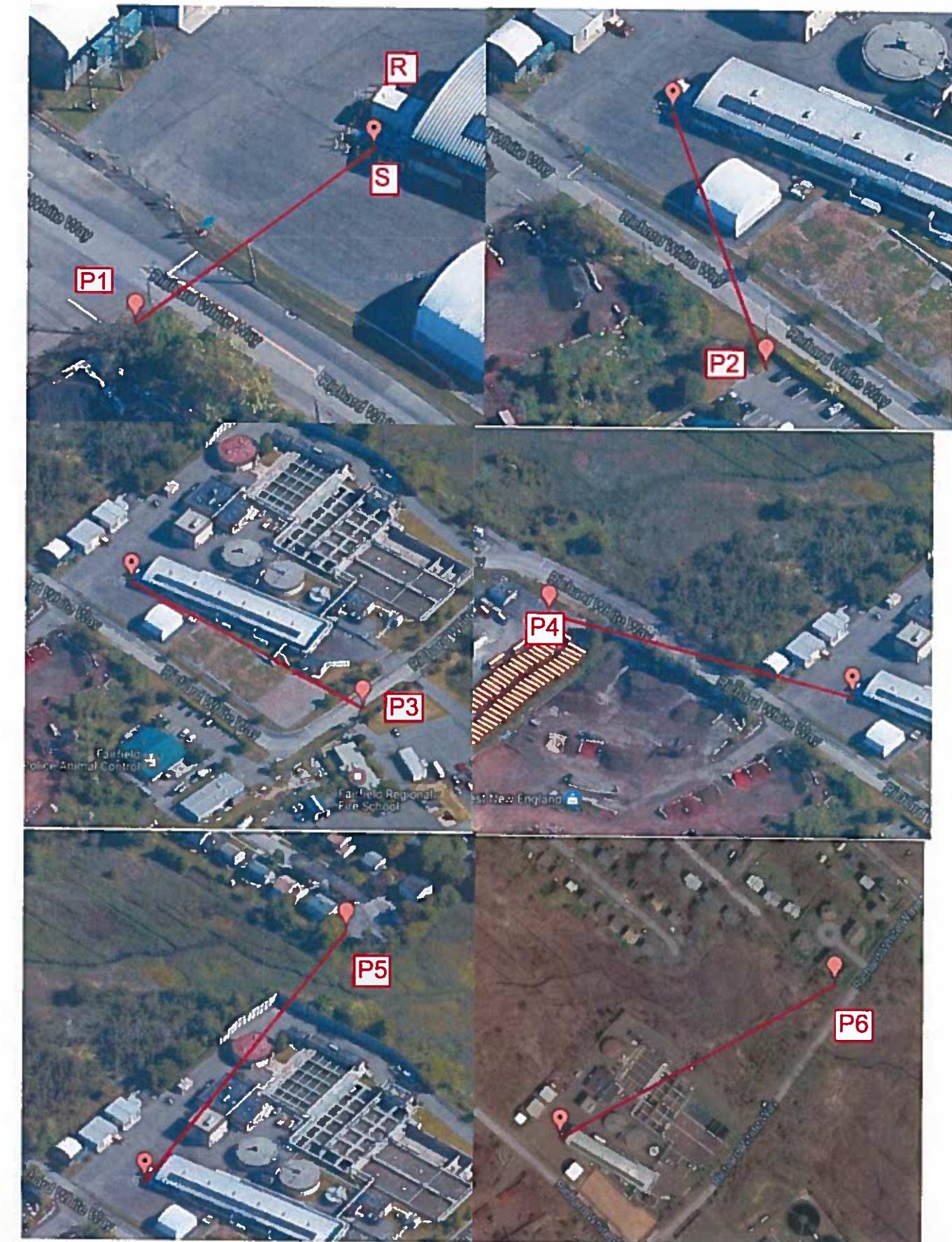
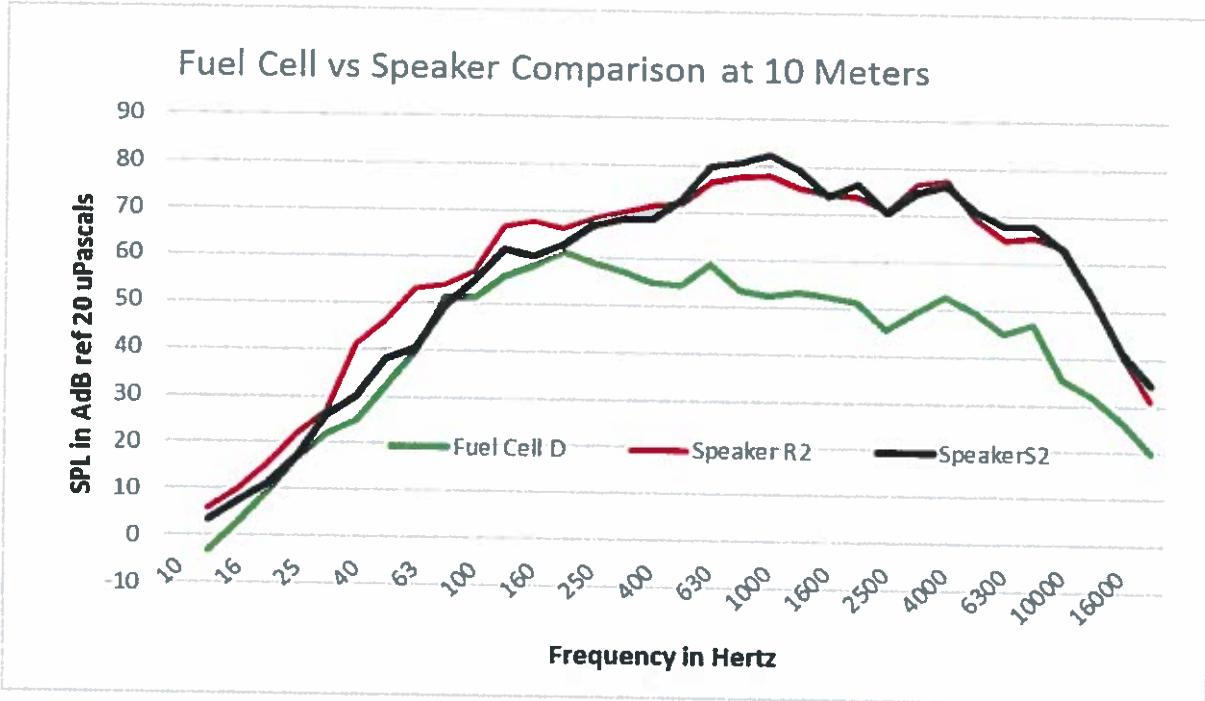


Table 2. Overall Sound Pressure Levels in dBA ref. 20 microPascals at Fairfield WWTF Site

Location	Range in Meters	Speakers On R	Background	Bkgd Corrected	Speakers On S	Background	Bkgd Corrected
Pos. R Ch 1	5	91.8	60	91.8			
Pos. R Ch 2	10	86.5	59.7	86.5			
Pos. R Ch 3	20	83	64	82.9			
Pos. S Ch 1	5				93.8	57	93.8
Pos. S Ch 2	10				88.5	59.7	88.5
Pos. S Ch 3	20				81	62	80.9
P 1 – 295 Richard White Way	54/40 m	67	61	65.8	73	61	72.7
P 2 – 211 Richard White Way	97/85 m	57	52.5	55.1	56	52.5	53.5
P 3 – 205 Richard White Way	144/140 m	58	55	54.9	57	55	52.6
P 4 – One Rod Highway	153/152 m	55.3	54	49.5	55.5	54	50
P5 - 248 Longdean Ave	180/194 m	45	43	40.6	42	43	Not Heard
P6 - 1 Ocean R D	288/299 m	45.9	44	41.5	43	44	Not Heard

Figure 6 The Four Speakers Generate Airborne Noise Well Above That of a Single Fuel Cell



Allowable Noise Levels

The Connecticut regulation for the control of noise provides in *CT section 22a-69-3* (Ref. 1) the requirements for noise emission in Connecticut. *CT section 22a-69-3.1* states that no person shall cause or allow the emission of excessive noise beyond the boundaries of his/her Noise Zone so as to violate any provisions of these Regulations. The Fairfield Noise Ordinance (Ref. 2) uses the same noise levels in the pertinent sections of the CT Noise Code basically changing only the nighttime hours on Friday and Saturday. The CT Code and Fairfield Noise Ordinance will be used to evaluate the noise generated by the Doosan Fuel Cell. Following sections discuss each type of noise using the results obtained from the measurements at the Fairfield WWTF site.

The southern part of the Fairfield zoning map is given in Figure 4. Fairfield WWTF is in the Flood Zone District. The other nearby businesses and residence are also in the Flood Zone District. The homes in the residential zones AAA, B, Designed Residence and Beach District are too far away (more than 330 meters) to hear the speakers and by comparison the operation of the fuel cell. The Mount Sinai Hospital report (Ref. 3) showed that its single fuel cell's airborne noise was estimated to be below the 45 dBA Hartford noise limit at about 75 meters from the fuel cell. Using the Fairfield speaker measurements, the airborne noise level expected at a distance of 85 meters at the Fairfield Animal Control property line should be about 38 dBA. The additional 200 plus yards to these other residential zones would reduce the fuel cell noise well below the required residential level of 45 dBA for an emitter in a residential or commercial zone. (This is the nighttime airborne noise limit for emitters in both residential and commercial zones.)

Impulse Noise

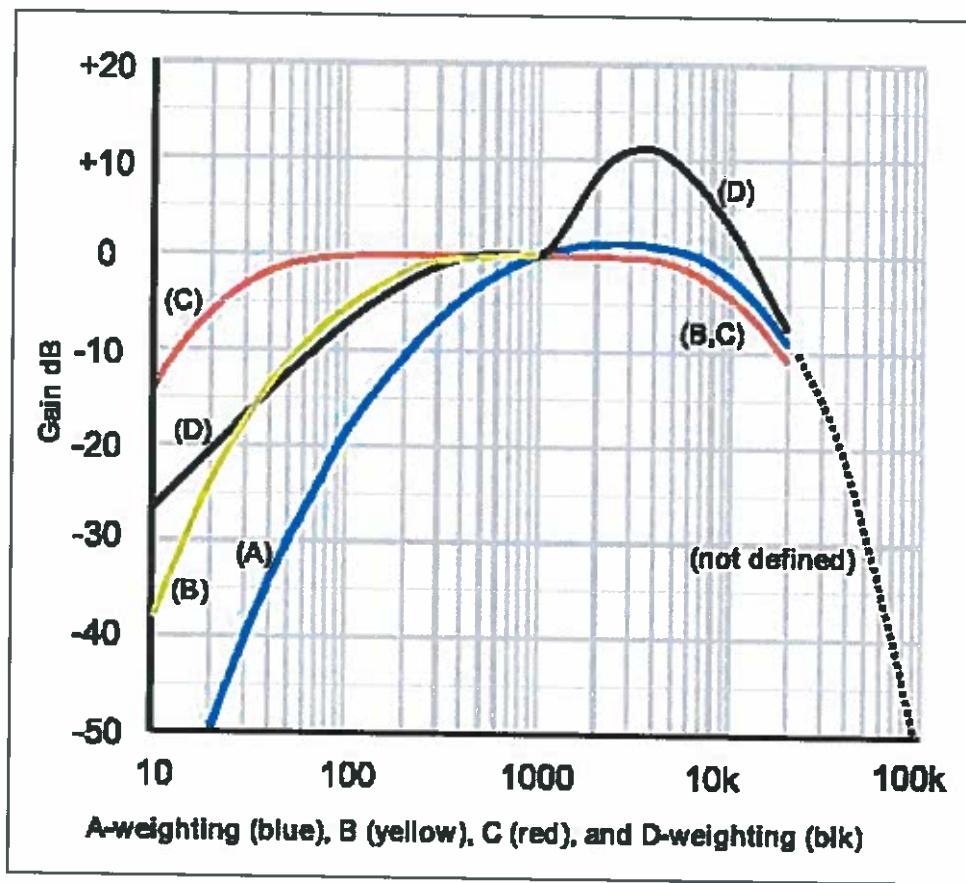
The Connecticut noise code states in *CT section 22a-69-3.2* (part a) *Impulse Noise* that no person shall cause or allow the emission of impulse noise in excess of 80 dB peak sound pressure level during the nighttime to any class A Noise Zone. Class A Noise Zones are residential. Nighttime hours are defined as 10 pm to 7 am. *CT section 22a-69-3.2* (part b) *Impulse Noise* states that no person shall cause or allow the emission of impulse noise in excess of 100 dB peak sound pressure level at any time to any Noise Zone. Fairfield adopts and then applies the state nighttime impulse noise limit to 80 dB to all daytime and nighttime hours and to all noise zones.

A few words are in order to discuss the difference between A-weighted and un-weighted impulse noise. A-weighting emphasizes the middle and higher frequencies while reducing the influence of the low frequencies. Figure 7 plots the A-weighting curve versus frequency in blue. Below a frequency of 1 kiloHertz the acoustic level is attenuated by increasing amounts. The reduction is about 10 dB at 200 Hertz, 20 dB at 90 Hertz and 30 dB at 50 Hertz. It also reduces the level at very high frequency being down in level by 10 dB at 20 kiloHertz.

Impulse noise in excess of 80 dB was not observed on the tape-recorded data during any of the measurements of the Doosan 400 KW fuel cell made at the Mount Sinai Rehabilitation Hospital on 18 January, 2017. This fuel cell design is similar to the unit that will be installed in Fairfield. Given the steady state nature of the fuel cell's noise signature there should be no acoustic issues with either the State of Connecticut's or the Town of Fairfield's impulse noise requirements.

Figure 7. Acoustic Weighting Curves

[http://upload.wikimedia.org/wikipedia/commons/3/39/Acoustic_weighting_curves_\(1\).svg](http://upload.wikimedia.org/wikipedia/commons/3/39/Acoustic_weighting_curves_(1).svg)



1 of 1

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Prominent Discrete Tones

The Connecticut regulation for the control of noise states in *CT section 22a-69-3.3 Prominent discrete tones*: Continuous noise measured beyond the boundary of the Noise Zone of the noise emitter in any other Noise Zone which possesses one or more audible discrete tones shall be considered excessive noise when a level of 5 dBA below the levels specified in section 3 of these Regulations is exceeded. The Regulations establish different noise limits for different land use zones. Residential (homes and condominiums) and hotel uses are in Class A. Schools, parks, recreational activities and services are in Class B. Forestry and related services are in Class C. By my reading of the regulations Fairfield WWTF is a Class B emitter in a Residential Zone. The noise zone standards in *CT section 22a-69-3.5* state that a Class B emitter cannot exceed the following overall sound pressure levels:

To Class C 62 dBA To Class B 62 dBA To Class A 55 dBA (day) 45 dBA (night)

The discrete tones limits are 5 dBA lower so that no tone may be higher than the following:

To Class C 57 dBA To Class B 57 dBA To Class A 50 dBA (day) 40dBA (night)

The Fairfield Noise Ordinance is more restrictive than the State Noise code by changing the noise limit rules to say that the noise limits apply to the location of the emitter and not the type. Even if Fairfield WWTF is Class B emitter in a Residential Zone then the lower Class A residential limits would apply. In effect the only number that would change is for a Class B receptor and that level would drop from 62 to 55 dBA. Thus, the Class A receptors (in a Residential Zone) have the same limit of 55 dBA in the day and 45 dBA at night regardless of whether the emitter was Commercial or Residential. Fairfield's noise ordinance does not mention discrete tones so the state ordinance limits shown above will be used.

To address the discrete tone issue we use measured data from the January 18 testing of a similar Doosan fuel cell. This data does not have A-weighting. The photo in figure 8 plots the airborne noise measured 10 meters from the Mount Sinai Cooling Module (Ref. 3) for frequencies from 0 to 1000 Hertz. This curve shows the two largest discrete tones produced by the Doosan Fuel Cell Cooling Module. The first tone is at 86 Hertz at a level of 65 dB reference 20 microPascals. The second tone is at 630 Hertz at a level of 56 dB reference 20 microPascals. The A-weighting corrections are -21.5 dB at 86 Hertz and -1.9 dB at 630 Hertz. Incorporating these corrections gives A-weighted levels of 44 dBA at 86 Hertz and 54 dBA at 630 Hertz both at a distance 10 meters from the Cooling Module. The transmission loss to the nearest Fairfield property line is at least 16 dB so the maximum possible discrete tone would be about 38 dBA across the street at the Harvest Supply property line which is below the 40 dBA nighttime requirement in the Residential Zone. The other nearby locations were shown to have more transmission loss with a minimum of at least 31 dB making the next highest level of 23 dBA at Fairfield Animal Control. Operating the Doosan fuel cell should produce airborne noise levels below the CT discrete tone requirement at all the property lines. There should be no acoustic issue with the State of Connecticut's discrete tone airborne noise requirements.

Infrasonic and Ultrasonic Noise

The Connecticut regulation for the control of noise states in *CT section 22a-69-3.4 Infrasonic and Ultrasonic* that no person shall emit beyond his/her property infrasonic or ultrasonic sound in excess of 100 dB at any time. 100 dB with respect to the reference of 20 microPascals is a sound pressure of 2 Pascals or 0.00029 psi. Infrasonic sounds are sound pressure fluctuations below a frequency of 20 Hertz. Ultrasonic sounds are sound pressure fluctuations at frequencies above 20,000 Hertz. Fairfield's noise ordinance does not mention either infrasonic or ultrasonic noise so the state ordinance shall be used.

Narrow bandwidth sound pressure spectrums in dB reference 20 microPascals at the 10 meter Cooling Module location given in Reference 3 can be used to compare with these Infrasonic and Ultrasonic noise requirements. Mount Sinai Hospital airborne noise data were processed in the 0 to 100 Hertz and 0 to 100,000 Hertz frequency ranges. The bandwidth of each data point is 0.375 Hertz for the 100 Hertz range and 375 Hertz for the 100,000 Hertz frequency range. The infrasonic noise for frequencies up to 20 Hertz is shown in Figure 9. The maximum level at 10 meters is 57 dB reference 20 microPascals. The entire 20 Hertz band can be power summed and

equals a value of 66 dB reference 20 microPascals, well below the requirement. The ultrasonic noise for frequencies up to 100 KiloHertz is given in Figure 10. The maximum level at 10 meters is 20dB reference 20 microPascals. The entire 80 KiloHertz band from 20 to 100 kiloHertz has been power summed and equals a value of to 31 dB reference 20 microPascals. Both levels fall well below the 100 dB limit at a distance 10 meters from the Cooling Module. The airborne noise level at the Forest Supply property line will be at least 16 dB lower. The noise levels at the other neighbors will be at least 31 dB lower based on the analysis in the previous section and there should be no issue with either infrasonic or ultrasonic noise at any of the neighboring properties. It should be noted that while the spectrum analysis covers frequencies up to 100 kiloHertz, the microphone sensors lose some sensitivity above 25 kiloHertz. The flat response below a frequency of 25 kiloHertz changes to a gradual roll off that reduces the amplitudes at higher frequencies. Fortunately, the measured noise levels are very low at 20 kiloHertz and decrease with higher frequencies and thus, no ultrasonic acoustic issues are expected above 25 kiloHertz.

Figure 8. Discrete Tones Produced by the Fuel Cell Cooling Module (0 dBV = 88.6 dB re 20uPa)

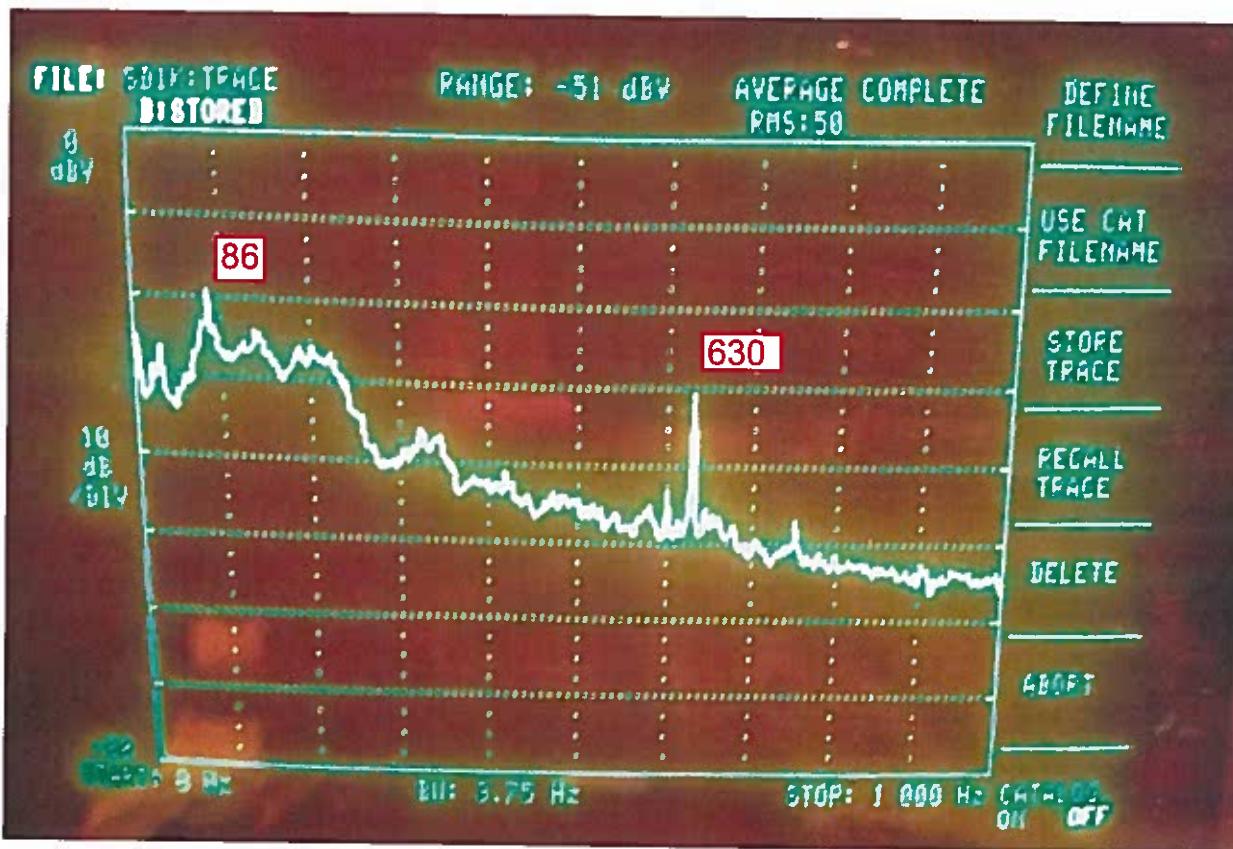


Figure 9. Infrasonic Noise from the Fuel Cell Cooling Module (0 dBV = 88.6 dB re 20uPa)

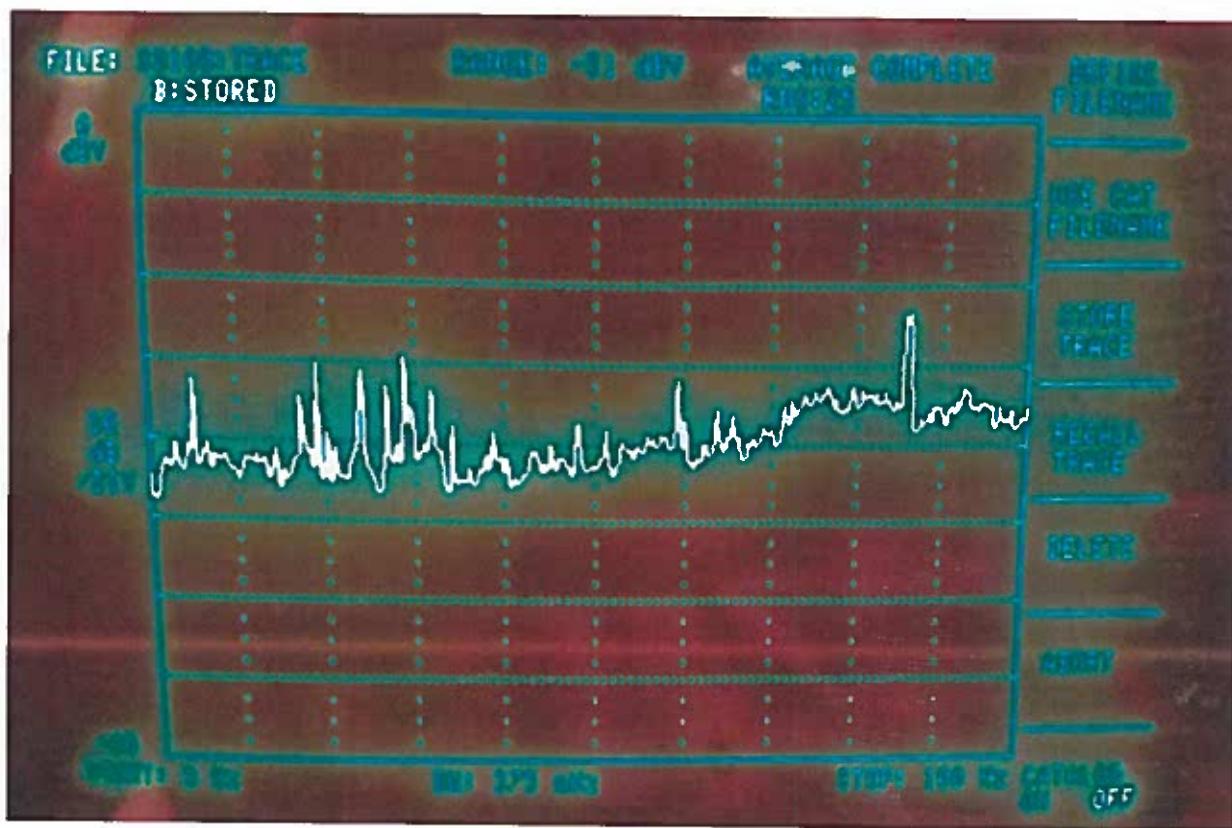
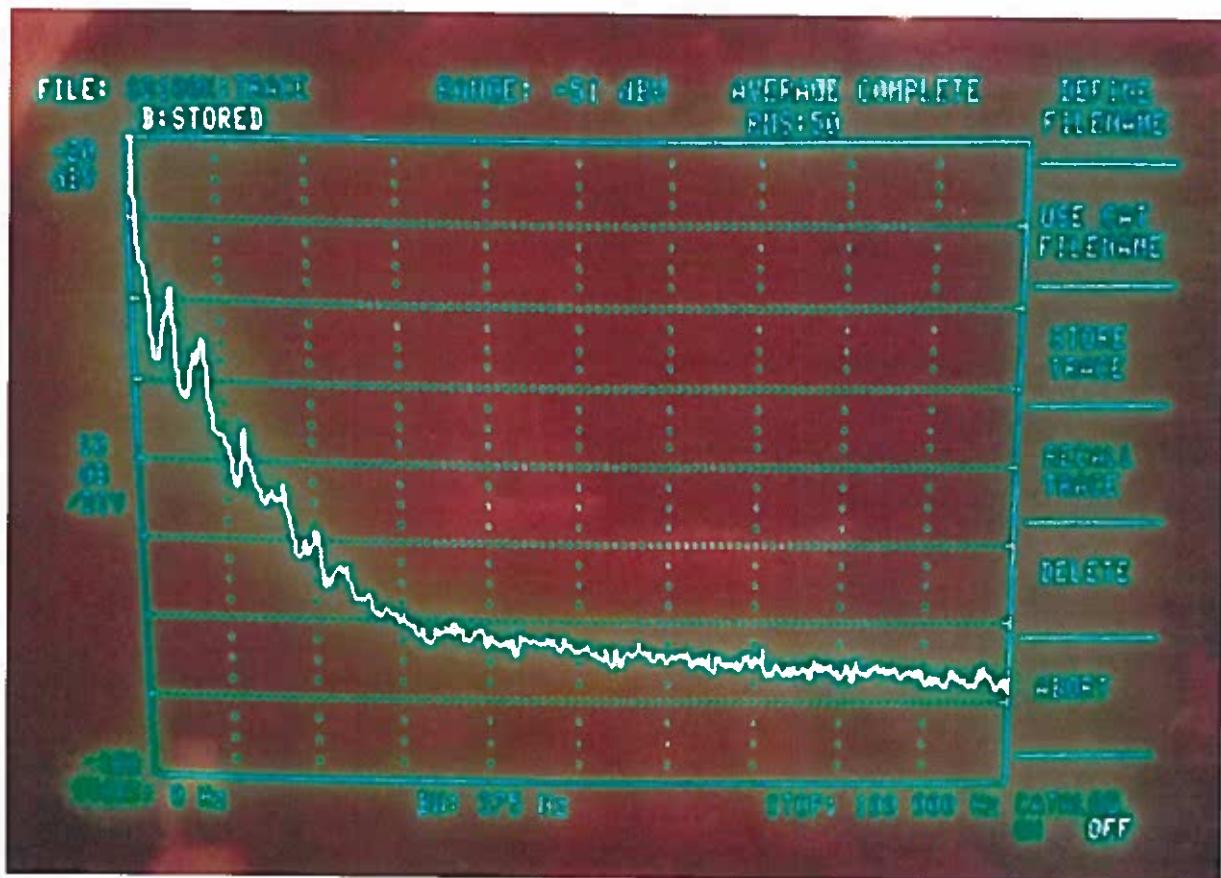


Figure 10. Ultrasonic Noise from the Fuel Cell Cooling Module (0 dBV = 88.6 dB re 20uPa)



Overall Sound Pressure Levels

The Connecticut regulation for the control of noise states in *CT section 22a-69-3.5 Noise zone standards* (a) *No person in a Class A Noise Zone shall emit noise exceeding the levels below:*

Class A emitter to *C 62 dBA* *B 55 dBA* *A/day 55 dBA* *A/night 45 dBA*

The Fairfield noise ordinance uses the same airborne noise levels but applies them to location. As a result, the Fairfield WWTF falls into Class A both as a zone and as an emitter. Please see the Fairfield Noise ordinance for details (Ref. 2). The neighbors are also classified as being in a residential zone even though they are mostly commercial businesses. The closest homes in the residential Flood Zone zones are too far away (more than 175 meters) to hear the speakers and by comparison, the operation of the fuel cell. A level of 45 dBA should occur at 75 meters.

The overall A-weighted sound pressure level measurements in dBA reference 20 microPascals are given in Table 2 above for the measurements made on January 25. The second column gives the approximate distance from the speakers to the measurement location, identified by a P number in Figure 1. The first number is the distance to the speaker at the "R," position while the second number is the distance to the "S," position. Column 3 gives the noise levels measured with the speakers "on," at position "R," while column 4 gives the background levels before the speakers were turned on. Background corrections are applied to column 3 and the background corrected speaker noise is given in column 5. The column 5 levels with the background noise removed are estimates of the contribution provided only by the speakers at each location. Columns 6, 7 and 8 repeat this same information for the case with the speakers at position "S,". In this case the background was taken after the speakers at position "S," were turned off

The following table compares the Fairfield WWTF speaker data with the Mount Sinai Hospital fuel cell measurements. Averages are calculated for the two speaker positions and the three 5 and 10 meter locations measured at the Mount Sinai Hospital. Doubling the measurement distance from 5 to 10 meters shows a drop in level from 4.5 to 5.3 dB, fairly close to the 6 dB expected. At 5 meters the speakers generate airborne noise levels 19.5 dB higher than the operation of the fuel cell. At 10 meters the speakers generate airborne noise levels about 18 dB higher than the operation of one fuel cell.

Table 3. Measured Airborne Noise Levels in dBA (20 microPascals) Corrected for Background

Source	5 meters dBA	10 meters dBA	Range Difference In dB	Level Difference In dB	Expected dBA Level For the Fuel Cell
"R,"	91.8	86.5	← 5.3	19.5	
"S,"	93.8	88.5	← 5.3	5 meters →	73.3
Speaker Avg	92.8	87.5		18	
Fuel Cell Avg	73.3	69.5	← 4.5	10 meters →	69.5
Mt Sinai "A,"	74	69.9			
Mt Sinai "B,"	74.3	70.3			
Mt Sinai "C,"	71.5	68.3			

Reviewing Table 2 it is clear that the airborne noise levels drop significantly in propagating to the nearby properties as the range increases. The highest property line background corrected level was measured at 72.7 dBA at the entrance to Harvest Supply (295 Richard White Way). This level was created by four speakers located at position S on the road side of the existing 200 KW fuel cell and these speakers were operating at least 19 dB above the level expected during operation of the Doosan fuel cell. The Harvest Supply property line should see airborne noise levels no higher than 54 dBA with the fuel cell operating with the cooling module on the road side of the 200 KW fuel cell. However, the current Doosan design calls for the cooling module to be on the other side of the 200 KW fuel cell at position R (See Figure 2). The level measured at the Harvest Supply property line was 65.8 dBA, about 7 dB lower when the source was at the intended location of the cooling module. (Doosan recognizes that the cooling module is the dominant noise source and should be located behind the large power module building to mitigate the cooling module noise.) Reducing this level by 17 dB means the Harvest Supply property line should see no more than 49 dBA, about 4 dB above the residential nighttime limit.

Because of the increasing loss with distance the remaining five property line measurements showed levels that would be no higher than 38 dBA with the fuel cell operating. All the expected maximum values (worse case between locations R and S) are shown in Table 4 below. All of the property line estimates meet the 55 dBA daytime limit. Only the estimate at the Harvest property line fails to meet the nighttime noise limit. This is the very closest property line just 40 meters from the fuel cell.

On further investigation Harvest supply advertises their operating hours as being from 7 am to 4 pm Monday – Friday and 7 am to noon on Saturday, closed Sundays. It is reasonable to expect that no one will be there during the nighttime hours to be affected by the fuel cell noise during the week. The Town of Fairfield has extended nighttime hours to 8 am on Saturday morning so there will be an hour from 7am to 8 am on Saturday morning when Harvest Supply is open, people might be there and the nighttime noise limit would apply. But this is just a minor technical violation since the background noise level was measured at about 61 dBA at the Harvest Supply property line due mostly to the continuous operation of the Fairfield WWTF. It is unlikely that anyone will be affected by the 49 dBA fuel cell noise in the presence of this much higher background noise. Also, the property line is at the road side edge on the property drive way and people would not be at this location. The additional distance to their actual location would allow the fuel cell noise to drop and make it unlikely that they would notice the fuel cell noise at all.

Table 4. Expected Airborne Noise Levels from Operating the Doosan Fuel Cell

P1	P2	P3	P4	P5	P6
49	38	38	33	24	25

Operation of the Doosan fuel cell will have no significant acoustic impact at the Fairfield WWTF site and to the nearby neighbors.

Conclusions

The purpose of this effort is to evaluate the acoustical environment at the proposed Fairfield WWTF fuel cell site in Fairfield, CT. This has been accomplished and the results show that the operation of a Doosan 460 KW fuel cell will meet all of the State of Connecticut and Town of Fairfield airborne noise requirements except for one hour per week on Saturday morning. The high level of background noise from the Fairfield WWTF is expected to mask the Doosan fuel cell noise at the closest neighbor resulting in no acoustic impact at the property line across the street at Harvest Supply or at any of the other neighbors.

References

- 1) CT DE&EP *Noise Control Regulation RCSA Section 22a-69-1 to 22a-69-7.4*
<http://www.ct.gov/dep/lib/dep/regulations/22a/22a-69-1through7.pdf>
- 2) Town of Fairfield Noise Ordinance
www.ct.gov/dep/lib/dep/air/noise/ordinances/fairfield_noise_ordinance.pdf
- 3) Mount Sinai Rehabilitation Hospital Airborne Noise Assessment, Carl A. Cascio, Acoustical Technologies Inc., January 26, 2017